A JOHNS HOPKINS PRESS HEALTH BOOK

THE EYE BOOK

A Complete Guide to Eye Disorders and Health

2ND EDITION

GARY H. CASSEL, MD

The Eye Book

A

Johns Hopkins Press

Health Book

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A Complete Guide to Eye Disorders and Health

Second Edition

GARY H. CASSEL, MD

JOHNS HOPKINS UNIVERSITY PRESS
Baltimore

Note to the Reader: This book is not meant to substitute for professional eye care, and decisions about treatment should not be based solely on its contents. Instead, treatment must be developed in a dialogue between the individual and his or her eye care professional. This book has been written to help with that dialogue.

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Preface

The eye, responsible for the vital sense of sight, is one of the most important organs in the body. When all is well, most of us take our eyes for granted. But as you no doubt know from experience, when your vision is blurred, or your eyes are itchy and watery, or it feels like there's something "sticking" in there, it's hard to concentrate on anything *but* your eyes. When something's not right with your eyes, then nothing's right with the world. As eye care specialists, we devote our working hours to helping people with eye problems of all kinds. This book has been written to help the many people who have such problems, or who are worried about their eyes or the eyes of someone they care about.

It's remarkable and humbling to consider how far the fields of ophthalmology and optometry—the specialties covering the anatomy, functions, pathology, and treatment of the eye—have progressed over the past five decades, a period when we have seen our patients helped by innovations in almost every aspect of eye care. New antibiotics and medications, safer cataract surgery with shorter recovery time, better glaucoma treatments, refined surgical techniques for mending retinal detachments and clearing vitreous hemorrhages, and retinovitreous treatments—not to mention a revolution in contact lenses and lens-making materials and technology—have helped thousands of people to see better longer.

This book describes many of these innovations and offers information and advice about what you and your eye doctor can do together to safeguard your vision and your eye health. In the first part of the book I describe the eye's anatomy and what changes occur naturally over time, as well as what changes are not natural and may be dangerous—and tell you what to do about them. In the second part of the book I demystify the eye examination, describe how eyeglasses and contact lenses work (and how to tell what will work best for you), and discuss popular vision-corrective surgeries.

Cataracts, glaucoma, and age-related macular degeneration are the three major diseases of the eye that rob older people of good vision. Knowing the signs and symptoms of these diseases and how to get proper checkups and screening are crucial first steps; once the diagnosis is made, treatment options must be weighed and decisions made. The three chapters in the third part of the book discuss each of these problems in detail.

In the fourth part of the book I continue the discussion of eye problems, beginning from the front of the eye, at the lids and lashes, and ending up at the back, with the optic nerve. Explanations of problems ranging from the annoying ("floaters and flashes," for example, or a twitching eyelid) to the more serious (uveitis, or arthritis of the eye) may be found here.

In the fifth part of the book I have included chapters on topics that are important for anyone wishing to have a better understanding of what happens to our eyes as we age. Eye trauma and emergencies are discussed so that readers will be able to take better care of their eyes and know how to recognize an eye emergency and what to do. A thorough explanation of how such diseases as diabetes, high blood pressure, and migraine headaches affect the eyes should be helpful to anyone coping with these problems. A chapter on low vision describes helpful devices and services and offers useful tips for people with declining visual acuity. The final chapters look at how common medications like antibiotics and blood pressure medications can affect the eyes and the good, bad, and ugly when it comes to cosmetics around the eye. In appendix A I discuss some myths about vision, and in appendix B I list common eye medications.

This book is designed to offer reliable and current information. I hope that it will help you understand your own eyes, your vision, and any problems you may be having. If you are facing a decision about eye treatment, you may want to take this book with you to your doctor's office, to discuss information that you find useful. As helpful as I hope this book will be, however, I know that only you and your doctor can make decisions about your treatment, based on your specific situation.

AN APOLOGY

My journey into ophthalmology began in the late 1970s at a cocktail party. As a medical student, this is where I was first introduced to Peter Savino, a neuro-ophthalmologist at the Wills Eye Hospital in Philadelphia, Pennsylvania. In conversation, he casually offered to allow me to spend some time at Wills in the neuro-ophthalmology service, along with him and Norman Schatz. At that time, Wills was located on Spring Garden Street, north of its current location. The building exuded history and respect, and the residents and attending staff were inspiring. I never dreamed that an entire hospital could be devoted to just the eye, let alone that you could learn so much from this tiny organ and how important it was to life. Peter and Norman were incredible diagnosticians, and showmen too, and I quickly became hooked on ophthalmology.

My entry into ophthalmology was through neuro-ophthalmology, but my true interest at the time was regeneration. Planaria regeneration had always fascinated me, and as I began to learn more about the eye, new blood vessel growth in retinal disease like diabetic retinopathy seemed to me to be a similar regenerative process. Therefore, after an incredible 3 years of training in ophthalmology as a Wills Eye resident, I decided to join the crusade of many basic science researchers in search of the holy grail, studying angiogenesis and finding the secret to new blood vessel growth and its control. Judah Folkman, a pioneer in this area of research, had just published a paper claiming to have isolated "angiogenic factor," and tracking down this protein became my mission while working in a lab at the Wilmer Eye Institute at the Johns Hopkins Hospital. I spent 3 years toiling in that lab day and night, and in any spare time that I had, I moonlighted as an ophthalmologist at a small community ophthalmology practice. Through my experience in this eye care practice, I eventually came to discover my love for the clinical practice of ophthalmology and how much I truly enjoy interacting one-on-one with patients and helping them with their eye problems.

Over the past 30 years, I not only have had the true pleasure to care for people but also have been honored to meet many nice and wonderful people who have sat in my exam chair. A good number have become friends too. They have spanned the religious, socioeconomic, political, and geographic spectrums and have lifted me outside the bubble of my own life. They have taught me a tremendous amount about the world and also about what it means to be a doctor, something that I now realize I most likely would have missed had I remained in research or academic medicine. I sincerely thank all of you—you know who you are. Also, among the many people I examined over the years, there are people whom I was not able to help. To those people permanently blind from birth or from trauma, to those people with visual impairment from degenerative eye disease, to those people confined in the house owing to severe dry eyes, and to those people who will still not find answers to their eye problems in this second edition, I apologize but offer hope.

The second edition of *The Eye Book* has helped me realize that eye care has come a long way in 20 years but still has a long way to go. The advances I have already seen make me hopeful that so many more advances in eye care are not too far off in the future. And although the second edition, like the first edition, cannot cover all eye care problems and issues of all ages, the book should be used as a starting point for your own investigation into your eye problems. Armed with the basic understanding and background I have provided you within these pages, I encourage you to search further for answers and latest treatments. Recognize that as time goes on, our understanding grows and our treatments change and become updated. Our eye care knowledge does not end with the printing of this book, so your quest should go beyond these pages. Furthermore, I recognize that the answers to your visual problems may not be discovered yet, but hopefully the answers you are looking for will be available in the near future, maybe even in the third or fourth edition of *The Eye Book*. Thanks to the tireless devotion of all those involved in eye research, so much has changed in just the past 20 years that we can only dream what the future of eye care will be like in 20 more years.

In an ever-changing health care environment, many different medical professionals are involved with general wellness and patient care. At different points in this edition of *The Eye Book* when I speak of health care providers or health care professionals, I am referring to all these medically trained people and don't mean to eliminate, exclude, or offend anyone. We all work together with a common goal—providing the best care we can for people.

ACKNOWLEDGMENTS

The new edition of *The Eye Book* revised by the author has its foundation in the first edition. The author would like to acknowledge his colleagues Michael D. Billig, OD, and Harry G. Randall, MD, who had assisted him as coauthors of the first edition, which was published in 1998. Special thanks is given to Dr. Benny H. Jeng, Chair, Department of Ophthalmology and Visual Sciences, University of Maryland Medical System, who provided invaluable advice about the content of this new edition. The American Academy of Ophthamology's *Basic and Clinical Science Course* (2019–20) has been a useful resource. In addition, the author would like to recognize the contribution of Michelle Bianchi, OTS/L, CLVT, who coauthored chapter 20.

Part I

INTRODUCTION

Chapter 1

A GUIDE TO YOUR EYES

As you can imagine, since the first edition of *The Eye Book*, our understanding about the eye has changed a lot thanks to new instrumentation and surgical techniques, as well as research in areas such as stem cells and gene therapy. I address a number of these new and exciting developments later in this edition. The basic anatomy of the eye and the effect of time on the eye are still the same. No matter how hard we fight it, certain unavoidable things happen to the body over time. Our skin starts to sag, for example; our bones begin to thin; so does our hair.

And inevitably, just like the rest of the body, our eyes age too. But because these changes are often much more subtle and incremental—in other words, because the eyes staring back at us in the mirror still *look* about the same as always—it's difficult for most people to detect any changes immediately.

This chapter is designed to help acquaint you with the parts of the eyes and how they work together so that we can see. In the next chapter I'll take a look at what's been happening to your eyes over the years, and later in the book I'll cover specific problems—and what you can do about them—in much more detail. Now, let's begin with a quick review of the eye's basic anatomy and the changes that most of us can expect to encounter as time goes by.

The Orbit

First, imagine a ping-pong ball. That's about how big your eye is. But unlike a simple ping-pong ball, your eye is wonderfully complex and intricately layered. Now, think of your eyelids as movable curtains on a stage. What we see of the eye is just the front surface that's visible between the opened lids; backstage in the eye is just as important and interesting. As you read the following description of the anatomy of the eye, you may find it helpful to refer to figure 1.1, panels A, B, and C.

A.

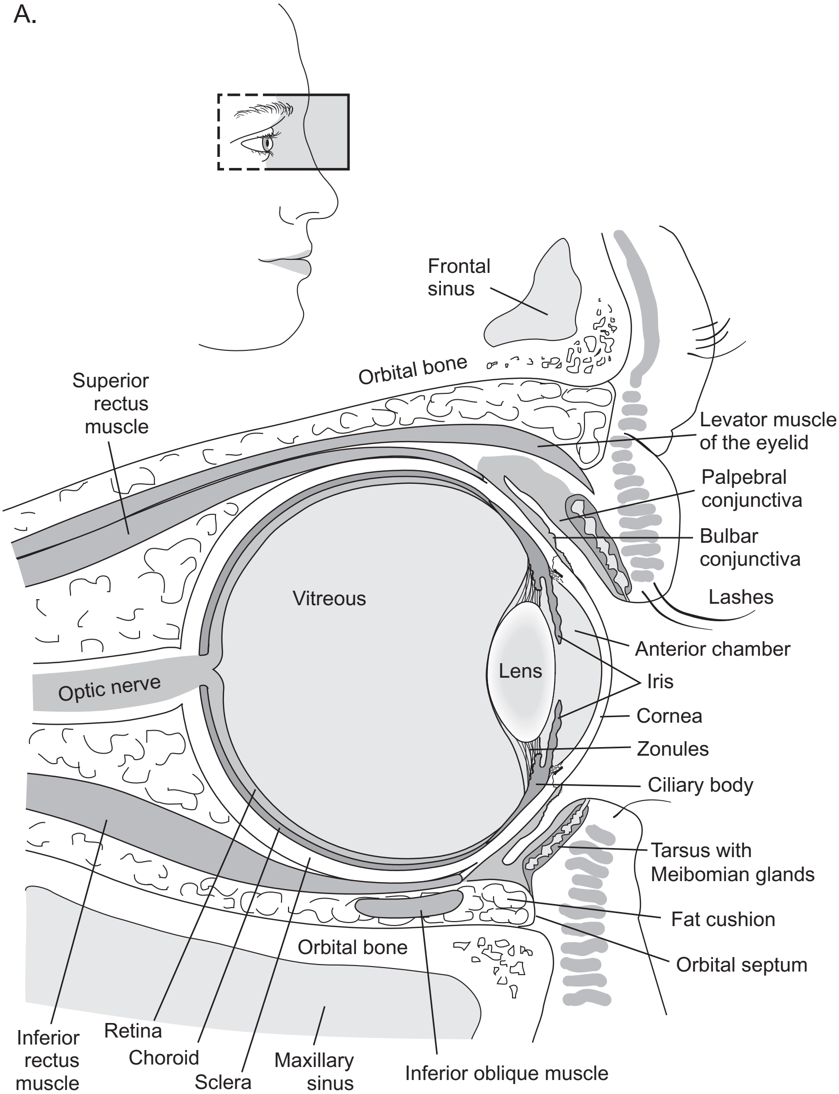
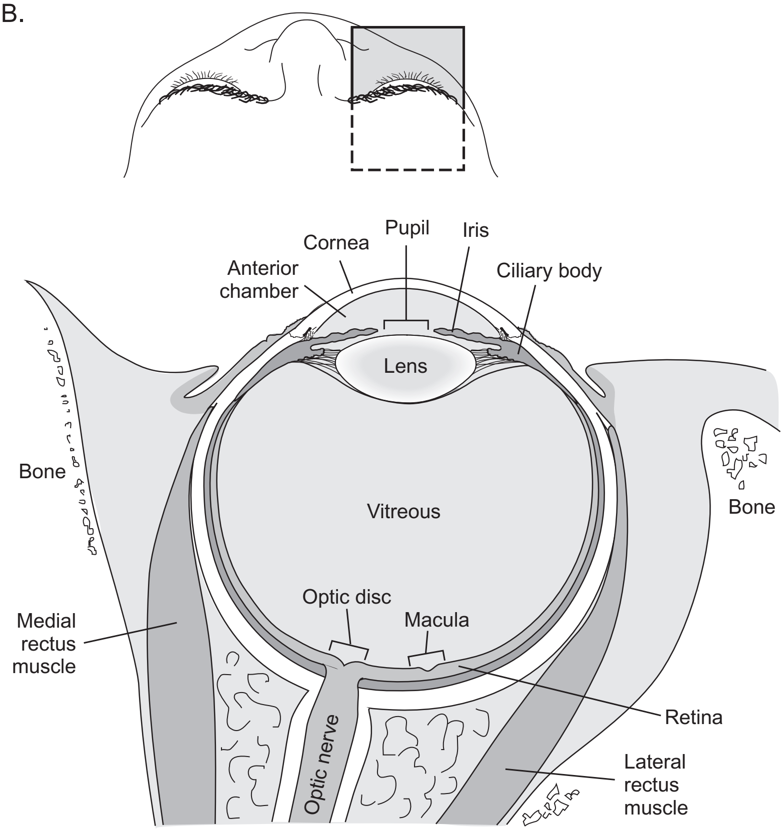
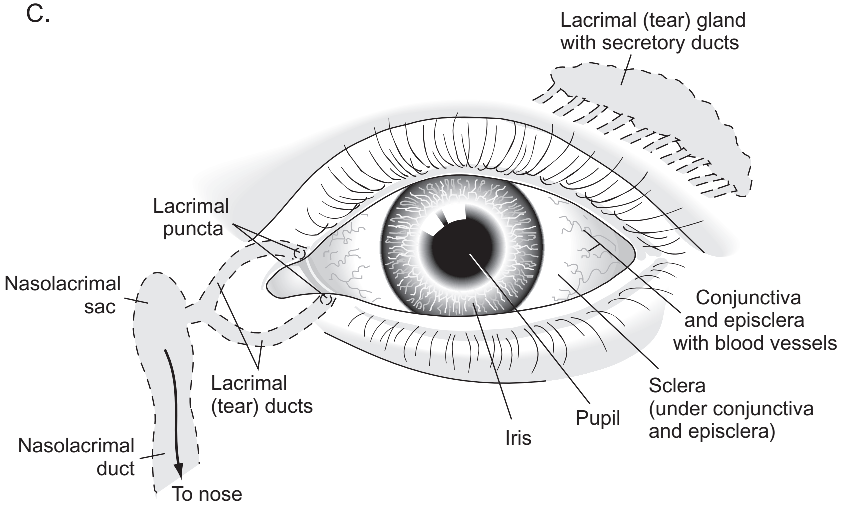


Figure 1.1. Anatomy of the eye: (A) side view; (B) top view; (C) front view

B.


Cornea
Pupil
Iris
Anterior chamber
Ciliary body
Lens
Bone
Vitreous
Bone
Optic disc
Macula
Medial rectus muscle
Retina
Optic nerve
Lateral rectus muscle

C.


Lacrimal (tear) gland with secretory ducts
Lacrimal puncta
Nasolacrimal sac
Conjunctiva and episclera with blood vessels
Lacrimal (tear) ducts
Sclera (under conjunctiva and episclera)
Pupil
Iris
Nasolacrimal duct
To nose

Nature provided the soft, vulnerable eye with excellent protection—a layered cradle, or socket, of bone called the *orbit*. The orbit has heavy bone on its outer edges, thinner bone on the inner (nasal) surfaces, and also a pillow of fat, which cushions the eye. This cavity also contains the muscles and nerves that allow your eyes and eyelids to move; blood vessels, which nourish and sustain eye tissue; and the *lacrimal gland*, which produces the tears that lubricate the eye. (Imagine how difficult and painful it would be to move your eyes back and forth, or open and close your eyelids, without this moisture.) The lacrimal gland is also part of the eye's defense system: in response to the sting of chemicals or onions, or to such irritants as dust or pollen, it turns on the faucet to dilute and wash away anything that might harm the eye. (For other reasons not entirely understood, this tear gland also responds to grief, great joy, and other strong emotions.)

Fortunately, unlike other bones, orbital bone—which is comparably thin to begin with—does not thin or weaken significantly with aging. In very elderly persons, the cushion of orbital fat sometimes atrophies, or shrinks, causing the eyes to sink noticeably back into the skull—which may pose an aesthetic problem, but not a functional one. In other people the orbital fat may herniate forward into the eyelids, causing abnormal puffiness or even "bags" under the eyes (see chapter 11).

The Eyelids

The *eyelids* are covered on their inner aspect with a clear sheet of thin, slippery membrane called *conjunctiva*, which folds back and connects to the front surface of the eye. Over this lining, and giving the eyelid some rigid support structure and strength—like the cardboard within the brim of a baseball cap—is a tough, fibrous plate of connective tissue called the *tarsus*; then come layers of muscle and skin. A thinner layer of fibrous tissue, called the *orbital septum*, connects the tarsus to the *periosteum*, the outermost layer of bone covering the orbit. The orbital septum is a thin fence that keeps the previously mentioned layer of orbital fat confined inside the bony orbit. As the orbital septum weakens over time, a few chunks of orbital fat can poke through this fence, making unsightly lumps in the skin under the eyes. (*Note:* Such lumps are “bad” only in that they’re not terribly attractive. For many people these lumps present only a temporary problem because they can be, and often are, removed surgically.)

As the skin of the eyelids ages—just like the skin on the face or arms—it tends to lose its suppleness and begins to droop. Sometimes the skin of the upper lid can sag enough to interfere with vision. (In the lower lid, this drooping skin—“bags under the eyes”—does not interfere with seeing, although again, some people consider it a cosmetic problem.) Sagging, excess skin on either or both eyelids can be taken care of with minor surgery, a procedure called *blepharoplasty* (see chapter 11).

At the edges of the eyelids are ducts for glands that secrete an oily substance, which helps keep tears from evaporating and from oozing out of the eyes and onto the skin. Here also are the bases of the eyelashes: delicate, efficient filters that protect our eyes from dust and myriad other foreign objects. Our eyelashes tend to become sparser as we get older. Interestingly, they become lighter, but rarely do they turn white with age.

The Sclera and Cornea

The “white” of the eye visible between the lids is the front portion of the *sclera*, a thick, protective sheath that encircles the eye, with a porthole at its very front. At this porthole, sitting like a watch glass on its casing, is the *cornea* (figure 1.2). The cornea is normally transparent, like a camera lens; through it you can see the iris and pupil. The normal cornea has no blood vessels, while the conjunctiva and episclera (two tissue layers that cover the sclera) do—a major difference and important for understanding the discussion of corneal neovascularization, or new blood vessel growth, later in this book (see chapter 6).

The back surface of the sclera is connected to the tough outer covering of the optic nerve, the cable that links the eye to the brain. (If you think of the eye as a kind of TV camera, the brain is where the electrical signals are sorted out and transformed into an image that makes sense.) Sometimes the white sclera of the eye develops dark areas (a condition called *senile scleral plaques* or *focal senile translucency* of the sclera). Don't worry—these dark areas are of no significance. They're caused by calcium deposits, which cause the sclera to lose its normal white color, allowing the dark pigment inside the eye to show through. (Oddly, calcium in the cornea causes the same problem in reverse: the cornea loses its transparency and turns white.)

The domed cornea is like a cake with five layers: the epithelial, or outer-lining, cells (the icing, if you will, on this cake); Bowman membrane; the tough but transparent stroma, the bulk of the cornea (the cake itself); Descemet membrane; and a single layer of endothelial, or inner-lining, cells. The inner endothelial cells tend to decrease in numbers with age. If too many endothelial cells are lost, through old age or injury, the cornea becomes cloudy, but fortunately the endothelial cells usually last a lifetime. As people get older, the outer cornea tends to develop a white ring called *arcus senilis*. This corneal ring is composed of cholesterol and its derivatives, but it is not usually related to an older person's blood cholesterol level. In some people the ring is very obvious, but the condition is so common as to be virtually normal, and it is of no significance.

The cornea is more than a window; it is a converging lens. As in a camera, it takes light rays and bends and focuses them to the back of the inside of the eye, the *retina*. The power of the cornea changes during growth but stays relatively constant in adults, with minor fluctuations in curvature causing slight shifts in vision, which require updates to eyeglass and contact prescriptions.

The Iris and Pupil

The *iris*, visible through the cornea, is composed of connective tissue and muscle with a hole in the middle. The color of the iris is actually due to the amount of pigment in the iris connective tissue layer. Brown eyes have a lot of pigment, blue eyes very little. (In the colloquial sense, if you have brown eyes, your iris is brown, and so on. No one knows why irises come in such a fascinating variety of colors and patterns.) The *pupil* is the hole in the iris, which allows light to reach the retina. The iris uses one muscle to constrict the pupil and another to actively dilate, or enlarge, it. Like an f-stop on a traditional camera, the pupil is wider in a darkened room and narrower in full sunshine. The iris characteristically loses pigment and thins with aging, resulting in the surprisingly bright "China blue" color of the eyes of some older people. The pupil tends to become smaller with age.

Around the iris, hidden by the sclera, is the *ciliary body*, the ring or tether that holds the lens in place, connected in back with the *choroid*, a bolstering, nourishing layer of blood vessels between the sclera and the retina. Normal aging changes the choroid, but usually not in any remarkable way. The ciliary body produces the *aqueous*, a watery solution that bathes the lens; manufactured behind the iris, it travels through the posterior chamber and the pupil and leaves the eye through a drain in the *anterior chamber angle*, where the iris meets the cornea. (This fluid must get out of the eye, and trouble can arise when its exit is blocked. An important job of the eye's plumbing is to keep the pressure in the eye from becoming too high.) The aqueous is secreted by one group of cells and eventually leaves the eye through a drain or meshwork created by other cells. This balance maintains what's called the *intraocular pressure*—and this, like the pressure in a balloon, is essential for maintaining the shape of the eye (and particularly for preserving the curvature of the cornea). (See chapter 9, on glaucoma, which is a problem that develops when eye pressure isn't normal.)

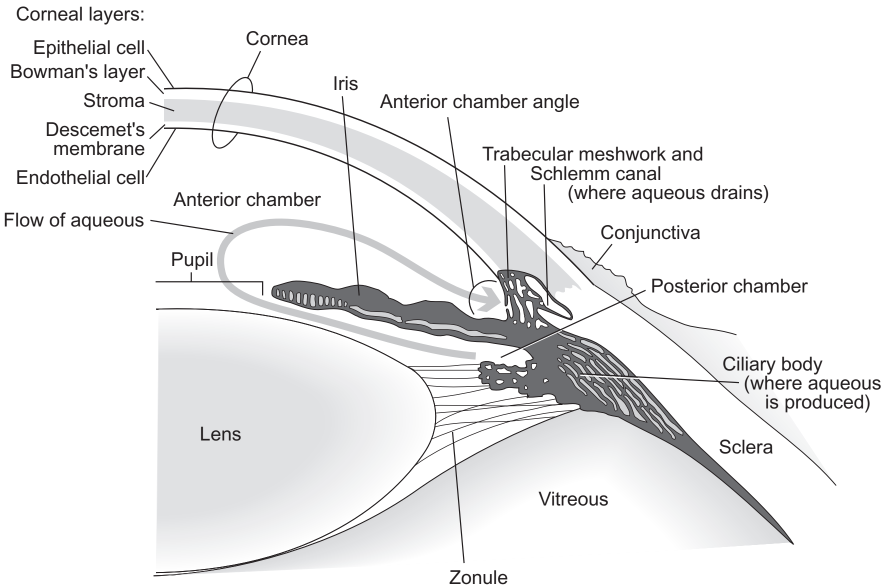


Figure 1.2. The cornea, iris, pupil, and lens

The Lens

Behind the iris is the *lens*—about the size and shape of an M&M candy—fastened to the ciliary body by thin fibers called *zonules* (figure 1.3). The lens is elastic: to focus, it stretches and snaps back into place. In the job of focusing light on the retina, the cornea does about three-quarters of the work and the lens about one-quarter, but the cornea has *fixed* focus power and the lens *variable* focus power—at least for a while. This brings us to a universally recognized signpost of aging, which arises when our eyes develop trouble mastering a task called *accommodation*. Accommodation takes place when a muscle in the ciliary body contracts, relaxing the tension on the zonules, thus allowing the lens to become less flattened and more spherical. Accommodation begins to diminish at about age 10, but the change is usually not noticeable until about age 40, when reading the small type on your mobile phone or computer suddenly isn't as easy as it used to be. What happens? The muscle of the ciliary body continues to work as well as ever, but the lens grows harder and less elastic; it no longer changes shape when the tension is relaxed. The result? The dawn of a sobering new phase in adulthood: dependence on reading glasses (or needing bifocals).

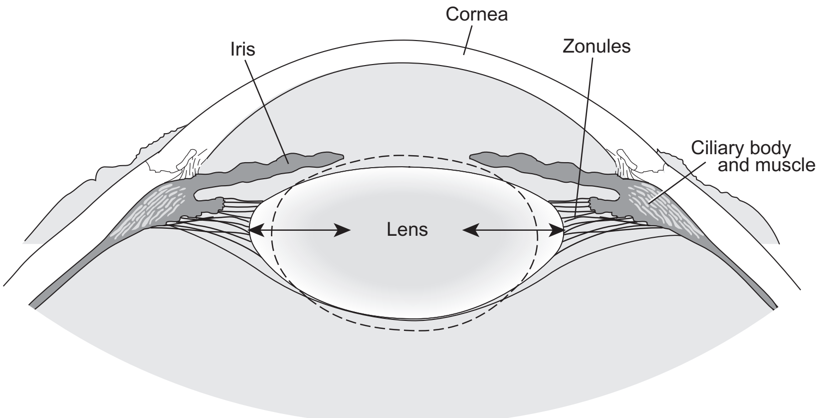


Figure 1.3. The lens, showing accommodation for fine-tuning focus

The Retina

Inside the sclera is the vascular choroid; inside the choroid is the retina, the reason for being of everything else in the eye (figure 1.4). The exquisitely complicated retina does far more than merely register an image like a bit of photographic film. Indeed, cells in the retina break down an image into countless elements—brightness, position, color, movement—and then encode all these elements as electrical signals and transmit them to the brain. Remarkably, all of this is done not only faster—literally—than the blink of an eye but also faster than we can even comprehend without the help of highly specialized scientific instruments.

The intricate structure and function of the retina could be the subject of an entire book in and of themselves, but let me provide a brief overview here: First, layers of *rods* and *cones* receive the basic units of light, triggering a photochemical reaction in these cells. Then, *bipolar cells* apparently receive, organize, and transmit this information to *ganglion cells*, which send these signals to the brain through a collection of nerve fibers called the *optic nerve*. Though many diseases affect the retina, normal aging of the retina does not usually affect vision appreciably. This is especially true in the *macula*, the area of the retina responsible for central vision, which is needed for such functions as reading and fine visual acuity. The macula, the most significant part of the retina, is located next to the optic nerve and is responsible for our *central vision* (as opposed to our *peripheral vision*). The macula is composed mostly of cones and is also an important part of color vision (figure 1.5).

Most of the interior of the eye is filled with *vitreous*, a nearly transparent substance that resembles Jell-O in texture. Vitreous is supported by scaffolding, a meshwork of collagen fibers, and a gel of water and hyaluronic acid. In normal aging, this gel slowly liquefies, allowing the meshwork to collapse and clump. The vitreous is attached at the far periphery of the retina, at the optic nerve head

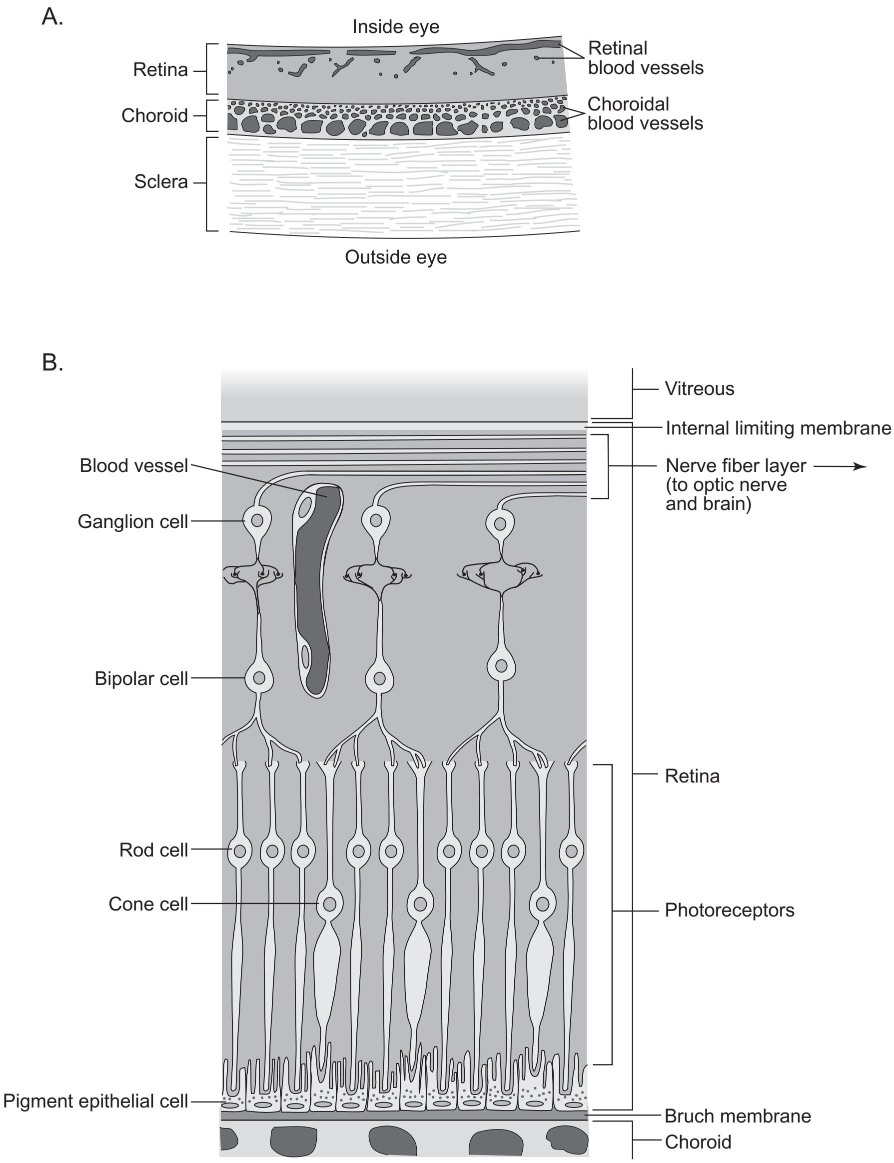


Figure 1.4. (A) Retina, choroid, and sclera; (B) neural connections of the cells in the retina

margin, at the macula, along major blood vessels, and possibly at various other places in the retina. Sometimes, as the gel liquefies and the vitreous shifts and collapses, the vitreous can slide or suddenly pull off from some of these attachments. This is called a posterior vitreous detachment or PVD (not to be confused with a retinal detachment, a much more serious condition). A PVD can result in visual floaters or flashes. Floaters are caused by vitreous opacities such as blood or other cells or tissues released as a result of the vitreous movement, all of which can cast bothersome shadows upon the retina. Flashes or photopsias are a result of the physical stimulation of the vitreous movement or pull upon the retina (see chapter 16).

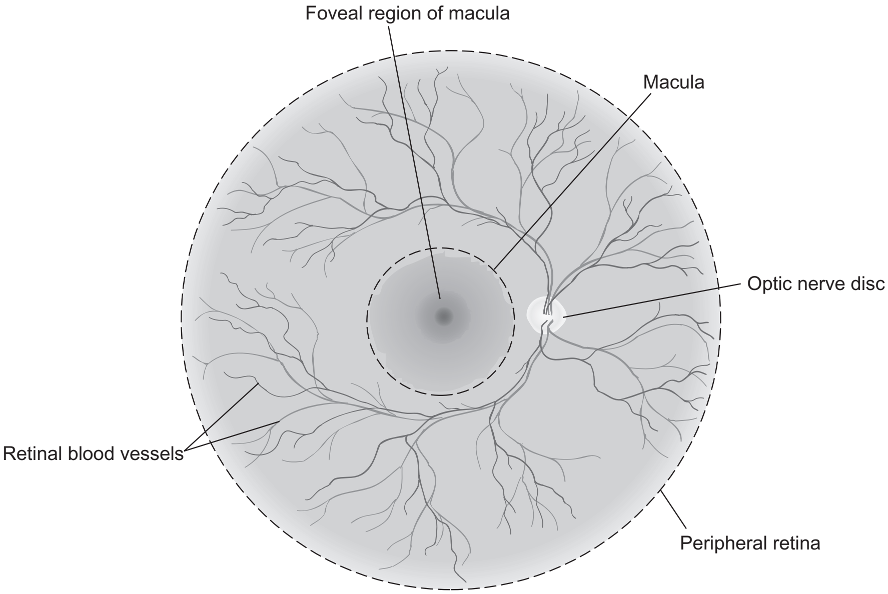


Figure 1.5. A view of the retina inside the eye

The Muscles

Part of the process of aiming the eyes to see an object is turning the body and moving the head. But the eyes can also move independently; in other words, you can move your eyes without turning your head. To keep the eyes correctly focused on a moving object, like a baseball, while the body is running and turning is truly an impressive bit of engineering. As illustrated in figure 1.6, there are six *extraocular muscles* fastened to the eye (in addition to muscles such as the ciliary muscles, which are inside the eye). The extraocular muscles are a *medial* and *lateral rectus*, mostly for horizontal movement, and *superior* and *inferior rectus* and *superior* and *inferior oblique* muscles, for vertical and torsional (twisting) movements, respectively. Understanding the actions of individual muscles in different eye positions gets complicated; there is a sophisticated feedback system in the brain to keep the eyes focused together,

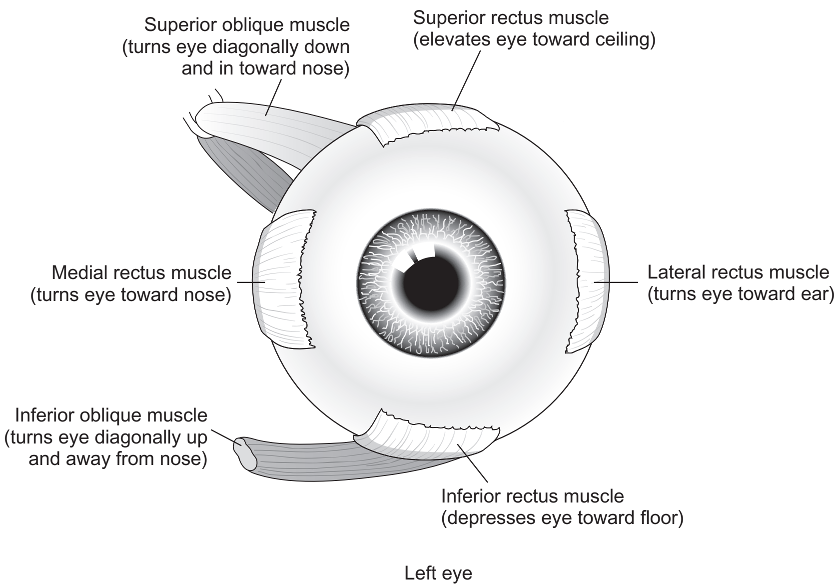


Figure 1.6. The muscles of the eye

to maintain binocular vision (that is, two eyes working together), and to avoid double vision (diplopia). Unless you have a specific muscle disease or some damage to the brain areas that control eye movements, the coordinated movement of your eyes shouldn't be affected by aging (see chapter 2).

As this brief overview indicates, the eye is one of the most complicated structures in the body, and its function—vision—is one of the most important. What goes on with the eyes when we age can affect our vision just a little bit or more seriously. Any disease, injury, or infection in the eyes, of course, can cause even more problems, affecting vision and also causing discomfort or pain. I'll get to these specific problems later in the book. For now, let's turn in the next chapter to a discussion of how *everyone's* vision changes over time, and how these changes matter.

WHAT HAPPENS WHEN WE SEE

Exactly what happens when we see something is illustrated in figure 1.7. Light, bounced off an object, reaches the eye and is refracted by the cornea and lens and focused into an image on the retina. But the eye's workings are like a camera's, which means that the image made on the retina is upside down and reversed. It's up to the brain to make sense out of it.

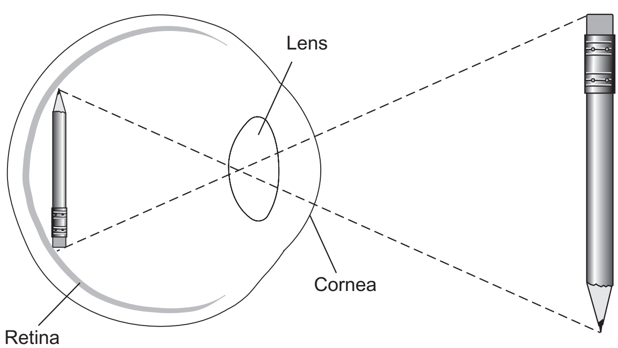


Figure 1.7. How we see an object

(*cont.*)

You may be aware that the left side of the brain controls the right hand and vice versa. Well, many functions of vision operate under this same confusing crossover system. With your eyes, in other words, the *right* half of the visual field in each eye goes to the *left* half of the brain. And the right half of the visual field corresponds to the left half of each retina (figure 1.8). The fibers from the left retina of the left eye go to the left half of the brain. The fibers from the left retina of the right eye cross over to the left brain via the optic chiasm (from chi, the Greek letter X).

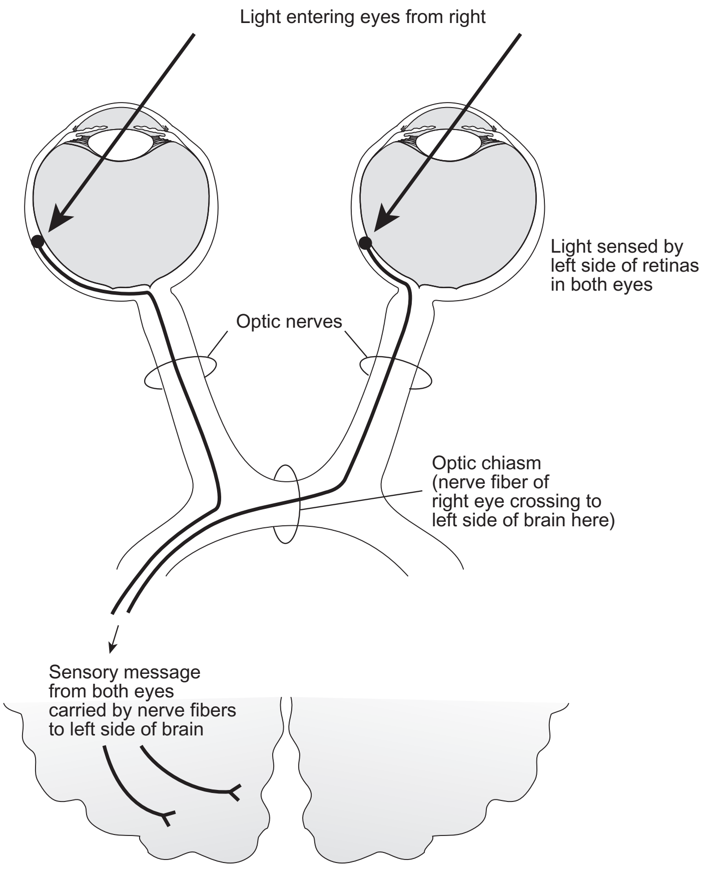


Figure 1.8. The crossover system between the eyes and the brain

Chapter 2

HOW OUR VISION CHANGES OVER TIME

When we're children, most of us see well enough on our own without needing glasses. But by the time we reach our forties, that's no longer the case; many of us need *something*—glasses or contact lenses—to help us see better. Even then, it can be frustrating. Every few years our prescriptions change; we all wonder when our eyes will finally settle down. Well, guess what? They never do. From a vision standpoint, our eyes are in a constant state of flux our entire lives. Even after we're fully grown, our eyes keep right on changing. Some of these fluctuations cause a shift in our prescriptions. Some of them cause a change in our vision, due to age-related eye disease.

Changes That Affect Our Prescriptions

What changes our prescriptions? To answer this question, let's take a minute to review how we actually see. (You may want to refer back to figure 1.1A.) It may help to picture the eye as a camera. The cornea, the front surface of the eye, acts as a converging lens: it takes rays of light and bends and focuses them. Next, the light is focused more finely still by the lens, which sits just behind the iris (the colored part of the eye).

In a perfect eye, all of this focused light is then beamed back to the retina—what you might call the eye's "film." The elegant, complicated retina processes all the information it receives, breaking it down into countless elements and then transmitting these elements in the form of electrical signals to the brain.

But as we get older, our eyes become less than perfect. Both the cornea and the lens change shape over time. Accordingly—inevitably—our eyeglass and contact prescriptions change too.

Changes in the cornea: When we're born, our upper eyelids are nice and tight and tend to press on our corneas. It has been suggested that this snug fit eases over time, and as it does, the cornea starts to reshape itself. What results is a mini-domino effect. The loosening of the eyelids causes the corneas to alter their contour, changing the way our eyes focus light—and, consequently, changing the prescription we need to correct this focus. Often this also causes us to have an increase in astigmatism (a focusing problem; see below) as we reach our forties and fifties.

Changes in the lens: Another issue is that the lens within the eye also changes throughout our lives, starting even before we're born. As it grows, layer after layer of cells—like the rings of a tree or the skins of an onion—add themselves to the front surface of the lens. This growth pattern also has an impact on our prescription. Older layers of cells within the center of the lens become more compacted, making the lens nucleus denser and the lens in general less flexible. Other chemical changes also occur in the lens with aging, making the lens cloudy with a yellow green or brown tint. Eventually lens changes affect our ability to focus on near objects and even see clearly. (An increase in lens density is also the most common cause of cataracts. For more on this, see chapter 8.)

Refractive Errors

When you need to wear corrective lenses in order to achieve clear vision, you have what's called a *refractive error*. *Refraction* is a physics term that refers to how light is bent as it passes through a lens. When your eye doesn't do a good job of bending and focusing light onto your retina—and thus allowing you to see—there's an error in the eye's "refraction ability." (*Refraction* also describes the technique doctors use to determine what your eyeglass prescription should be.) Refractive errors for the eye are myopia, hyperopia, astigmatism, and presbyopia.

Myopia

Myopia means "nearsightedness." A nearsighted eye can focus better on close objects than on distant objects. But this is a relative term, meaning that the degrees of nearsightedness vary considerably. Without corrective lenses, someone who is extremely nearsighted really only sees clearly at too close a distance to be functional and practical, while people who are only mildly nearsighted can generally see well enough to perform most of their daily tasks (figure 2.1).

The myopic eye is actually an eye that has *too much* focusing power. There are three possible reasons for this excess power: the cornea has too much curvature, the eye is too long from front to back, or the lens within the eye is focusing excessively. In all of these instances, light is focused *in front* of the retina (in other words, it undershoots its mark). Your prescription is designed to have the opposite effect, so that your corrective lens offsets the eye's high power and allows the light to focus directly on the retina. Eyeglass prescriptions written for someone who's nearsighted have a minus sign in front of the lens power. This indicates that the lens of the eyeglasses is effectively *taking away* the excess power of the eye. A nearsighted eye is not weak; instead, it's too strong.

A −1.00 prescription is a low nearsighted prescription, whereas a −2.00 prescription is a somewhat moderate nearsighted prescription. As the nearsighted number after the minus increases, the eyeglass prescription to effectively take away the excess power of the eye becomes greater, and it can even reach a very high degree of nearsightedness like −20.00.

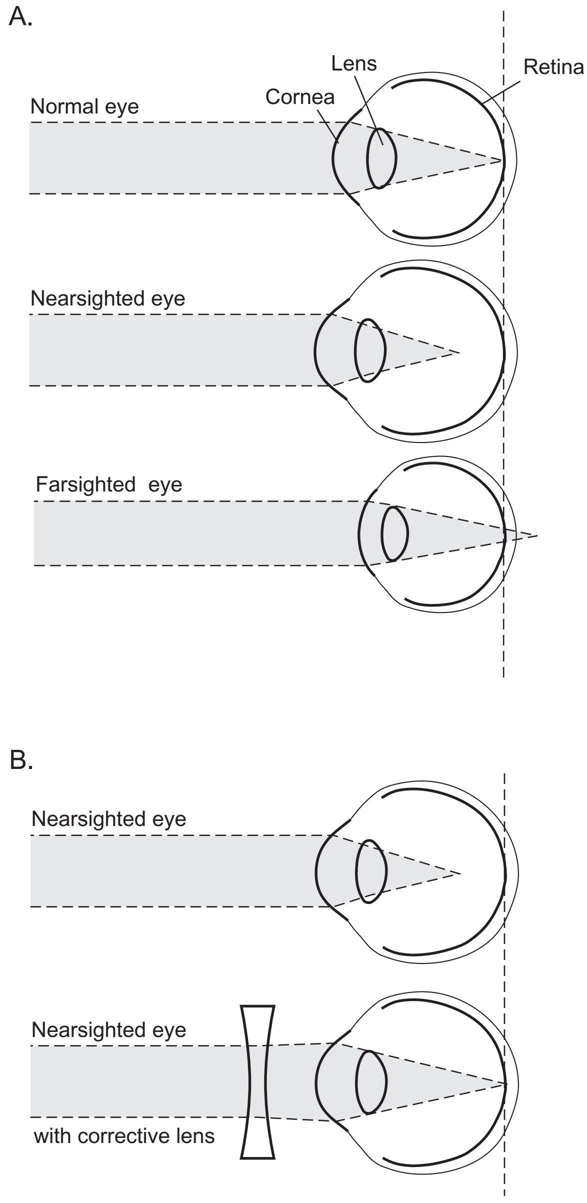


Figure 2.1. (A) Normal eye, nearsighted eye, and farsighted eye; (B) nearsighted eye with and without corrective lens. (*cont.*)

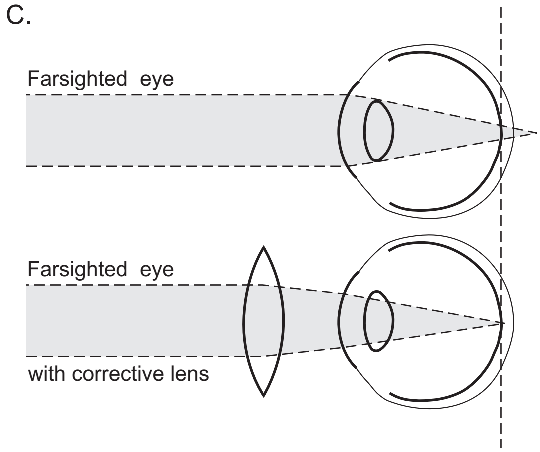


Figure 2.1. (*cont.*): (C) farsighted eye with and without corrective lens

Hyperopia

Hyperopia is the technical term for farsightedness (figure 2.1). As you might expect, a hyperopic eye is the opposite of a myopic eye in that it doesn't have *enough* power to focus light precisely on the retina. Either the cornea or the lens doesn't have enough curvature, or the eye is too short for light to be focused appropriately. The term *accommodation* refers to the way the eye muscle and lens work together to focus on something nearby—a book, for example, or a makeup mirror. Farsighted people use this same accommodative system to compensate for their lack of focusing power, in order to see at a distance. When farsighted people try to read, however, they must focus for their hyperopia as well as for the reading distance—an effort that requires significantly more eye muscle power. For farsighted people, then, vision is relatively clearer at a long distance than up close because it takes less muscular effort to focus at a distance than to focus up close (like reading in bed). For someone who is extremely farsighted, the world really is blurry at all distances. The hyperopic prescription is the opposite of the myopic prescription: there's a plus sign before the lens power, indicating that the eyeglass or contact lens is adding more power to the eye.

A +1.00 prescription is a low farsighted prescription, whereas a +2.00 prescription is a somewhat moderate farsighted prescription. As the farsighted number after the plus increases, the eyeglass prescription to effectively add power to the eye becomes greater, and it can even reach a very high degree of farsightedness like +20.00.

Astigmatism

Astigmatism may be one of the most misunderstood and misused terms in our field; I've heard patients use it to describe everything from lid twitches to floaters. Actually, astigmatism is a refractive problem in which an eye doesn't focus light evenly (figure 2.2).

A short lesson in physics may help illustrate this. Imagine that you have a tiny light bulb, the size of a pinpoint. This light sends rays out equally in all directions, forming a sphere of light. If this light is focused through a lens that is also spherical—in other words, if it's curved equally in all directions like a basketball—then this light, when focused onto a flat surface such as a wall, forms a circle, just like the round spot of light you create when you shine a flashlight at a wall.

A lens that has astigmatism isn't curved evenly in all directions. Instead of a basketball, it's like an American football. In an eye that has astigmatism, usually the corneal curvature is greatest in one direction and least in the opposite direction. A football has less curvature across the ball than around it. Both directions—across the ball and around the ball—have some curvature, but it's not evenly distributed, as it is on the basketball.

If you focus a pinpoint of light through a football-shaped lens, the light gets focused more around the lens than across the lens, and it exits as a stretched-out circle or oval. Because the eye's variations in curvature are much more delicate, you really can't see this football shape. But this subtle difference in curvature tends to blur images that we see, so that the world looks stretched out, just like that contorted circle of light.

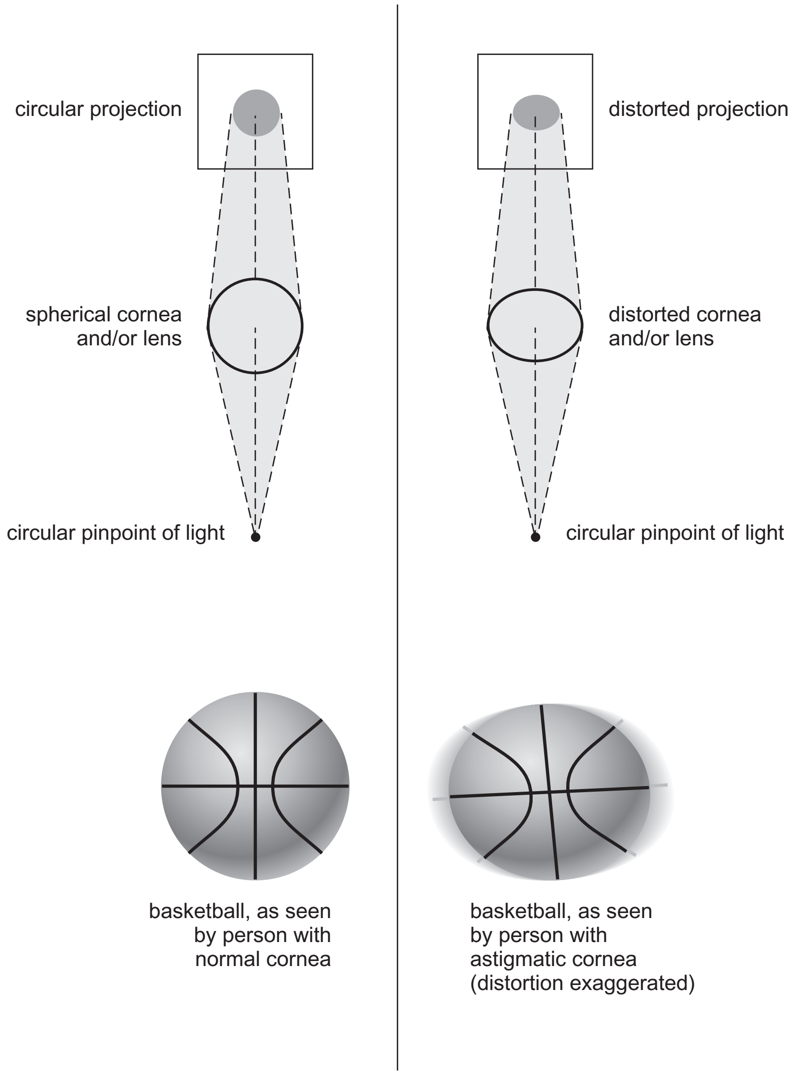


Figure 2.2. How astigmatism distorts vision

If you have astigmatism, a good way to demonstrate this distortion is for you to look at the taillights on a car in front of you at night without your glasses (while someone else is driving, of course). The red taillights will send off streamers in the same direction as your astigmatism. These streamers will diminish when you put your glasses back on, but they won't fully go away because of some scattering of the light at the edges of your glasses.

In eyeglasses, an astigmatic prescription is designed to create the opposite of the eye's curvature, so that light is focused evenly onto the retina. In an astigmatic prescription, the power is referred to as *cylinder power*. This is the second number in a prescription, if you have it. The *axis* (the third number in a prescription) is specified to tell the optician at what angle to direct the cylinder power (either horizontally, vertically, or somewhere in between). For example, a prescription written −2.00 +2.00 × 102 means that this person needs in his glasses a cylinder power of +2.00 located at 102 degrees in the eyeglasses, in addition to his nearsighted eyeglass prescription of −2.00. Not to purposely add to your confusion about astigmatism, but simply understand that the above prescription is written in what we call "plus cylinder" notation. The same prescription can be translated into "minus cylinder" notation, similar to how you can translate between two languages. Whether an eye doctor writes your prescription in plus or minus cylinder doesn't matter and has a lot to do with their training. Contact lens prescriptions with astigmatism are often written in minus cylinder for reasons beyond the scope of this discussion.

Presbyopia

The word *presbyopia* is derived from Latin and translates literally—though rather unflatteringly to those of us who develop it—as "old eyes." The term describes the phenomenon that eventually befalls everyone: the loss of our ability to focus up close. Presbyopia generally starts anywhere from age 35 to 50. You may first notice it when you're trying to read the label on a bottle of aspirin or the fine print of a magazine ad.

This is what happens: Remember the accommodative system, the muscle and lens system within the eye that enables us to focus on near objects? The ciliary muscles, part of this system, sit just behind the iris. When these muscles contract, they cause the lens to bulge forward and change the focus of the eye, so that we can see something up close (see figure 1.3).

Now, remember how the lens in our eye is always growing? Well, by the time we reach our midthirties, this constant thickening has taken its toll; the lens has lost the flexibility needed to adjust its shape. Consequently, we can't accommodate—in other words, we can't see close-up—nearly as well as we used to. Over time, the *closest* point at which the eye can focus moves farther and farther away—which is why one day we start holding the newspaper at arm's length to read it. But our arms are only so long, and eventually they're just not long enough to let us read without the help of corrective lenses.

Because presbyopia is part of the normal growth and development process of the lens, it isn't really what we think of as an "age-related degenerative change" to our body. That is, the ciliary muscles aren't weakening, and no tissue is breaking down. This ongoing evolution of the lens is simply an inevitable part of aging, something we can't change or control. There are no exercises or treatments that can stave off presbyopia, or even slow it down.

How will presbyopia affect you? It depends. If you're mildly to moderately nearsighted, presbyopia means you can read comfortably without your glasses because your myopia does the job of focusing on a near object in place of your ciliary muscle and lens system. Because you can read more easily without glasses, presbyopia might not even trouble you until your late forties or early fifties. If you're farsighted, problems with presbyopia will likely occur much sooner; your ciliary muscles already have extra work just compensating for the hyperopia as well as focusing on objects up close (see figure 2.3). People with astigmatism often compensate by bringing reading material closer, which makes it relatively larger and easier to see. When presbyopia begins, you probably won't be able to compensate as well for your astigmatism, and you might need a presbyopic prescription sooner.

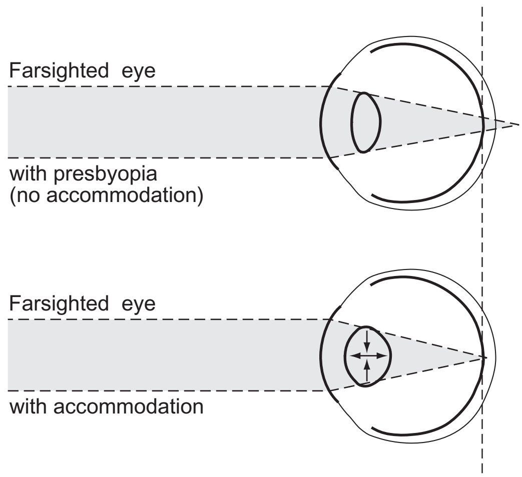


Figure 2.3. Farsighted eye with presbyopia, with and without accommodation

The presbyopic prescription is described as the *lens addition* or the *add*, and it's usually the same in both eyes. That is, your distance prescription (if you need one) balances out your vision, so that you see as well as you can with either eye by itself and with both eyes together. Because both eyes receive the same message from the brain to accommodate for up-close viewing, once your distance vision is balanced, you'll probably need an even amount of lens power added to both eyes to help you see to read. You can think of the distance prescription as the basic foundation for an eyeglass correction. The reading prescription is added on to this to give the eyes the extra power they need to see up close.

Refractive Changes That Occur with Age

With each of the refractive errors discussed above, the changes in eyeglass prescriptions that occur throughout our lives tend to follow certain basic patterns. However, no two people are exactly alike; in fact, no two eyes are exactly alike. That's why, even though both eyes follow the same general trends as we get older, it's not unusual for one eye to change at a different pace than the other. But here are some changes you can expect, depending on your particular eyesight.

Aging and Nearsightedness

Here is the typical lifetime course of myopia: As our eyes grow, over the first 25 years or so, nearsighted people tend to become more nearsighted. Also, because so much of these early years is spent in school, the many hours a day spent reading and focusing up close probably add to the problem. All of the accommodation (discussed above) necessary for this focusing creates a situation in which the ciliary muscles are constantly contracted and the lens is constantly focused at near; eventually the eye can adapt to that contracted state—in other words, by getting used to focusing mostly at a reading distance—and become still more myopic.

Between ages 25 and 35, the nearsighted prescription usually doesn't change much. However, as you might expect, those of us whose work involves extensive reading, writing, or other up-close focusing may still need increasingly stronger prescriptions during this time.

After about age 35, the eye changes that cause accommodation problems begin to affect our degree of nearsightedness as well. As the up-close focusing system starts to fail, myopia that was brought on by excessive accommodation actually starts to get better; often this trend continues into our late fifties and early sixties. However, because this decrease in nearsightedness is a sign of diminishing accommodation, this seemingly happy turn of events may simply turn out to be the first step on the road to needing bifocals. Thus, for many people in their sixties there comes, after years of enjoying milder prescriptions, a reality check of sorts: becoming more nearsighted again. Cataract development may also make a person more nearsighted. The most common type of cataract, *nuclear sclerosis*, is a consequence of years of growth and subsequent hardening of the lens. (For more on cataracts, see chapter 8.) In people with myopia this hardening of the lens at first may tend to *increase* its focusing power, and once again, we start getting more nearsighted.

Aging and Farsightedness

With hyperopia, again, there's a typical lifetime cycle of progression. Up to about age 25, farsightedness sometimes gets better on its own, as our eyes grow and develop. (If, for instance, the problem is that the eye is too short for light to be focused appropriately, this might resolve itself when the eye simply gets *bigger*.) Often there's no need to correct this problem in someone younger than 25 because the accommodative system has a tremendous ability to compensate for this kind of anatomical shortcoming.

But the eye changes that cause us to need bifocals can manifest themselves much earlier in someone who's farsighted, and they can begin to affect our ability to read and focus up close as early as our twenties. As we get into our late thirties and early forties, when we begin holding the newspaper at arm's length, we also start to lose the ability to accommodate for our hyperopia. We begin having trouble with our distance vision and may require corrective lenses to help us to see better. Eyeglass prescriptions for distance vision often get stronger in our late fifties and early sixties.

For farsighted people the dawn of cataract formation may cause the opposite effect of the change that occurs with nearsighted people: a shift in the power of the lens within the eye causes an *increase* in the eye's focusing power (as in a nearsighted person), which results in a *decrease* in hyperopia. That is, in a farsighted person, distance vision without eyeglasses can actually improve with early cataracts. This is known as *second sight* (see below and chapter 8).

Aging and Astigmatism

Astigmatism doesn't change as much with age as myopia or hyperopia do. After the eye stops growing, astigmatism levels off; decades may go by before you need a new prescription. Then along comes presbyopia—and this, plus changes in lid tension across the cornea, can cause changes in astigmatism that may be for better or worse, depending on your particular case. Early cataract formation can also cause changes, as the cataract subtly changes the shape of the lens within the eye.

Aging and Presbyopia

After its onset, presbyopia produces a classic pattern of change over the next 15–20 years. Initially your eyeglass prescription is doing part of the focusing for you. As your accommodative system changes, the eyeglass prescription increases, until eventually the prescription does *all* of the focusing for you.

Usually the first symptom of presbyopia is that we can't seem to bring an object as close to our eyes *and keep it in focus* as we used to. Also, it takes longer to bring a near object into focus and then to shift our focus to look at something across the street or even across the room. (The cause of this delay is the ever-thickening, increasingly less flexible lens, which doesn't do its job as fluidly and effortlessly as it once did.)

As presbyopia progresses, the point at which we can focus moves farther and farther away, until eventually most things inside of 20 feet look blurry. While your presbyopia progresses to the point where your reading addition to your distance prescription does 100 percent of the focusing for you, your near range of focus tends to diminish until your vision is really only clear from about 12–20 inches.

What's happening is that as you need more lens power in your glasses to compensate for your presbyopia, your ciliary muscles and lens are less flexible for range of vision, and your near working distance keeps inching closer, to where the spectacle lens focuses.

Those of us who spend a lot of time viewing objects at intermediate distances of 20–40 inches—the computer monitor, for example—often need additional lens prescriptions. For many people the best solution is either a progressive addition, "no-line" bifocal that allows for multiple working distances or a trifocal that adds another lens to your spectacles, designed particularly for intermediate-distance viewing. Special intermediate "computer" eyeglasses are also an option.

Early cataract formation, or nuclear sclerosis, also affects presbyopia. Because this causes a shift in vision that can make people either more nearsighted or less farsighted, some of us suddenly find ourselves able to read without our bifocals (a delightful phenomenon often referred to as second sight). Unfortunately, this is a short-term improvement; as the cataract progresses, vision at all levels tends to get worse.

Binocular Fusion

Besides refractive errors, the eye is also subject to other changes that affect our vision. Remember, we see not with our eyes alone but with our eyes and brain together (see chapter 1). Everything we see—image information beamed into each eye—is transmitted to the brain. In turn, the analyzed information from *both* eyes is then processed by the brain to allow us to view the world, as eye doctors put it, “binocularly.” The term *binocular vision* refers to our ability to use both eyes together to provide an enhanced, in-depth view of the world. (Most of us see better with both eyes together than with either eye alone.) If you try closing one eye now, you may notice that your ability to judge distances (your depth perception) is off: you may miss when you try to reach for an object across the table with one eye closed.

This ability of our eyes to work together is harder than it sounds, and it requires extensive coordination. Messages from the brain enable both eyes to move together when viewing and tracking the movement of any object. When our eyes work together in this manner, it’s called *binocular fusion* (figure 2.4). Binocularity is a combination of *motor* and *sensory fusion*. Motor fusion is the mechanical ability of the eye muscles to work together; sensory fusion is how well the brain can turn these visual messages from both eyes into one coherent image.

Because the eye muscles from both eyes are rarely perfectly coordinated, it’s the sensory fusion that helps fine-tune any slight mechanical misalignment (strabismus). As we age, our ability to maintain good motor fusion, or mechanical alignment, tends to weaken; the muscles start to weaken in the eyes, just as they do elsewhere in the body. If your eyes tend to cross (esotropia) or drift apart (extropia), this tendency can increase as you get older and the sensory fusion system starts to labor harder than usual to help keep your eyes working together. When this happens, unfortunately, people are all too aware of it. Headaches located in or around the eyes can become common; so can symptoms of the eyes “pulling” together, plus overall fatigue and eyestrain with any big visual chore such as a long time spent behind the wheel of a car. Finally, if the sensory fusion system becomes too overburdened—if it can no longer compensate for misaligned eye muscles by keeping the images fused—the result is double vision.

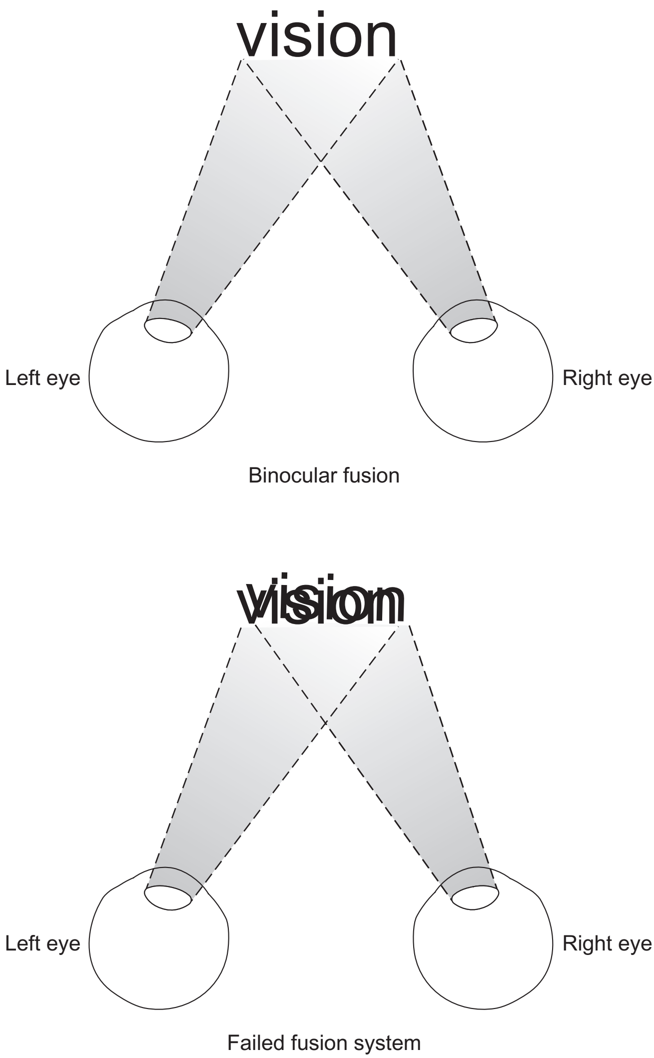


Figure 2.4. Binocular fusion system

The most common fusion problem with age is also a consequence of presbyopia. When you read, both eyes have to turn in slightly, in order for them to focus together on the page. This process is called *convergence*. The simple act of looking at something up close, like a book, sets off a series of actions in the brain and eyes just so that you can focus the lens within your eye, to make the book appear clear, and converge your eyes, so that the words appear single.

Remember the accommodation process that enables our eyes to change shape so that we can see up close? Each amount of accommodation is matched by the same amount of convergence to maintain clear and single vision. In other words, it's not enough just to focus on something up close; the eyes must also be *coordinated* enough that we see a single, understandable image. With presbyopia, as we discussed above, this ability to accommodate diminishes. Also, the signal the brain sends—to tell the muscles to converge what we see into a single image—gets weaker over time. The sensory fusion system tries to overcome this problem and keep our eyes working together.

By the time our presbyopia reaches the point where our reading prescription does 100 percent of our focusing, the motor convergence system is basically kaput; for some people who had an underlying convergence problem before they developed presbyopia, the sensory fusion system isn't up to the task of maintaining single vision at near viewing distances. The result? Reading becomes an arduous grind. The print swims, runs together, and doubles.

But there is hope. Fusion problems can be treated with eyeglasses, eye exercises, eye muscle surgery, or a combination of any of these. Eye exercises have proven helpful in increasing sensory fusion in some people, but often the sensory system can't be built up enough to overcome the increasing weakness of the eye muscles. Eye muscle surgery is often a last resort, when all other attempts have failed to restore binocularity. Often the best solution is to incorporate into the eyeglass prescription a lens correction called *prism*. This isn't the prism you might have played with as a child—the long, triangle-shaped glass that spun rainbows when light shone through it. In spectacle lenses, prism is used to bend and redirect the light coming through the lenses without changing the lenses' ability to refract the light. That is, the prism doesn't change the power of the prescription; it just helps compensate for the misalignment of the eye muscles. Prism can be ground into an eyeglass prescription so that it can't be seen in the lens, and your view of the world with either eye by itself doesn't change. But with it, your view of the world with both eyes together is much more comfortable and clearer; the prism boosts the motor fusion system, so that your eye muscles don't need to work as hard. At the same time, the prism eases the sensory fusion system, so that the images of both your eyes come together more completely for clear single vision.

Some Questions You May Have about Changes in Your Vision

It seems like my eyes keep getting worse. Will I just keep getting more nearsighted until I'm blind?

Relax. Most of the increases in nearsighted prescriptions occur during the growth and development phase of life. Then, the changes slow down. It might seem that every time you go to the eye doctor you need something stronger, but that trend usually reverses itself between the ages of 35 and 60. Myopia typically stops progressing and actually starts to *reverse* with the onset of presbyopia. However, early cataract formation (also called nuclear sclerosis, discussed above) sometimes causes a shift in the prescription, which can make your myopia worse.

You may have heard about a rare condition called *pathological myopia*, in which a nearsighted eye can progress to the point of blindness. The blindness occurs because the eye becomes so large and the retina becomes so stretched and distorted that it may eventually degenerate. The people most likely to develop pathological myopia are those who were very myopic as young children. But again, this is a *very rare* condition and is far from the normal course of the aging eye.

I never used to wear eyeglasses when I was younger. What's wrong with me now? Why do I keep needing stronger eyeglasses every time I come in, and why can't I see as well without my eyeglasses?

This question is usually asked by someone who is hyperopic, or farsighted. (For a discussion of farsightedness and accommodation, see above.) As your focusing system, which involves your ciliary muscles, begins to lose its ability to "accommodate" for reading, it also becomes less able to compensate for your hyperopia. If you're farsighted, you've probably been using these ciliary muscles all your life to compensate for this relative eye weakness. Because of this, when you're younger, the ciliary muscles tend to stay somewhat contracted; as a result, any early eyeglass prescriptions you may have are weaker than you might need if these muscles were fully relaxed.

As you get older and—like everyone else—develop presbyopia, the muscle tone in these ciliary muscles starts to decrease. (Basically, these muscles get out of shape because they don't have much luck trying to push an aging, inflexible lens to focus.) As this muscle tone becomes more lax, the prescription for distance vision increases as the *latent hyperopia*—which was there all along, but masked by the efforts of the ciliary muscles—begins to express itself.

Even if you don't progress beyond a certain distance prescription for hyperopia, you may still notice a deterioration of your vision at a distance without your glasses. As the accommodation system fails and your vision without glasses is not compensated for by the ciliary muscles and lens system, you'll probably find yourself relying on your glasses more and more to see at a distance. You might not need stronger glasses over time, but you just won't see as well without them.

This is great—I used to need my eyeglasses for reading, but now I don't. Did my eyes get better?

Well, the best answer may be, enjoy it while it lasts. The earliest onset of age-related cataracts, or nuclear sclerosis, causes a shift in the focusing ability of the eyes. This shift tends to make nearsightedness worse and farsightedness better for a time.

But sadly, as noted above, this "second sight" is a relatively fleeting phenomenon. Eventually the cataract takes its toll on our vision; we notice that, with or without our glasses, we don't see as well as we used to, and once again we need a new prescription or perhaps cataract surgery (see chapter 8).

It's official: I'm a senior citizen. Should I worry about my ability to drive?

Yes. For many of us, however much we hate to admit it, getting older means we don't see as well to drive as we used to.

Relax—we're not suggesting that you turn in your driver's license the first time you have trouble seeing a traffic light or road sign. But your ability to drive is something you'll need to consider, with unflinching honesty, from now on. Next to the notorious 16- to 24-year-old age group, drivers older than 65 are second in the number of auto accidents per vehicle mile traveled. Nobody knows exactly how many of these accidents are due to poor vision, but it has to be a factor.

Currently, more than thirty-three million American drivers are age 65 or older—and this is just a drop in the bucket compared with what's going to happen over the next decade, as more baby boomers hit the bifocal and cataract years. By the year 2030 an estimated sixty to sixty-three million drivers will be over age 65 according to data provided by the American Automobile Association (www.aaa.com).

Most states (forty-two so far) require vision testing for a driver's license renewal; there is a good chance that all states will eventually adopt such policies. An older study once showed that between

1985 and 1989, states that *did not* require vision testing for driver's license renewal had significantly more fatalities each year among older drivers than states with mandatory vision screening. Two studies analyzed data from the United States from the 1980s and concluded that requiring older drivers to pass a vision test to renew their license was associated with reductions in rates of fatal crashes (studies published in the medical journal *Injury Epidemiology*).

What does this mean to you? Mainly, just be careful and use your common sense. If you have any trouble seeing at night, limit your driving to daytime. If your peripheral vision is not great—from glaucoma or diabetic retinopathy, for example—do your best to avoid busy intersections, where side vision can be particularly important. If glare is a problem, consider purchasing glasses with special antireflective coatings (see chapter 5).

Why do I see double, and is there any help for me?

Double vision is often a result of the weakening of the extraocular eye muscles, the muscles that move the eyes. These muscles can lose their ability to keep the eyes working together as they should. When this happens, your right and left eyes aren't working well together; each eye sees a slightly different image. The brain can't put these two images together, and you see double. *Close one eye*; if you can lose one of the images by closing either eye, then your double vision is caused by this kind of muscle imbalance.

In rare circumstances certain diseases can affect the positioning of the eyes. An overactive thyroid gland, for example, can affect the eye muscles, resulting in a misalignment of the eyes. Certain tumors can affect the nerves in the brain that control eye muscle movements, and this may also lead to double vision.

If you still see double after closing one eye, then your double vision is likely caused by one of three other factors besides the relatively common muscle imbalance and the rare diseases that affect vision.

First, your double vision might be caused by cataracts, which occasionally develop at an inconvenient spot within the lens of the eye so that light that enters the lens is scattered by the cataract and splits into two images (see chapter 8).

The second possible reason is a sudden increase in astigmatism, which can also happen with the development of a cataract. Uncorrected astigmatism distorts an image so that it's stretched in one direction. Occasionally this will appear as a clear image with a second "ghost image" next to it—kind of like what you saw in the old days when you had bad TV reception.

The third reason can be the most serious of the three: age-related changes within the macula, the center of the retina that provides our best vision, can also cause a splitting of the image.

If you have double vision—even if it goes away for a time—*seek immediate attention*. Usually the problem is indeed related to the eyes; however, it's also extremely important to rule out any other problems that may be jeopardizing your general health.

What does 20/20 vision mean?

The top number 20 refers to the testing distance of the eye chart. *Optical infinity* is a term that describes the minimum distance that an object needs to be from your eye so that it can be seen without any accommodation effort, or focusing of your eye muscles. The minimum distance between an object and the eye to be effectively at optical infinity is 20 feet; that's why this has become a standard testing distance for eye charts. The bottom number represents the size of the letter or target that you view. Years of research have yielded an average-size letter that you should be able to see at a given testing distance if your eyes have normal vision. (Technically, a 20/20 letter subtends 5 minutes of arc at 20 feet.) This letter size was given the designation 20. When you mathematically divide 20 (the size of the letter) by 20 (distance in feet), you get a result of 1, so that 20/20 vision becomes an index of normalcy. If, for example, you have 20/40 vision, then 20 divided by 40 equals 1/2, and it could be said that your vision is *half as good* as it should be. Another way to interpret 20/40 vision is to say that you need to double the size of a 20/20 letter, or double the visual angle that a 20/20 letter makes, in order for you to be able to read that letter at 20 feet. Very simply, a person with 20/40 vision can see an object clearly from 20 feet that a person with "normal" eyes can see clearly all the way from 40 feet.

Eye charts were designed by analyzing all of the letters in the alphabet and categorizing each letter according to how difficult it is to read at the testing distance. The letter *L*, for example, is not confused with many other letters and is therefore easy to spot at a distance. The letter *E*, however, can look like a *B*, *F*, *P*, *R*, *S*, or *Z* at a distance, and it's usually the first letter that is missed on a line. Each line on an eye chart contains letters from easy and hard categories, so that if you misread a letter on a line, the specialist performing the test can determine the significance of your error. Missing a hard letter like *E* is not as significant as missing an easy letter.

Chapter 3

TOP TIPS TO TAKE CARE OF YOUR EYES AND YOUR VISION

Even if you are not a football fan, you have probably heard it be said that "your best offense is a good defense." This is true even with your eyes. According to a World Health Organization (WHO) report in 2018, approximately 1.3 billion people in the world live with some degree of distance or near vision impairment. Most vision impairment is due to the need for glasses or cataract development. Therefore, approximately 80 percent of all visual impairment can be eliminated by proper eye care, which unfortunately is not always available everywhere in the world. While not all eye diseases can be fixed by a simple pair of glasses or through cataract removal, we now know that there are reasonable lifestyle changes that you can make to keep your eyes healthy and reduce your chances of visual problems in the future. Let's take a look at some of the defensive moves you can take.

Get an Eye Exam

It always amazes us that in areas of the world where eye care is readily available, people can go decades without ever getting an eye exam. Vision screenings, such as often done when obtaining a driver's license, are not a replacement for an eye examination by an eye care professional.

Take a child for an eye exam by an ophthalmologist or optometrist at least by the time they are 8 or 9 years old. For adults, the American Academy of Ophthalmology (AAO) recommends that all adults by age 40, even those without signs or risk factors of eye disease, should have a baseline eye exam. If you have a medical condition known to affect the eyes like diabetes or hypertension, or a family history of eye disease, you should get an eye exam much sooner and regularly. How regularly? This depends on the condition and the recommendation of your eye care professional. The American Optometric Association recommends at least every two years but more frequently for people considered at risk for eye problems and annually for those over 65.

For what to expect at your eye exam, see chapter 4. Some parts of your eye exam may be automated, but there is no substitute for a complete eye examination, including dilation, in the hands of a qualified and knowledgeable eye care professional.

Protect Your Eyes

Fireworks, champagne corks, welder's flashes, lacrosse balls, chemical splashes—you name it, and it is pretty certain there is a way that it can injure your eye. You can never be too cautious about protecting your eyes, but you would be very surprised how often people don't take the time or forget to do so. The AAO estimates that each year 2.5 million eye injuries occur in the United States. What can you do? Wear protective eyewear appropriate to the circumstances—not just glasses or sunglasses, but eyewear specifically designed, tested, and certified to protect the eye. The American Society for Testing Materials (ASTM) and various sports governing bodies have issued standards that should be met by protective eyewear for a given occupation or sport, but it is up to you to be aware of these guidelines and to purchase and wear the protection. When it comes to your sight, you only get one pair of eyes, so please protect them.

Aside from traumatic injuries affecting the eyes, you should also protect your eyes from sunlight's direct UV rays, which are known to accelerate the development of cataracts and encourage cancerous and noncancerous growths on the eye. It is advisable to wear sunglasses certified to offer 100 percent UV protection, blocking 100 percent of both UVA and UVB rays.

Short-wavelength blue light often found in popular, long-lasting, energy efficient, and inexpensive light-emitting diode (LED) technology may affect biologic rhythms and sleep patterns. That is, LEDs found in cell phones, tablets, computer monitors, and laptop screens do not seem to pose a phototoxic threat to the eye but can contribute to eye fatigue and eyestrain. Rather than purchase special glasses to block blue light (with debatable benefits), the AAO simply recommends that you follow the "20-20-20" rule to improve eye comfort when you are racking up screen time: "Every 20 minutes, shift your eyes to look at an object at least 20 feet away for at least 20 seconds."

Oh, and one last thing: Watch out for those laser pointers. Laser pointers can permanently damage the retina. There are many laser pointers on the market, and they are often poorly labeled, but those under 5 milliwatts are felt to be safer than most, although the time of exposure and intensity of the pointer are always a consideration when concerned about retinal damage.

Eat, Drink, and See

Your mother's claim that eating carrots will improve your vision may have been more myth than reality, but balanced diets and nutritional supplements can be beneficial for eye health. Vitamin A deficiency (VAD) is felt to be the leading cause of preventable blindness in childhood, often beginning as night blindness. The WHO estimates that VAD affects about one-third of children under the age of 5 around the world. And although carrots are a source of vitamin A, a diet containing a variety of vegetables, including leafy green ones, is beneficial for eye health. Green leafy vegetables have specifically been reported to lessen a person's risk of developing primary open-angle glaucoma and may lower your risk for age-related macular degeneration too. Nutritional supplements, in addition to a balanced diet, have also been studied but offer less profound links than the association between VAD and blindness. As mentioned in chapter 10, the AREDS and AREDS2 studies highlighted the benefits of multivitamins in slowing the progression of macular degeneration. Vitamin C, an important antioxidant, also seems to have some effect on the rate of cataract development but will not eliminate this natural aging change in your eye. Clinical studies have been conflicting regarding the popular recommendation of fish oil and omega-3 fatty acids for dry eyes. As with many of the eye health claims of nutritional supplements, the difficulty in finding consistent, statistical proof of their benefit highlights the complexity of these eye conditions and how much we still need to learn about their basis and treatments.

In researching this section, I found a long list of holistic eye health recommendations, including the importance of dietary preferences, general exercise regimens, environmental factors, and addressing physical, emotional, and mental issues, for treating your specific eye issues. As with your general health, the importance of addressing these aspects of your overall health are not to be denied but should not replace the specific recommendations and treatments made by your eye care specialist regarding your eye problem. Additionally, many people consult a homeopathic and naturopathic doctor about various nutritional supplements for eye heath, including bilberry, lutein, vitamin A, and beta-carotene. It is beyond the scope of this book to discuss each of the many nutritional supplement recommendations and their validity as tested in well-designed clinical trials, but suffice it to say that healthy eating habits and vitamin supplements do have a role in all aspects of our health, including our eye health. But a word of caution: more is not always better. Ask a lot of questions, speak with your medical doctor or other health care provider before you start on any supplement, and read on your own about the benefits and side effects.

Be a Good Eye Care Patient

As with the majority of health conditions, early detection and diagnosis can be very important in preventing vision loss. But people can be their own worst enemies when it comes to being proactive about their health, especially their eyes.

First, understand the difference among eye care professions—ophthalmology, optometry, and optician (see chapter 4)—and make an appointment with the eye care professional who will best address your needs, be it a routine eye exam or an eye exam for a specific eye issue. The early detection of eye diseases like glaucoma, macular degeneration, diabetic retinopathy, and many other eye conditions is very important for proper treatment and management. In particular, glaucoma is known as the silent thief of vision. In 90 percent of people with glaucoma, they had no warning signs or symptoms before it was picked up on an eye exam. Therefore, be a good patient and get an eye exam.

Also, if you are seeing your eye care specialist for the first time, please bring your past medical and vision records to your eye exam. These can be very helpful to your new doctor. The new doctor will also want to see all your eyeglasses, contacts, and medications (or at least an accurate list). Other helpful things you can do are to take a selfie if your problem is changing over time and visible to the naked eye, and for visual changes, test yourself on an Amsler grid (see chapter 4) so you can accurately describe and diagram your visual problem at the time of your exam, and bring a list of compounds and solutions you have used if you think that you have an allergic or toxic eye reaction. Even the nickel in certain eyeglass frames and the coatings of certain sunglasses can cause subtle eye discomfort or even periorbital rashes. Good eye care patients also are compliant with taking their medications, especially their eye drops. Lastly, don’t be afraid to get a second opinion. Good eye doctors respect good eye care patients for getting second opinions and becoming fully informed about and comfortable with their eye care.

Some Is Good, but Too Much May Be Harmful

Years ago, a patient unexpectedly developed an extensive hemorrhage around her eye when given an injection of anesthesia at the beginning of cataract surgery. The only thing that she was taking orally was fish oil, which can be an anticoagulant, but this woman was taking 10 times the normal dose. The patient said that she knew fish oil was good for you so she figured that the more she took, the better it was for her—not in this case. The same goes for the use of eye drops that whiten the eye (see chapter 22), steroid eye drops, ointments, face creams, or even inhalers that can cause elevated eye pressure and glaucoma if taken for prolonged periods of time without careful eye pressure monitoring; glaucoma drops, which can lead to breathing problems; and overdoing with supplements like zinc, which can lead to an iron deficiency anemia. Even too much eye makeup can contribute to the development of annoying blepharitis and hordeolum/chalazion (see chapter 11).

Curb Your Habits

Simply put, don't smoke. Age-related macular degeneration has been associated with smoking. Smokers also have shown an increased risk for developing cataracts, uveitis, and optic nerve problems, as well as exacerbated symptoms associated with dry eyes. And if you are thinking of smoking marijuana for your glaucoma, beware. You need to use it continuously to get the pressure-lowering effect you want, thus constantly impairing your cognition and motor skills.

Are you in the habit of spending hours upon hours each day staring at a screen—desktop, laptop, tablet, or a combination of the above? Do your eyes feel tired and strained during your screen time? Try following the 20-20-20 rule (as mentioned above): for every

20 minutes staring at your screen, look at something 20 feet away for 20 seconds. Since close viewing can induce eye fatigue as it strains your accommodation and eye muscles to converge your eyes, viewing a distant target will help relax them, just like you can relax other muscles in your body after vigorous use or exercise.

Another habit to break is driving without glasses when you really need them to see better at distance. Without question, if your vision is not being fully corrected with glasses for seeing at a distance, this can be very dangerous, especially when driving in low-light situations.

Contact Lens Cautions

Contact lens wearers seem to be especially prone to eye problems that can be easily prevented with some common sense. Don't use your saliva or tap water to wet your contact lens. Don't wear your contact lens overnight if it is not approved for overnight wear. Don't use expired contact lens solutions. For colored or hand-painted contacts, don't overwear them, and maintain regular follow-up visits with an eye doctor. Don't keep wearing your contact lenses if your vision is blurred or if your eye is red, light sensitive, or sore. And one more thing: all contact lens wearers should have a backup pair of eyeglasses with a current prescription in case they can't wear their lenses or need to keep them out for a while.

Consider Your Family Medical History and Genes

It is said about people that "the apple doesn't fall far from the tree." Well, this includes their genes and genetic makeup too. We have a growing body of evidence that supports the association between various eye conditions and your genetic makeup, as well as your family history. Know your family history regarding eye conditions and visual impairment because a family history of an eye problem may increase your risk of developing the same or a similar eye problem. Tell your eye doctor of your family eye history too. Genetic and familial conditions particularly concerning are Leber's, retinitis pigmentosa, glaucoma, and many corneal dystrophies.

Glasses, Glasses Everywhere, but Where to Go . . . (Apologies to Samuel Taylor Coleridge)

Everywhere you look these days it seems you can purchase eyeglasses. You can find them in the drugstore, in the grocery store, all over the mall at various optical chains, at retail stores in your neighborhood, and now even online. The choices of where to buy are overwhelming, and the number of selections and options when buying glasses can add a lot of anxiety to what should be a fun shopping experience. How do you narrow it all down? Well, it all depends on the type of person you are when it comes to your vision and your appearance.

In chapter 5, we describe in detail the various types of frames, lenses, and considerations that are part of selecting the right eyeglasses. We urge you to read this section before deciding where to get your next pair of eyeglasses. If you are a do-it-yourselfer, age 18–40, you might be satisfied buying your glasses online. You'll need your eyeglass prescription and pupillary distance, and if the price is right and you find a color you like, you will probably be satisfied with what you order over the internet. Check the return policy, though, and determine where you can go for adjustments if the fit is not right when they arrive.

On the other hand, if you enjoy a more personal shopping experience with advice and input from a professional, buying from a brick-and-mortar optical establishment and from an experienced optician will be a better option for you. Experienced opticians can help you choose the right frames, which goes well beyond the color and includes helping you select the proper style of glasses (saddle bridge or adjustable nose pads), width and depth of the eyeglass lens, centration of the lenses, temple size, and frame material. For bifocal wearers (usually people over 40 years old), proper frame selection and lens positioning are very important, especially for progressive lenses. An experienced optician will also be able to help you decide what warranties and lens options might be right for you. So while buying online is a good option for some items and for some people, for something as important as your vision and that you most likely will use every day, how important is it to you to get the advice of a professional, even if the cost is a little more than the discount prices online (possibly attractive prices that do not include shipping, an easy return policy, or a warranty)?

Know Your Eye Insurance Coverage and Make Sure It Is Current

Wouldn't it be nice if from birth we were all entitled to one eye exam per year and all the eyeglasses and contact lenses we will need for a lifetime? Well, while the logistics and costs of this wish are being grappled with among the politicians, most of us are left to pay for eye exams, glasses, and contacts either out of pocket or with private insurance. As an eye care patient, it is very important that you understand the insurance coverage you have *before* you schedule an appointment for an eye examination. Are you covered for a *routine* eye examination (to get your vision and eyeglass prescription checked), or just for a *medical* eye examination (to check on a specific eye problem)? Health insurance coverage is different for each of these types of visits. Therefore, once you know your health insurance coverage, determine which type of examination you are coming in for. As the name implies, "routine" means a scheduled exam of your eye that is not for a specific problem. Having trouble seeing when you drive, watch TV, or read, if not sudden or very severe, is usually considered a reason for a routine eye examination, not an eye problem. Eye or vision insurance plans (like Davis Vision, VSP, and EyeMed) cover free yearly and biannual routine eye exams and usually offer discounts toward eyeglasses or contact lenses. As of this writing, Medicare does not provide coverage for a routine check of your eyeglass prescription or for routine eye examinations but will cover eye examinations related to specific eye problems. Vision or eye care plans for routine eye exams usually do not cover an eye exam for another reason such as infection, stye (known commonly as "sty/sties"), profound and sudden loss of vision, or eye trauma. These problem or medical visits to your eye care specialist are covered by your medical health insurance, if you have it. Medicare will cover these visits as well. There is always a gray zone when it comes to eye care insurance coverage and medical insurance coverage, such as annual eye exams for diabetics, so it is always best to check with your carrier to understand your coverage before you schedule your eye appointment.

A Few Parting Thoughts

At the first sign of a "stye," use warm compresses. (Read chapter 11.)

All eye irritation is not "pink eye." (Read chapter 13.)

Blinking is good. (Read chapter 14.)

The new onset of floaters should not be ignored. (Read chapter 16.)

Living well with low vision is possible. (Read chapter 20.)

Part II

GETTING TO 20/20

Chapter 4

THE EYE EXAM

Getting your glasses and your eyes checked can be a fairly simple prospect or a very complicated one, depending on the problem—and, of course, on who's doing the checking (in other words, on how in-depth your exam is). Routine eye examinations can be performed by ophthalmologists and by optometrists, and parts of routine eye exams can be done by technicians who may or may not have a specific degree or certification. Before covering the specifics of eye examinations, though, let's take a moment to discuss the professionals who perform them.

Eye Care Professionals

Ophthalmologists

An ophthalmologist is a medical doctor, a graduate of an accredited medical school with an MD degree—which means that you can expect them to have a pretty good understanding of the illnesses that can befall the *rest* of your body and the ramifications of such ailments (diabetes, for instance) for your eyesight. Ophthalmologists can also be doctors of osteopathic medicine (DO). In addition to the medical degree, ophthalmologists have completed an internship and at least 3 years of residency training, with some also having done 1 or 2 years of subspecialty fellowship training. Furthermore, a board-certified ophthalmologist has passed extensive written and oral examinations in diseases and surgery of the eye.

Many ophthalmologists provide total eye care, beginning with the comprehensive medical eye examination: they prescribe glasses and contact lenses, diagnose eye diseases and disorders, and perform the appropriate medical, surgical, and laser procedures necessary to treat them. Other ophthalmologists perform eye exams and diagnose and treat diseases of the eye but limit themselves to a fairly narrow range of surgical procedures, referring patients needing different procedures to other ophthalmic subspecialists. And some subspecialists—doctors who concentrate on treating specific diseases and performing certain procedures (literally, they're specialists *within* a specialty)—don't perform routine eye exams at all.

Like many other branches of medicine, ophthalmology has become increasingly subspecialized over the past 50 years. Although some policy makers are fond of making the blanket statement that "there are just too many specialists," the undisputed fact is that *anyone* (even, one suspects, those policy makers) who needs a surgical procedure wants the operation to be done by a surgeon who has performed *that very same procedure* many times—someone who does it every day, or at least several times a week, someone who is deeply familiar with every detail of the operation, and with every nook and cranny of that particular body part—rather than by a generalist, whose job is to know a little bit about everything, who might have done that procedure only a few times before. (This means—and I'll make this point again in later chapters—that if and when you need a surgical procedure, consider *getting a second opinion*, and find the best, most experienced doctor you can to perform it. Think about it: it's your precious vision at stake here, and your one chance to get the job done right.) It's also true that most surgeons want to do only the operations that they do really well. The situation is complicated, and it keeps changing.

Optometrists

An optometrist is someone who has earned a doctor of optometry (OD) degree after completing 4 years of postgraduate-level optometry school, following a 4-year undergraduate college degree. Optometry school covers the structure and function of the eye, mechanisms of vision and optics, and the diagnosis and treatment of eye disease. Board-certified optometrists "demonstrate that they exceed entry level requirements and are maintaining the appropriate knowledge, skills and experience to deliver quality eye care."* Some optometry schools have even developed collaborative arrangements with medical schools to give optometry students the opportunity to develop a better understanding of how the eye relates to the human body and its overall condition.

In the past, optometrists had traditionally limited their scope of practice to nonmedical treatment of eye problems. This included prescribing glasses and contact lenses to improve the quality of vision and the use of vision therapy to enhance the overall functioning of the visual system. Today, the training of optometrists has also emphasized an understanding of medical eye conditions and their treatment. Doctors of optometry now can prescribe medications for certain eye problems. Legislation in some states has even expanded an optometrist's scope of practice to include certain laser treatments and minor surgical eye procedures.

Opticians

An optician is an eye care professional licensed to fit, adjust, and dispense eyeglasses and other optical devices following the written prescription of an ophthalmologist or optometrist. In some states opticians can also fit and dispense contact lenses.

Recently, controversial legislation in many states concerning the use of diagnostic and therapeutic eye drops and procedures by optometrists has heightened the public's awareness of the

*https://americanboardofoptometry.org/wp-content/uploads/2012/06/Bd-Cert-MOC-program-overview-2015.pdf differences in training among ophthalmologists, optometrists, and opticians. Most eye care professionals, however, agree that each of these specialists has a separate yet complementary role in eye care—and in the future, you're likely to see these three groups settling their differences and working more closely together. This will allow for a more comprehensive approach to eye care, one that can also be cost-effective for patients and their insurance companies, as well as for eye care providers.

How Often Should You Get Your Eyes Checked?

The largest professional association of ophthalmologists, the American Academy of Ophthalmology, recommends the following:

Specific eye examination recommendations and guidelines have been proposed for children and can be found on the website of the American Academy of Ophthalmology, but for adults: If everything's fine—if you have no symptoms and are at low risk for eye disease—you should get a comprehensive baseline medical eye examination at age 40, to establish a point of reference for future checkups, and then go back for follow-up checkups every 2–4 years.

If you're over 65: Again, if everything's fine—if you have no symptoms and are at low risk for eye disease—you should have a comprehensive eye exam every 1–2 years. Why the need for more frequent checkups as you get older? Because, as with other ailments, your risk of developing certain eye problems such as cataracts, glaucoma, and macular degeneration goes up slightly with each passing year, and your best odds of maintaining good vision lie in catching any problems early, at the first signs of trouble.

If you have any symptoms of eye trouble: Even if you've just had your regular eye examination, it's very important to get any new symptoms checked out right away. Symptoms of blurred vision, for example, can mean much more than needing to change your eyeglass prescription. Therefore, waiting for the next routine examination—especially if it's 2 years away—is not a great idea. By then you might have some permanent vision damage from a problem that could have been much less serious if caught in time.

If you have other health problems or a family history of eye disease: In this case you'll probably need more frequent eye exams. Remember, the eye isn't immune from the repercussions of systemic medical conditions (hypertension and diabetes, for instance, can be particularly hard on the eyes). Also, if you have a family history of eye disease—glaucoma, cataracts at an early age, retinal detachment, or macular degeneration, for example—then your own risk of developing these is higher, and your doctor will want to be on the lookout for early signs or symptoms as you get older.

What You Can Expect at a Routine Eye Examination

To begin the exam, the doctor or a member of the staff will take your medical history, asking a series of basic questions, beginning with your age (see box). You should be open and honest about providing as much detail as possible about any health issues that you've encountered, types of medications that you are taking, and other pertinent topics.

Visual Acuity Tests

After taking your medical history, the doctor or technician will usually test your *distance visual acuity* (how well you're able to read letters correctly across the room) and *near visual acuity* (how well you read letters up close). In years past, the distance vision test was always done at a length of 20 feet, but today the test chart distance is generally downsized with mirrors, and visual acuity can be measured at a distance of 16 or even 14 feet (or even less), so don't worry if the examining room seems small. The classic “20/20” visual score measure can simply be thought of to mean that at 20 feet, *with or without corrective lenses*, you can read the same letters that a person lucky enough to have perfect vision can read at 20 feet (see chapter 2). So a score of 20/40 on this test means that you see *less well* than normal (you must stand at 20 feet to read the same letters a person with perfect vision can read from 40 feet), whereas 20/15 means your vision is *better* than normal (you can read from 20 feet away the same letters a person with perfect vision can only read at 15 feet).

YOUR MEDICAL HISTORY: TEN IMPORTANT QUESTIONS ABOUT YOUR HEALTH

Your eye examination will begin with your ocular history, followed by a few basic, important questions about your general health, beginning with your age. Although the questions may vary, you can probably expect to answer at least the following:

- What eye problems are you having now?
- What eye problems have you had in the past?
- How is your vision?
- Do you wear glasses? If so, do they work?
- Have you ever had eye surgery?
- How old are you, and how is your general health?
- What medical problems do you have?
- Do you take any medicines?
- Do you now or have you ever smoked cigarettes or cigars or used other tobacco products?
- Do you have allergies?
- Has anyone in your family had eye trouble or eye disease such as glaucoma?
- Has anyone in your family had diabetes, hypertension, heart disease, or thyroid disease?

Usually, visual acuity, both distance and near (near acuity is measured at the usual reading distance of 14–16 inches), is recorded for each eye separately (with the other eye covered or closed). Since when we see we usually have both eyes open at the same time, both distance and near visual acuity is also recorded with both eyes open. Some of these measurements may be skipped, depending on how much the doctor already knows about you. For example, in someone young enough to have normal accommodation, or focusing power, who has no trouble reading, recording near acuity may not really be a useful test.

Refraction

Refraction is the process by which the doctor determines the lens combination that helps you to see the best. Refraction can be done in several ways. One is for the doctor to hold up lenses and ask you questions (this is called *subjective refraction* or *manifest refraction*). This is the line of questioning you are familiar with, where you are asked to compare different lenses: "Which is better, #1 or #2?" Another is to shine a light into your eye and neutralize the movement of the light with lenses (a process called *retinoscopy*). Or your doctor may prefer to use one of several types of automatic refractors—computerized machines that estimate the lens combination that's best for you. Subjective refraction is then often used to fine-tune your prescription, using your response to questions. After all, you are the best judge of how you really see.

All of these methods of refraction are useful under certain conditions, but none of them can be counted on in every circumstance or for every patient, which means that your doctor will need to determine which one is most accurate for you. For example, retinoscopy is invaluable for determining proper corrective lens strength for children or adults who cannot cooperate with subjective refraction. While most 12-year-old children can participate in subjective refraction, only some 10-year-olds, and fewer still 8-year-olds, can do so. Automatic refractors are wonderful time-savers and do almost as good a job as subjective refraction. However, most of us who use the subjective refraction process are sure we do at least a little better than the machines.

Note: Unless mandated by law, as in the case of your driver's license, or required by your job, just because the eye doctor can find a lens combination that provides the best possible visual acuity for you does not automatically mean that you must wear those lenses—or any lenses. Other than children with lazy-eye problems, no one has to wear glasses just because the doctor says so. People need to wear glasses only in order to correct *the problems that bother them*. Eye doctors are often surprised by the vision problems that people will tolerate in order to avoid wearing glasses. Going without glasses may seem silly to some people, but after all, they're *your* eyes; even though you may squint a lot or not see as well as you could, it doesn't hurt your eyes *not* to wear glasses, and it is ultimately your decision.

External Examination

After vision and refraction comes the external examination—what your doctor can learn simply by looking at your eyes without any specialized instruments. We may not write all of the observations down, or we may do so very briskly, but we do pay attention to the following:

- The appearance and symmetry of the face
- The skin of the eyelids
- The edges of the lids and the lashes
- The position of the lids, and how well they open and close
- The clarity and shininess of the cornea, the irises, and the pupils, and their reaction to light

- The color, texture, and moisture of the conjunctiva (the slippery membrane on the front surface of the eye)
- The position, movements, and coordination of the eyes

This external exam can be done quickly. If there's anything abnormal looking or anything that needs to be looked at more carefully and in more detail, we generally notice it during the exam, even if we don't always comment on it. If you think that your doctor missed something, or if you have a particular concern, by all means, ask. If, for example, you say, "What did you think of the black spot on my right eye?" your doctor may need to take another look—but more likely they have already formed an opinion about it.

Pupillary Testing

The pupil is the black area of the eye, the part that is surrounded by color (the iris). All images must pass through the pupil before they are processed by the retina and perceived by the brain. The pupil, just like the aperture of a camera, opens and closes in response to light. In bright light the pupil gets small. In dim light it opens wide to allow more light to the back of the eye, to enhance the visual image. The shape and symmetry (or asymmetry) of your pupils and the way they react to light can give your doctor a lot of information about how you are seeing. Since the nerves that control pupil function have a relatively long course, including a circuitous route through the neck, abnormal pupil function can also provide clues about disease and other problems taking place elsewhere in your body, such as tumors, aneurysms, and vascular disease.

Examination of Important Structures within the Eye

Next, your doctor will examine your eyes with a *slit lamp*—a microscope with magnification of 10 times to 40 times or even higher (figure 4.1). This lamp has a light source that can be used either to provide illumination or to produce a thin, controlled beam of light. The intense line of light produced by this “slit” can illuminate a thin section of the cornea, the anterior chamber, or the lens. (For a look at these parts of the eye, see chapter 1.) These important structures of the eye are relatively transparent, so, like someone peering through a windowpane, we can look *through* one of them to focus on another. The slit lamp can also magnify and illuminate the iris, the conjunctiva, and the lids. With special stains and color filters, the slit lamp can reveal abnormalities of the cornea and conjunctiva from injuries or infections, or it can point out a deficiency of lubricating tears. The slit lamp is also an important tool to help examine the lens; when it becomes hazy and increasingly opaque, this signifies a cataract, which older people typically develop (see chapter 8). With additional optics the slit lamp can also be used to examine the vitreous and the optic nerve, along with the macula region of the retina and its blood vessels.

Measurement of Intraocular Pressure

The measurement of intraocular pressure (pressure within the eye) is a routine part of the exam for adults, and often for younger patients as well. To measure intraocular pressure, the doctor or technician must use a specially calibrated device. Several instruments have been designed for measuring intraocular pressure. Some use weights and look like small food scales, and others shoot a puff of air at the eye. The most commonly used instrument, however, is the *applanation tonometer*, which is mounted on the slit lamp as seen in figure 4.2. (This tool can swing out of the way when the slit lamp is being used to look at the eye.) Before using the applanation tonometer, the doctor will place a local anesthetic in the eye, as well as a dye called *fluorescein*, either separately or together. (These may sting briefly.)

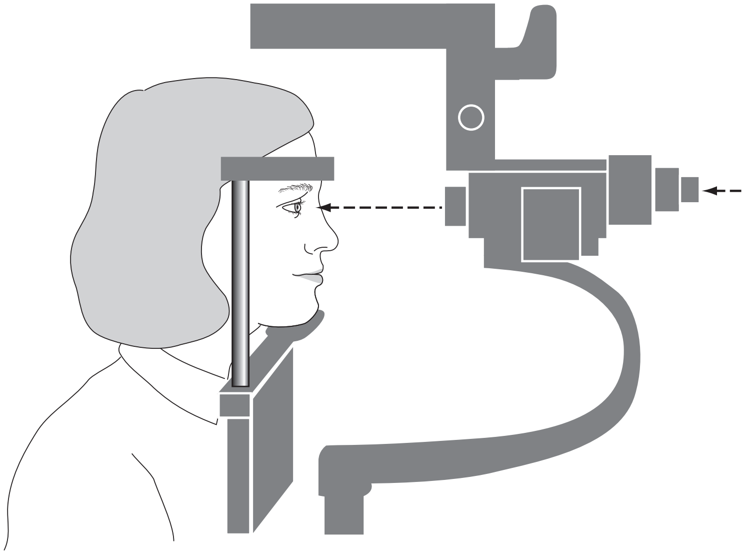


Figure 4.1. Slit lamp biomicroscope

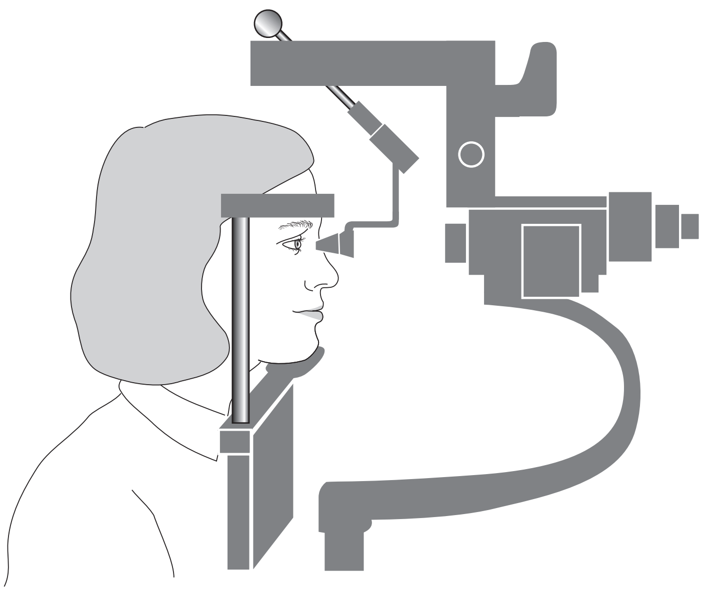


Figure 4.2. Slit lamp biomicroscope with applanation tonometer

When a cobalt blue filter is put on the light source, the fluorescein glows (or “fluoresces”) a bright, otherworldly green. The doctor or technician looks through the tonometer and turns a dial until the tonometer tip flattens a given amount of corneal surface. The amount of pressure in the eye is calculated using the relationship between (1) the force required to flatten the cornea and (2) the area of cornea flattened. During this process, the smooth plastic tonometer actually touches the front of the cornea, but the local anesthetic keeps the patient from feeling any discomfort. Finally, the doctor reads the dial of the applanation tonometer to find out how hard the tonometer had to work to flatten the cornea. This reading, the intraocular pressure, is registered in millimeters of mercury. The tonometer is an extremely useful instrument that makes it easy for ophthalmologists and optometrists to measure pressure within the eye.

While the applanation tonometer is still very commonly used, smaller handheld portable devices are also available. These devices have the advantage of being able to measure the intraocular pressure without necessarily being at the slit lamp or in an office setting.

Examination of the Retina

Using special lenses, the slit lamp can also be used to illuminate the retina and can be used along with an *ophthalmoscope* for this important part of the examination. There are two basic varieties of ophthalmoscopes. The *direct ophthalmoscope* is a handheld instrument; the doctor holds it up to their own eye and then shines the light into the patient’s eye. The *indirect ophthalmoscope* looks like the classic miner’s lamp, with the light fastened to a headband. This light shines through a lens, held by the doctor in front of the patient’s eye. The lens focuses the light reflected *back out* of the patient’s eye into an optical image. The indirect ophthalmoscope can explore a larger area of retina, allowing the doctor to see farther into the peripheral retina, and in three dimensions. Ophthalmoscopes can reveal most abnormalities of the retina; in addition, they're used to examine the optic nerve, the vitreous, and the blood vessels of the retina. (For a depiction of these structures, see figure 1.5.)

The retina is best viewed through a dilated pupil. Pupils are dilated by instilling dilating drops (see appendix B) into the patient's eyes and waiting 15–30 minutes for the drops to be fully effective. (In people whose irises are a dark color, this may take longer.) These drops affect each person differently and last longer for some people than for others, depending on the type and strength of the drop or drops used. In general, pupil dilation will also be accompanied by a loss of accommodation, or the ability to see things up close. Most people maintain adequate distance vision, so they can see to drive home, but they will need to wear their distance glasses if they usually do so for driving. Sunglasses may also be necessary, especially on a bright day.

If you are uncertain about how dilating drops will affect you, the safest approach is to bring someone along with you to the eye examination—a designated driver. Usually the effects of the dilating eye drops wear off after a few hours, but in very rare instances these effects can take days to go away. Eye doctors must be very careful when using drops to dilate the pupils, since these drops can bring on acute closed-angle glaucoma in people with a narrow anterior chamber angle (see chapter 9).

Additional Tests You May Need

What I've just covered are the basic parts of the standard eye examination: your medical history, the measurement of visual acuity, refraction, the external examination, examination of the internal structures, the measurement of intraocular pressure, and the retinal exam. Remember the beginning of this chapter, where I said that an eye exam could be fairly simple or more involved? Well, of all the many tests that can be done on eyes, some, like these, are done always and are considered routine.

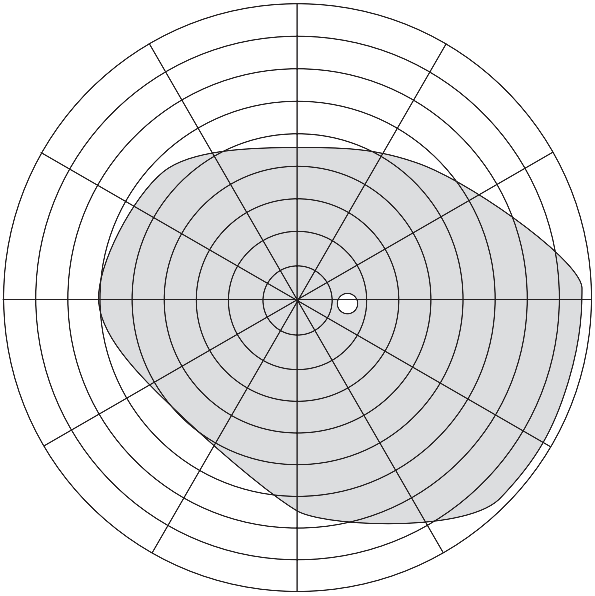
Some additional tests, however, are done often but not always; many others are done only occasionally, unless the doctor has a special interest in, or specializes in diagnosing and treating, a specific type of problem.

This second group of tests—those that are done often but not always—includes measurement of visual fields, A-scan biometry, optical coherence tomography, central corneal thickness measurements, gonioscopy, exophthalmometry, and tests of tearing, of eye coordination, and of color vision. Let's go over these.

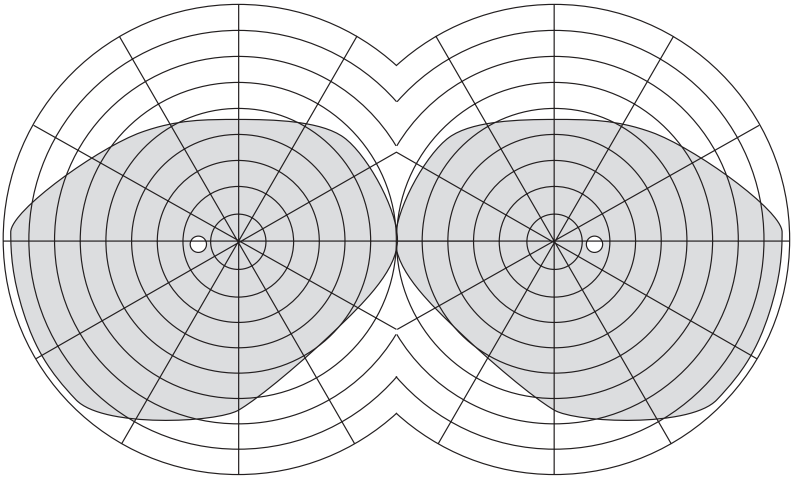
Measurement of Visual Fields

Your visual field is pretty much what it sounds like: the total area, up, down, and sideways, that you can see with one eye. It is also the drawing or diagram that represents what you can see. A visual field drawing indicates what size or color object you can see, at what distance from straight ahead, diagrammed as odd-shaped circles. To get a better idea of how this works, see figure 4.3. People see best straight ahead, with the macula, and then less well the farther the object is from "fixation," or dead center—in other words, at the outer edges of our visual field, or what we can glimpse from "the corner of the eye."

Like nearly everything else in our high-tech world, visual field testing has become much more complicated and expensive over the past few decades—but also better, in this case with the use of automated, computerized "perimeters," or visual field testing machines. These usually measure how high or how bright a light has to be in order for you to see it at a given position. Some of the more elaborate tests, involving hundreds of spots of light, can be tiring, but most are reasonably brief. Your doctor can also measure your



Visual field of right eye



Combined visual field of both eyes

Figure 4.3. Visual fields

visual field by having you observe a light at a certain spot getting brighter, or a light of fixed size moving in from the periphery toward your center of vision.

As a means of quick screening, to see whether someone's visual field warrants further study, a simpler test can be done. In this test your eye doctor might ask you to focus on their face and then note at what point you're able to see a pencil or finger coming into view from below, above, and the sides. This type of "confrontation" field is a good way of screening whether your visual fields are normal or not. However, tests of this type are useless for detecting glaucoma, and because such tests do not accurately diagram any abnormality, they can't tell us anything about whether a specific condition is getting worse.

Another, specialized type of visual field test, called an *Amsler grid*, is a square with a pattern of small squares (like a piece of graph paper) and a dot in the middle (see figure 4.4). It was designed by Professor Marc Amsler as a rapid self-test to detect changes in the central 20 degrees of the visual field. The test is particularly helpful at identifying diseases of the macula and optic nerve that affect vision.

Here's how it works: First, you'll be asked to focus your gaze (using one eye at a time) on the dot in the center of the square. Then, you'll be asked some questions. How does the pattern of small squares look to you? Does any part of it seem to be missing, distorted, blurred, or warped? Which part? Distortion is an important warning sign; in most cases the distortion a patient sees matches a problem in the corresponding area of the retina.

Amsler grids can be administered at home as self-tests by people who are considered likely to develop retinal problems. (Particularly at risk, for instance, are people who have already had retinal trouble in one eye. For a more detailed discussion of retinal problems, see chapters 10 and 16.) Here's how to use the grid at home: Post it someplace where you can easily see it every day—some hard-to-miss spot like the refrigerator door or bathroom mir-

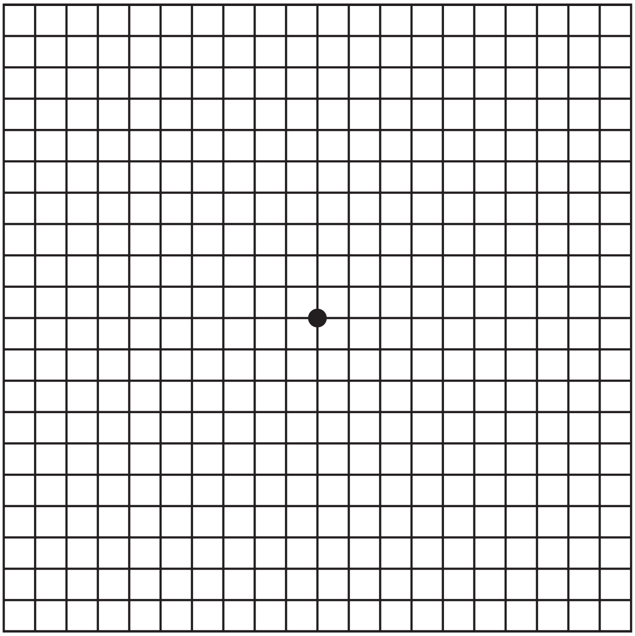


Figure 4.4. Amsler grid

ror. It's designed to be looked at, *in modest light*, from a distance of about 1 foot. If you wear glasses, contacts, or bifocals for reading, use them for this test too.

It's simple to use. First, cover one eye and study the grid with your other eye. Look *straight ahead at the central dot and nowhere else*.

Now, answer these questions:

- Can you see the dot in the center?
- Can you see all four corners of the grid?
- Are all the small squares the same size?
- Are all of the lines straight, or are some of the lines wavy? Are any parts of the graph missing?
- Is there any movement? Any color aberration?

Now, repeat the test using the other eye. If you notice any changes—distortion, blurring, discoloration, or a complete absence of any part of the grid—contact your eye doctor *immediately* for an examination. If you're at high risk for macular or optic nerve problems—if you have advanced macular degeneration, for example—you should test yourself daily. Other people should consult their eye care specialist for a recommendation about how often they should perform this test.

A-Scan Biometry

Suppose you took a rubber ball, dropped it 2 feet onto a concrete surface, and measured the time it took to bounce back to your hand. Next, you took the same ball and dropped it from a height of 3 feet onto the same concrete surface, again measuring the time it took to bounce back to your hand. You repeat this "bounce test" from 4 feet, 5 feet, 6 feet, and so on, carefully recording the time it took from each distance to bounce back to your hand. Theoretically, by dropping the same ball onto the same surface but from an unknown distance, you could then use the "bounce back time" to measure that distance. Using ultrasound—high-frequency sound waves—and measuring the bounce back time of the echo produced as this wave passes through different parts of the eye, we can measure the length of the eye, as well as the size of other structures and spaces in it. Basically, this is how A-scan biometry works—it has a variety of uses and is the basis for imaging the inside of the eye, which has revolutionized our understanding of eye development and diseases, as discussed below. Today, the most common use of A-scan biometry is to measure the length of the eye. This length measurement is performed in patients who will be undergoing cataract surgery because it is an important component for the calculation of the implant lens that will be placed in the eye once the cataract is removed. This implant lens returns focusing power back to the eye, as discussed in chapter 8. Other uses of A-scan biometry in the eye include measurements of the depth of the anterior chamber, the thickness of the lens, and the central corneal thickness, our next topic.

Measurement of Central Corneal Thickness

Measurement of the eye's pressure, an important aspect of the eye examination and a helpful predictor of glaucoma, is most often performed using applanation tonometry (see chapter 9), which involves numbing the corneal surface with a topical anesthetic, adding a dye (fluorescein), using a cobalt blue light filter on the slit lamp, and then measuring the amount of pressure it takes to flatten a small circle on the central cornea. This is the "blue light test" you may recall having at your eye doctor's office. The test is quick and painless, but the pressure reading is invaluable to your eye doctor in assessing the health of your eyes. As you can imagine, though, thinner corneal surfaces may be easier to flatten with this applanation test than thicker corneal surfaces. Therefore, researchers studied the effect that central corneal thickness has on this eye pressure reading and created ways to come up with a "correction factor" to take this difference into account. A-scan biometry to measure the central corneal thickness is at the heart of this correction factor and has helped us to standardize intraocular pressure readings obtained by applanation tonometry.

Nowadays, there are specific instruments ("pachymeters") designed to measure the corneal thickness. In addition to its use for intraocular pressure measurements, pachymeters are useful to track the progression of corneal diseases that result in thickening or swelling (see chapter 12 on corneal disorders).

Optical Coherence Tomography

Returning to our rubber ball and bounce test above, what if, instead of dropping one rubber ball at a time (A-scan), we dropped many rubber balls at one time onto an unknown surface made of concrete, wood, and packed soil? By measuring the bounce back times of each ball at various points across this varied surface and mapping out your times, we would be able to make an educated guess which surface at which location produced each bounce and then map out the surface. This is the basic principle behind a B-scan (yes, the same scan done during pregnancy). B-scans consist of a collection of many A-scans, but instead of balls, we use high- frequency sound or light waves, and instead of concrete, wood, and soil surfaces, we project these waves through living tissue. Specifically, when we use a broad-spectrum light source, accurately measure the bounce back rate of light as it is reflected back to the light source from tissues, and do this 20,000–70,000 times a second, we get tissue images of the inside of the eye. This imaging is referred to as optical coherence tomography (OCT) and has become particularly useful for looking at the tissue layers of the retina in the back of the eye.

Gonioscopy

A *gonioscope*, or *gonioprism*, is a device about the size and shape of a thimble that fits against the cornea. With the help of an anesthetic eye drop and a gooey drop to help improve the view by eliminating air and air bubbles between the gonioscope lens and cornea, the doctor can use this instrument to detect some kinds of glaucoma. An angled mirror inside the gonioscope—similar to the one your dentist uses—allows the slit lamp to focus "around a corner" into the space where the back of the cornea meets the front of the iris. (For more on these parts of the eye, see chapter 1.) This space is called the *angle of the anterior chamber*, and the angle itself is important: a narrow chamber angle may signal glaucoma.

Exophthalmometry

An *exophthalmometer*—one of our real tongue twisters—is a ruler with two arms that rest on the outer rims of the patient's orbits. Its angled mirrors enable the doctor to check, basically, whether the eye sticks out, or projects, farther than it should. The exophthalmometer is used most often to measure the amount of abnormal eye protrusion (also known as *exophthalmos*) associated with thyroid disease, but it is also used to monitor other causes of protrusion of the eyes.

Tests of Tearing

Do you have dry eyes? (The problem of dry eyes is discussed in chapter 14.) Would artificial tears help you? There are several tests available to help us answer these questions. One of these tests for diagnosing "deficiency of lubricating tears"—in other words, dry eyes—involves using paper strips to measure tear production, often along with an anesthetic drop (which helps decrease reflex tear production during the test). This is called the *Schirmer test*. One end of each paper strip is bent to fit inside the lower lid; the rest of the strip hangs down over the cheek. The amount of the strip wetted by tears is measured after 2–5 minutes. *Note:* There's a surprising amount of disagreement among ophthalmologists about the accuracy and usefulness of the paper strip test.

Nontoxic dye applied to the corneal surface such as either *rose bengal* or *lissamine* provides another gauge of whether the patient has dry eyes and will find artificial tears useful. In this test a drop of dye is put inside the lower lid. The dye usually stings and is usually applied after application of anesthesia. If someone has a tearing deficiency, the dye leaves tiny pink-stained (rose bengal) or green-stained (lissamine) dots on the cornea and conjunctiva. The dots are visible with the slit lamp and represent areas where the corneal epithelial cells are either devitalized or missing. The doctor can tell by the patterns of dye staining whether there's a problem with dry eyes. (*Note:* While these dots are not permanent, there is in this test a possibility of spilling the dye on clothing, where it probably *is* permanent, so be careful not to rub your eyes immediately after the test, and make sure your doctor carefully rinses this dye from your eyes before sending you home.) Remember the applanation tonometry test mentioned above, which uses fluorescein and the cobalt blue light to check your eye pressure? Fluorescein dye can also be used to check your tears. Besides revealing unique dry eye staining patterns of the cornea, similar but different from those dyes just discussed, fluorescein can also be used to measure the integrity of your tear film. When you blink, fluorescein becomes evenly dispersed in your tear film, and under a cobalt blue light, this looks like the smooth surface of a shiny, green marble. When there is a problem with the quality of your tears, your tears have trouble coating the cornea and quickly break up. This tear breakup under a cobalt blue light reveals dark, black holes among the once smooth green surface. The time it takes for the tear film to "break up" on the cornea is called the breakup time, and this measure helps your eye doctor assess your tear film integrity. Like other tests mentioned above, there is even technology today that evaluates the quality of your tears.

Tests of Eye Coordination

Most people see a little better with *both* eyes than with either eye alone. When this seems not to be the case, the problem usually has to do with the coordination of the two eyes—how well they work together. The brain uses a highly sophisticated feedback system to keep our eyes coordinated and avoid double vision. This system can correct large amounts of horizontal drift, quite small amounts of vertical drift, and almost no amount of rotational drift (see chapters 1 and 2).

As with any complicated system, some problems are more fixable than others. Here are some examples: If it's an eye muscle problem making someone see objects as level with one eye but tilted with the other eye, either we can patch one eye and hope the other one will get better, or we can perform eye muscle surgery in an attempt to level the tilted eye. Much more common—and much more easily correctable—are small but annoying amounts of horizontal or vertical muscle imbalance when both eyes are trying to work together. Such muscle imbalances are usually not detectable with an external exam, but we can distinguish them with tests such as the *cover-uncover test*, the *alternate cover test*, and a *red glass test*. Here's how the red glass test works: When you look at a light, your brain knows you're seeing just one light, and it works hard (but not cheerfully) to keep single vision. If, however, you hold a red glass in front of one eye, the brain relaxes its effort, and the white image seen by one eye separates from the red image seen by the other eye. The amount of this separation can be measured by the amount of prism necessary to line the two images up together. A prism lens can bend light in predictable amounts to compensate for eyes that cannot line up visual images by themselves. Putting a portion of the calculated amount of prism into the patient's glasses is often very helpful in solving such problems of muscle imbalance.

Tests of Color Vision

Tests of color vision are mainly used to diagnose inherited genetic defects of color vision. Such testing is rarely done in adults but may be used in diagnosing some optic nerve and retinal problems completely unrelated to inherited color blindness (for example, in checking for possible toxicity—in other words, too much of a drug in the system—from Plaquenil, a drug used to treat malaria and autoimmune conditions like rheumatoid arthritis). These tests consist of asking the patient to identify colored numbers lying in a field of another color, or arranging various color samples in a specified order (as at the paint store, when we are trying to find the perfect shade of blue for the living room walls). If someone has trouble distinguishing different colors, the tests will reveal the problem and identify the problem range—red and green, for example—in the color spectrum.

Other, Less Common Tests

Still other diagnostic tests, used much less commonly, are *retinal photography* and *retinal fluorescein angiography*. As with angiography of the heart, this is a series of pictures of the blood vessels—in this case, those within the retina—taken using a luminous dye. Pictures are captured in sequence as this dye, injected into the vein of the arm, moves through the arteries, capillaries, and veins of the eye. These pictures can reveal specific problems inside the eye such as age-related macular degeneration and diabetic retinopathy.

Another test occasionally needed is an *ultrasound examination of the eye*. This painless, noninvasive test—just like the ultrasound imaging commonly used in pregnancy—creates a picture with sound waves. This is the B-scan mentioned above as a collection of A-scans. When used in the eye, it can detect abnormalities such as tumors or retinal detachments (when, for example, bleeding in the eye or a dense cataract makes them impossible to detect during an eye examination). Examinations of the eyes and their surrounding structures by other imaging techniques, including X-ray, computerized tomography (CT) scans, or magnetic resonance imaging (MRI), can also be helpful in some cases. If one of these tests is necessary, it will usually be performed by a subspecialist, preferably someone recommended by your ophthalmologist.

In summary: Most eye exams are quick and simple; a few are long and complicated. Knowing which tests to do under specific circumstances requires the doctor to be well educated and trained, to listen well, and to consider carefully what's best for the patient.

Some Questions You May Have about Eye Exams

I'm getting my eyes dilated today. Will I be able to drive myself home?

Probably. Most people are able to drive after getting their eyes dilated, but everyone reacts differently.

Dilating drops work by enlarging your pupils and relaxing your accommodation (see chapter 2). If you're nearsighted, or if you don't normally wear glasses, you may have trouble with bright sunlight and glare, especially if there's snow on the ground. (If you need them, your doctor will probably provide a pair of plastic sunglasses to help cut the glare.) Also, this temporary loss of accommodation usually makes up-close work such as reading a bit more challenging. (If you need to read soon after getting your eyes dilated, it might help to remove your glasses or contacts. The latter probably shouldn't be worn during an eye exam anyway, unless you are specifically getting checked for problems reading when your contacts are in your eyes or being evaluated for how they fit.) But you probably won't have trouble driving; the eye drops don't hamper distance vision for most people.

If you're farsighted, however, you may have some trouble temporarily—just for an hour or two, depending on the particular eye drops and their strength. Because the drops affect the eye's ability to accommodate, and your eyes work by using accommodation to see things far away, it's possible that your distance vision could be disrupted for a short while.

If you're concerned about your ability to drive home, discuss this beforehand with your eye doctor. This part of the exam may not be necessary, or you may be able to postpone it to another visit. Or you could bring a "designated driver" to help you get home.

One more thing: as of this writing, there are still no eye drops that will rapidly reverse this dilation.

My husband's doctor said that he's legally blind. What does that mean?

Legal blindness is a confusing term. It's not so much a particular diagnosis as a purely legal definition that enables sight-impaired people to qualify for helpful services—many of which are free—including "low vision" assistance, occupational therapy, and tax benefits.

Every state has its own guidelines for legal blindness. To learn more about these, and to explore the range of services for which you may be eligible, call your state's Department of Social Services. If you have legal blindness, or if you know someone who is legally blind, you may also find chapter 20 of this edition very helpful.*

According to federal guidelines, you're "blind" if your vision *in the better eye*, when *best corrected* with glasses or contact lenses, is 20/200 or worse. For example, if you have macular degeneration with a visual acuity of 20/200 in one eye and 20/400 in the other, this would apply to you. (If, however, your vision is terrible in both eyes *without* glasses *but you see 20/20 with glasses*, then you'd be ineligible.) If your vision is better than 20/200 but your field of vision is severely limited—as if, with no peripheral vision, you were constantly looking at the world through a tube or tunnel—you may also be considered legally blind.

If you are classified as legally blind, you may be eligible to receive an extra deduction on your federal income taxes. To qualify for a legal-blindness deduction on your federal income taxes, you'll need to attach to your tax return a written statement from your eye doctor, indicating your visual acuity or field of vision. (You should be sure to keep a copy for your own records as well.) If your condition will never improve, you can file an eye doctor's statement to this effect with the Internal Revenue Service. This will be on permanent record for all future tax returns.

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*I have updated and expanded this chapter from the first edition with the help of Michelle Bianchi, an occupational therapist and low vision specialist.

Are headaches often due to eye problems?

Not as often as you might think. Headaches (see chapter 19) come in many forms. Some are mild, some severe; some are fleeting, while others linger for days. Some go away with a couple of aspirin; others require much stronger, prescription medication. *But very few of these are actually caused by eye problems*. Discomfort around the eyes can be related to eyestrain and the need for glasses, but this usually results from using your eyes for long periods—especially for close work—and is often relieved by a simple change in activity or by an over-the-counter pain reliever.

Note: If you're having frequent or severe headaches, besides seeing your eye doctor, you should also see your general medical doctor or other health care provider. They will want to rule out other health problems. Other factors that can cause headaches include tension, allergies, sinusitis, and temporal or giant cell arteritis (see chapters 18 and 19); intracranial problems, migraines, and other systemic disorders may also need to be considered.

Chapter 5

ALL ABOUT EYEGLASSES

Many of us are all too familiar with the concept of a "vision correction"—usually eyeglasses or contact lenses, but increasingly refractive surgery as well—because we've dealt with less-than-perfect eyesight for years. But there are just as many first-timers out there who are new to all this: adults, often in their forties and fifties, who suddenly find themselves needing extra help to see better. This prospect and all that it might represent, including the inevitability of growing older, can be, at the very least, unsettling.

But take heart. Your timing couldn't be better. Never before has there been such a wide and remarkable range of options, including choices that might have seemed like science fiction 50 years ago.

Major technological advances in the way eyeglasses and contacts are manufactured now allow us to *see better* with *fewer compromises* to lifestyle and appearance. Today surgery is a possibility for correcting some vision problems that decades ago could be compensated for only by those thick, uncomfortable, Coke-bottle lenses.

So, faced with all these choices, what do you do now? If you've never before needed anything to help you see better, how do you go about deciding what's right for you? What factors are important in making this decision? First, you'll need to consider carefully your own needs, including your lifestyle, job, and hobbies, and then weigh them against the general health of your eyes and the particular vision correction you require. Also, know that you certainly don't have to decide things all by yourself; that's where this book—and, of course, your own eye doctor and optician—can help. In this chapter I'll discuss all of these options and, I hope, help you narrow down your choices and come to an appropriate decision.

How to Find What's Best for You: Your Guide to Lenses and Frames

Eyeglasses are the most frequently used means of correcting vision. Until about 50 years ago they were strictly functional and, as anyone whose face has ever been dwarfed by huge black horn-rims can attest, not much of a fashion statement, unless you want a retro or vintage look. Now, with literally thousands of frames and hundreds of lens designs available, the selection can be overwhelming.

What's best for you? The physical attributes of your face may be one limiting factor; obviously, not all frames will look good on everyone. Your prescription may be another; a bifocal prescription or a very strong prescription might not fit well into a certain type of frame. A frame that doesn't fit your face won't do you much good, either; stylish but ill-fitting glasses won't allow the prescription to align properly over your eyes, and as a result your vision won't be clear or comfortable. Lastly, the cost associated with glasses may be important to you; you may need to check whether frames and lenses are covered by your insurance. If you don't have insurance, there are other options, including programs provided by organizations such as EyeCare America and others that offer free or discounted eye care for you and your loved ones. Please refer to information provided on the websites of the American Academy of Ophthalmology and the American Optometric Association.

Ask for help. Your doctor and optician can guide you to the best selection of frame and lens design. Then, you and they can work together to make a decision. Discuss your concerns with your doctor at the time of your eye examination. Be sure to mention any specific visual needs—if you spend a lot of time reading, for instance, or using a computer—and ask what type of lens design would best suit those needs. Then, consult with your optician. Ask what type of frame is best suited for your face and the prescription. Lenses that provide the same function can be manufactured in numerous ways, some of them better for your needs than others. One more thing: while many items can be ordered and purchased online today without the need to check measurements and fit, or even try them on, eyeglasses that you are going to rely on every day are best fit by an experienced optician with you physically sitting in front of them.

Some websites do have some cool features where you can upload an image of your face so that you can try on eyeglasses virtually to see what options (square frames, rectangular frames, etc.) may best fit your face. These are helpful tools when frame shopping, but it's always best to work with an optician to help with fit or any problems that may come up.

First, the Lenses

Configurations

Eyeglasses are made in two basic configurations: *single-vision* and *multifocal*. As the names suggest, single-vision eyeglasses have only one prescription, or lens power, whereas multifocals have more than one power within each lens. Traditionally, single-vision lenses were used by people who didn't need more than one prescription—someone who needed eyeglasses only for driving, perhaps, or just for reading. Or maybe someone needed eyeglasses for both activities but used the same lens power for both. Single-vision eyeglasses sometimes work better for specific activities, such as viewing a computer screen at a fixed distance.

Multifocals may be bifocals, trifocals, or progressive addition lenses (figure 5.1). These lenses address more than one need and often allow people to perform various visual tasks wearing the same pair of eyeglasses.

Bifocals have two prescriptions within the same lens, one for distance and one for reading. Bifocals may have a line across the entire width of the lens, with the reading portion on the bottom, or they may contain the reading area within a small part of the lens.

Today bifocals can be made without a noticeable line, thanks to a sophisticated polishing technique. These "blended" bifocals—not to be confused with progressive bifocals, discussed later—may look better cosmetically. However, there's a drawback: the seamless line leaves a wide area of distortion where the two lens powers meet, and this shrinks the size of the available reading area. This blend is also noticeable—and, to some people, a nuisance—whenever you shift your gaze from distance viewing to near viewing. That is, although others see no line in your glasses and probably won't realize that you're wearing bifocals, *you* see a line, and it's fairly wide.

Trifocals add a third lens for intermediate vision, for viewing distances of about 2–3 feet. The intermediate lens has to be positioned just below the pupil, so that the reading portion can still sit high enough in the lens for you to use it comfortably. Because the intermediate lens sits up so high, the line is much more noticeable than with a bifocal, but trust me, you *will* get used to it, and your awareness of the line will diminish greatly as you do.

Progressive addition lenses are seamless multifocals. These lenses are much more functional than the blended bifocals. Their design offers a smooth transition from the distance portion of the lens into the reading portion. With progressive addition lenses you can't see a line from behind the lens. But as your eye moves from the top of the lens through the *intermediate channel* and into the reading area, the power of the lens gradually increases, or *progresses*. With this type of technology there's an appropriate lens power for every viewing distance. Say, for example, you need to view a computer monitor at 30 inches but you're working from a sheaf of papers just 16 inches away; all you need to do is look *just slightly higher* in the lens to bring the computer monitor into view. Because these lenses include an appropriate part for *all* viewing distances, your vision often seems more natural. For example, say you're using standard bifocals to peruse the contents of a file cabinet drawer. How well can you see what you're doing? The files at the back of the drawer are somewhat in focus through the distance half of your lenses, and you can see the files at the front pretty well, using the near portion of the lens. But what about the files in between? To see them requires that you move your head, either closer to the drawer or farther away from it. Kind of awkward, isn't it? The beauty of the progressive addition lens is that you should be able to see the *entire* drawer, all in focus, all at once.

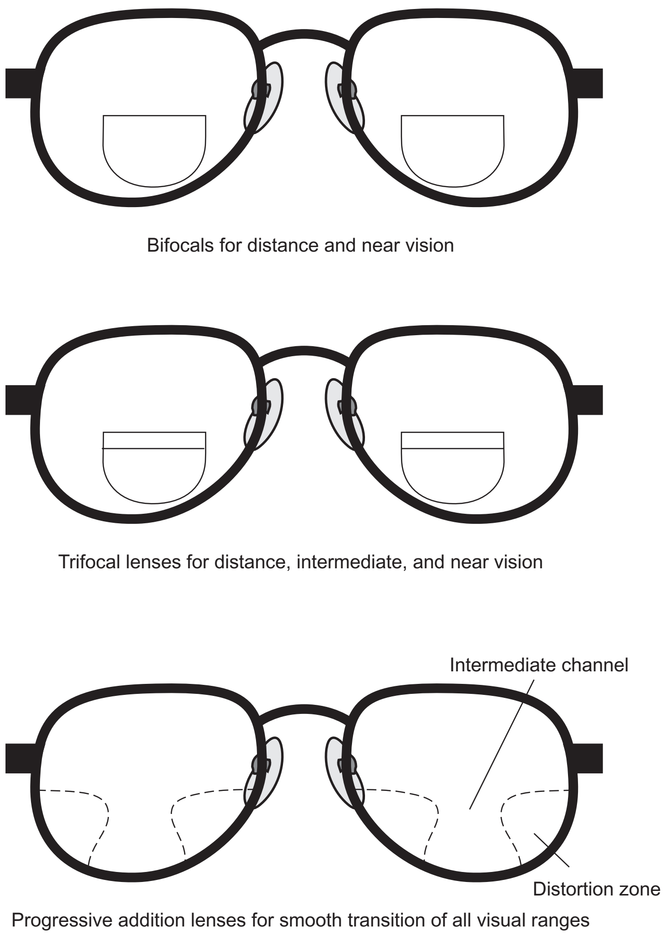

Figure 5.1. Bifocals, trifocals, and progressive addition lenses

The drawback to such lenses is that in creating the progressive optics, a small part of the lens becomes unusable and the sides of the lenses become visually distorted. Still, the technology for crafting these lenses has improved greatly since the late 1970s, when they were first made, and the peripheral visual distortions are much milder in current lens designs. And, as with other kinds of lenses, you do grow accustomed to the slight inconveniences. At first, when you glance to the side with your progressive addition lenses, your vision will appear wavy, and you'll probably find yourself looking at things with your whole face, pointing your nose toward whatever you're observing. However, after you fully adapt to your new lenses, you'll hardly notice these distorted areas.

Glass or Plastic?

Here's another big decision: selecting the lens material. Sure, lenses are made from either glass or plastic, but that's just the tip of the iceberg. Many more choices lie within these two major categories.

Glass lenses tend to be more scratch-resistant than plastic lenses, but you pay the price: they're also twice as heavy. Plastic lenses are usually the lens of choice because of the weight difference; also, with special coatings, they can become more scratch-resistant. Plastic lenses have other advantages as well. They're more impact-resistant than glass. As a result, they're less likely to shatter or break. And because they're less brittle than glass, plastic lenses are easier to work with, which means that they can be machined to fit into more types of frames than glass lenses.

Also, manufacturers can tint plastic lenses simply by dropping them into a vat of heated dye, where they soak up the tint like a sponge. The amount of tint can be varied by the amount of time the lens is left in the dye. And later, if you decide that your lenses are too dark, the tint can be bleached out. Other tinting methods are available for polycarbonate and glass lenses, which are not as easily tinted as plastic lenses. *Photochromic* lenses, which get darker when exposed to sunlight, most commonly change in response to UV rays. Early photochromic lenses, developed by Armistead and Stookey at Corning Glass Works Inc. in the 1960s, were glass and darkened through the reaction of silver chloride or silver halide embedded into lenses. Today, through a variety of proprietary dyes, these photochromic lenses are available in many lens materials and designs, including polycarbonate, high-index, bifocals, and progressive lenses. Photochromic lenses also come in an array of colors and can filter 100 percent of UVA and UVB light. Since the darkening and lightening of these lenses is a thermal process, this change is temperature dependent and will be different in warm and cold weather. Beware: photochromic lenses are not for everyone. You should discuss the pros and cons with an optician to help you figure out if they are right for you.

Other Options

Both glass and plastic lenses can be made in high index. Made of denser material, a high-index lens can bend light more powerfully. The result is a thinner—and, to some, a more aesthetically appealing—lens. High-index lenses made of glass tend to be almost as heavy as regular glass lenses. But when they're made of plastic, especially polycarbonate lenses, the lenses are much more lightweight than standard plastic ones.

Other coatings and dyes can be added to lenses to improve both vision and safety. *Antireflective coatings* reduce the amount of light reflected off the front and back surface of the lens, as well as light reflected *within* the lens itself. Why is this important? For people with early cataracts, glare can be debilitating and even dangerous. The antireflective coatings can make a tremendous difference in vision, especially for driving at night.

UV protection: Plastic lenses can also be treated with a screening dye to filter out UV light before it has a chance to enter the eye. UV light, the ultrashort wavelength of light that causes skin damage and sunburn, may also contribute to certain cataracts and retinal problems. *Therefore, UV protection is especially important for sunglasses*. Sunglasses should have 100 percent filtering for UVA and UVB light, the two wavelengths of UV radiation that affect the eyes. If you're buying over-the-counter sunglasses, look for ones with labels that say "100 percent UVA and UVB filtering," or "100 percent absorbing below 400 nm" (which means that they filter out all light below the wavelength of 400 nanometers).

Blue light: What's the concern about blue light? Why are people anxiously buying eyeglasses that claim to filter out blue light emitted from computers, smartphones, and tablets? Should you be concerned? Like the warning some people give to their kids that sitting too close to TV is bad for the eyes, worries about the harm of blue light emitted by digital device screens on the eyes is not supported by scientific evidence. Simply said, "there is no evidence that the kind or amount of light coming from computer screens is damaging to the eyes."*

Blue light is *everywhere*. Although blue light is emitted from computers, smartphones, and tablets, the largest source of blue light exposure is from sunlight. Even with the amount of blue light that we receive directly from light exposure from the sun, there has not been any evidence of damage or harm to the eye, but research is ongoing. In fact, cutting out blue light exposure during the daytime can have a *negative* effect on a person. Blue light has been shown to affect our circadian rhythm (our natural cycle of being awake to falling asleep) by suppressing the body's melatonin production. Blue light wakes us up and helps keep us alert while we are awake. At night, too much blue light from a mobile phone or computer screen may make it difficult to fall asleep. Therefore, altering our blue light exposure can potentially play havoc with our day.†

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*https://www.aao.org/eye-health/tips-prevention/are-computer-glasses-worth-it
†https://www.aoa.org/news/clinical-eye-care/health-and-wellness/blue-light-hype-or-much-ado-about-nothing

You may have thought that the eyestrain you feel when working on the computer is from blue light emitted from the digital screen—after all, that's what your friend said. Well, stop scapegoating blue light. When you stare at anything for a long period of time, you can feel eyestrain, primarily because you don't blink as often as you should, and this leads to dry eyes. So, before you run out and buy the next latest and greatest blue light filtered glasses advertised to "prevent" eyestrain, try the 20-20-20 rule. For every 20 minutes that you stare at a digital screen, look at least 20 feet away at something to relax your eyes for at least 20 seconds. Also, position your screen at least an arm's length away, cut the glare, and use artificial teardrops when your eyes feel dry or tired. If these steps don't do the trick, please see an eye doctor. Your problem may be due to trouble with accommodation at the distance of your screen, and a pair of prescription glasses may be just what you need.

Specialty Eyeglasses

If you're shopping for safety eyeglasses, look for frames with side shields and for more impact-resistant lens materials such as polycarbonate or glass that is at least one and a half times thicker than standard glass lenses. Polycarbonate lenses are a good choice for people with one eye who wear glasses, since they provide protection for this "good" eye.

Occupational lenses are custom designed to match specific needs with particular activities. Say you need to look above your head at something close-up—as a mechanic does, for instance—and you wear bifocals. The object will be blurry through the distance portion of your lens. An occupational bifocal can be made with a second bifocal segment placed in the top of the lens—just like the one at the bottom of the lens—so that you can focus on what you need to see close-up. One of the most common uses for occupational eyeglasses is for the computer. With bifocal computer eyeglasses, you can look at your computer screen through an intermediate-vision prescription at the top of the lens and still see your keyboard through a near-vision prescription in the bottom of the lens.

Next, Finding the Perfect Frames

So many decisions already, and we haven't even tackled the issue of frames yet. Again, the range of choices can be overwhelming. It's not unusual for people to spend hours trying on frames, looking in the mirror and soliciting opinions from total strangers, or even taking selfies with their choices and putting them online for family and friends to vote. Why is this? Why do we agonize so? One big reason is the long-term commitment involved here. After all, we're not talking about a pair of shoes or a new hat; most of us wear the same pair of eyeglasses all day, every day, for years. Therefore, we find ourselves in the quandary of attempting to find the perfect frames, ones to match our entire wardrobe (or, a tougher assignment, ones to match our every mood).

First of all, relax. You don't have to go through every single pair of frames in the store. The optician can usually help narrow down your choices, and lighten your burden considerably, by guiding you to a selection that will look best with your particular prescription and facial structure. *Note:* Don't let anybody talk you into buying huge frames—that is, unless you want them—simply because "your prescription is so strong." In fact, if you have a very strong prescription, you'll probably want to choose a frame as small as possible to help reduce the thickness and weight of your lenses. Other considerations are the shape of your face and nose. If you have a round face, for instance, you probably won't want to choose a perfectly round frame that exaggerates this. If the bridge of your nose is uneven, metal frames may fit better than plastic ones; metal frames typically have nose pads that can be *individually adjusted* for each side of your nose (figure 5.2). Lifestyle is an issue as well. For instance, if you perspire a lot because you exercise strenuously or live in a hot, humid climate, you may prefer plastic frames; salt, produced by sweat, can be corrosive to metal frames, damaging the frame and causing skin irritation wherever the frame touches the face.

Our advice? Because this is a decision you'll most likely have to live with for some time, take a trusted friend or family member with you. *Note:* Some understanding opticians will take pictures of you in different frames to email to your closest fashionistas or even allow you to purchase a frame to take home, try on for everyone, and return for credit toward another frame if your family and friends don't like your new look.

Finally, the Right Fit

Thank goodness—you've run the gauntlet of frames and lenses and made your selections. Now it's time for the fitting.

First, the optician needs to measure the physical attributes of your eyes. This is to make sure that the lenses will be properly centered over your pupils, and that when the lenses are centered for your eyes, they'll still fit appropriately in the frame. If you wear a multifocal, the optician needs to measure where the intermediate and near portions of the lens should be placed within the frame. Sometimes the optician will examine your old eyeglasses to see how those measurements compare. Good opticians often try to match anything that was unusual about your old glasses to make your transition to the new ones as smooth as possible. The eyeglasses are then sent to a lab so that the lenses can be ground and set into the frame.

When your new eyeglasses are completed, the optician will shape the frame to fit the bridge and temples to your face, for optimal comfort and vision. Keep in mind that there's almost always an adjustment period for new eyeglasses; this may last from days to weeks. (Most likely, even if your new eyeglasses aren't a new prescription, you'll still experience a brief period of adaptation just because of the new frame and fit.) It's definitely not unusual to ex-

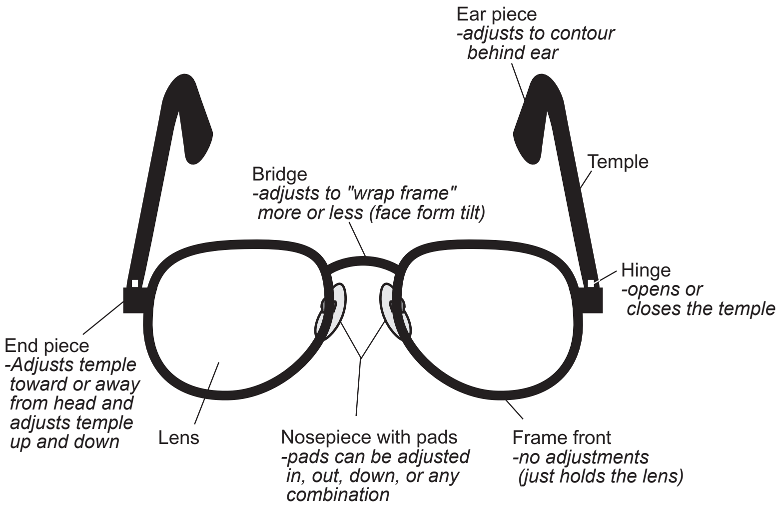

Figure 5.2. Eyeglass adjustments: all of these parts can be adjusted to improve comfort and vision

perience a few aches in your eyes at first. *However, these aches should not be unbearable, and they should diminish over time*. Often a quick trip back to the optician to readjust the frame can make all the difference in the world. But if this doesn't help—and if your vision is clear with the new prescription and the comfort level is bearable—try to stick with the frames for 2 weeks before returning to your doctor to recheck the prescription. Give your eyes time to adjust.

The need to adapt to new eyeglasses is especially demanding, and often annoying, for those who wear multifocals. One of the easiest and most pleasant ways of adjusting, if you're getting used to multifocals for the first time, is simply to curl up with a good book. As you read, occasionally look up across the room. This will help your eyes to learn to move smoothly *through* the lens. Then, once you feel comfortable with reading, give yourself and your eyeglasses new challenges. Take a walk around your home. Because moving around with new bifocals—as you may soon find out—is often easier said than done, practicing in a familiar environment makes the adjustment easier. Finally, know that your predicament is only temporary. You really will get used to your new glasses. After you do, you won't spend your time thinking about "how to use them"; you'll just live your life and do what you need to do, and you'll see better than you did before.

When Something Goes Wrong

Having said all that, it's also important to address the fact that sometimes in the world of eyeglasses, as in life, there are glitches. So, you've just picked up your new eyeglasses and they're less than great. Something doesn't seem right. You had such high hopes: you thought that you would see better, that the world would look and feel better than it had in a long time, and that's not the case at all. What happened?

The first thing to do is check with your optician and make sure these glasses were made to the doctor's prescription. Frankly, this is almost always a formality; almost invariably the optician will tell you that the lenses are the correct power and that you'll need to return to your doctor to have the prescription rechecked.

However, there's much more to seeing clearly and comfortably than just the power of your new lenses. When eyeglasses are made for you, the frames and lenses need to be measured and fit to tailor the glasses to your face and eyes. Every lens has an *optical center*, the part of the lens where the prescription is the purest and most precise. *The optical center should be located exactly over your pupil*, and this can happen only if the frame fits properly and the lenses within that frame are perfectly aligned.

When you have a problem with your new glasses that doesn't go away over time and the optician tells you that the eyeglasses are made "to the doctor's prescription," you need to return to your doctor to have both the eyeglasses and your prescription rechecked.

You may understand the problem better if you arm yourself with some working knowledge of "optical jargon." To that end, I've included a brief primer to help you understand some key terms often bandied about the optical shop.

An "Optical Jargon" Primer

"PD": PD stands for "pupillary distance," the distance between the centers of your two pupils. This measurement can be taken with a ruler, but it's most accurately calculated with an instrument called a *corneal reflex pupillometer* (CRP). Using the lights, lenses, and prisms on the CRP, your optician can shine a precise point of light at the center of your pupil. First, the optician will place the CRP over your eyes and ask you to look at a light inside. Then, using that light's reflection off your cornea as a means of alignment, the optician can measure the distance from each eye to the center of the bridge of your nose. Because most people are not perfectly symmetrical, it's not unusual for one eye to be closer to the bridge of the nose than the other. (This becomes important when measuring for progressive addition lenses, where the optical center of each lens must be exactly over each pupil.)

Induced prism: When you look through a lens that is a prism, whatever you see through that lens is displaced. Say, for instance, you're looking at a ball. The ball may appear to be in one place, but it's actually located a few inches or feet over. The ball looks perfectly normal—the size and clarity don't change, in other words—it's just shifted a little. If problems with your eye muscles hinder your eyes from working together precisely, prisms can make a world of difference. They can realign the images each eye sees so that your brain can interpret the world as one image instead of two.

However, sometimes the problem isn't your eyes at all but your glasses. If the optical centers of your glasses aren't properly calibrated over your pupils—when, as opticians say, the PD is not correct—this, too, can create prism. When prism isn't intentional—to clear up an eye muscle problem, for instance—your vision can be distorted or doubled. This is called *induced prism*. The farther your pupils are from these optical centers, the greater the "shift"; with stronger prescriptions, the prism problem is even more noticeable. For example, say two people have their new glasses made incorrectly, with the optical centers of their lenses made just 5 millimeters wider than the actual distance between the pupils (5 millimeters may not seem like much, but in this precise science, every millimeter counts). The person with the stronger prescription will have the worse case of prism misalignment. (Prism is discussed in more detail in chapter 2.)

Refraction: This is a physics term describing the way light bends as it passes through a lens. (*Refraction* also describes the procedure your doctor performs when determining your prescription.) When you wear glasses, the lenses bend the light to correct your eyes' refraction problems and refine your ability to focus. (Refraction is discussed in more detail in chapter 2.)

Reflection: This term denotes the bouncing of light off a surface. Light that reflects off your eyeglasses can create glare.

Diffraction: Another physics term, this refers to how light scatters when it meets a surface (think of sunshine on a lake, for instance). On a bright day, light can scatter at the edge of your eyeglass frames and create glare. Cataracts can create the same problem: by diffracting the light that enters your eye, they can cause glare *within the eye* and make your vision seem hazy.

Base curve: Think geometry here. Base curve is the curvature of the front surface of a lens. The total power of a lens equals the sum of the *front surface curvature* and the *back surface curvature* of the lens. You can vary the lens curvatures for a given prescription but keep the power of the lens constant. For any prescription, the lens can be made with many different base curves. (For more on how an incorrect base curve can cause problems, read on.)

Pantoscopic tilt: This term describes how the top of your frame angles away from your face. The frame should be fit with a slight pantoscopic tilt to compensate for a downward posturing of the eyes while reading. Too much pantoscopic tilt, however, will move the optical center farther from the pupil and thereby change your prescription.

Retroscopic tilt: This is the opposite of pantoscopic tilt, when the bottom of your frame is angled away from your face, making the top of the frame sit closer than it should. Retroscopic tilt is a bad thing because it distorts vision for both distance and near viewing.

Face form tilt: This term refers to how your frame wraps around your face. Too much face form tilt effectively changes the position of the optical centers of the lenses and results in a distorted view of the world.

Progressive addition lenses: Discussed above, this is the most common type of no-line bifocal, featuring a progressive change in power from the top to the bottom of the lens. The top of the lens, of course, is for your distance vision. The middle of the lens is referred to as the *intermediate channel*; this provides vision at distances of approximately 2–6 feet. As you gradually look down into the reading portion of your lens, objects that are closer to you come into focus. These lenses do a great job except when you glance to the side, where the world can appear wavy or even tilted. This is entirely normal, the downside of the progressive optics, and simply part of the nature of these lenses. *Note:* In recent years major strides have been made in decreasing the size of this distorted side area.

Blended bifocals: They're not as common as progressive addition lenses, but blended bifocals are also used to create a no-line bifocal. The concept here is basically that of a lined bifocal, except that the line is smoothed out for cosmetic purposes. Someone looking at your eyeglasses can't see any telltale bifocal line, but you yourself aren't so lucky. You actually see much more of a line than with regular lined bifocals. In smoothing the line, the blending process seems to widen it, leaving a wide area of distortion in the lens.

Seg height: That's "seg" as in "segment." Seg height is where the bifocal segment sits in a lens. For most people who wear lined bifocals, this line of demarcation is at the top margin of the lower eyelid. In progressive addition lenses, the optical center of the distance part of the lens is placed over the pupil, and the amount of seg height is predetermined by the manufacturer of the lens.

Vertex distance: The distance at which your frame holds the lens from the eye is the vertex distance. If you push your eyeglasses in or pull them down on your nose, the prescription will shift away from what it's supposed to be. Your doctor's prescription usually assumes that your frame will sit 7–10 millimeters from your eye.

High-index lenses: All lens materials have what's called an *index of refraction*: how much light is bent, or refracted, when it passes through the lens. A high-index lens bends light much more powerfully than a standard lens of the same curvature and thickness—which means that, compared with a standard lens, the high-index lens is thinner (and, to some, more cosmetically appealing).

Polarizing filters: When a light wave bounces off a surface, it becomes polarized: it splits into horizontal and vertical components. The horizontal component of the light wave is what we see as glare. Glasses can be made with a filter that screens out *only* the horizontal light waves to reduce glare. Such filters are especially helpful for people who spend a lot of time driving or on the water.

Surfacing: This is the term for the manufacturing process that produces a *lens blank*, a large round lens (approximately 75 millimeters in diameter) with a specific prescription. The lens surfacing machine polishes both the front and back surfaces of the lens to create the desired lens power.

Edging: Edging is the process of grinding a lens blank to be fit into a frame. The lens blank is placed in the edging machine, or "edger," and aligned according to (1) the lens's optical center, (2) the person's PD, and (3) the size and shape of the frame. The edger follows a specific frame pattern to grind, bevel, and polish the lens edges, so that each one fits exactly into the frame.

Troubleshooting Problems with Your New Eyeglasses

Now, what do all of these factors mean to someone whose new eyeglasses don't work? If your doctor finds that the prescription is correct and that the lenses have been made correctly, then obviously, something else is wrong—and chances are, the culprit is one of these features.

Incorrect PD

If the PD is off, for instance, you might experience blurred vision, aches in the front of your head or in your temples, a pulling or drawing sensation between your eyes, dizziness, reading problems, and possibly double vision. The induced prism (see above) does not allow for your eyes to work together, and your eye muscles will probably ache from trying to compensate for the incorrect eyeglasses.

In a progressive addition lens, an incorrect PD adds another problem. When we read, our eyes need to "converge," or turn in slightly, so that we can focus with both eyes together on the page. When you wear a lined bifocal, you're measured for a *distance PD* and a *near PD*. (The difference between the distance PD and the near PD is called the *inset*.) The near PD takes the needs of reading into account: it allows for the optical centers to be a little closer together, to match how your eyes converge when you read. With a progressive addition lens, the near PD is preset by the manufacturer and is designed so that each eye individually can follow the progressive path down through the lens into the reading area. If a lens is made incorrectly for the distance PD, this could throw off your ability to read: your eye might not fall within the appropriate area of the lens when you look down to read, and the vision will be blurry.

When this is the case, you may be able to read with either eye at a time but not with both eyes together because the image is not clear for both eyes at the same time.

Problems with Frame Adjustments

Occasionally, even with a correct PD you may experience symptoms similar to those of an incorrect PD. If, for instance, your old eyeglasses were made with an incorrect PD and you adjusted to the induced prism (see above), then you might miss that prism when your new eyeglasses are made to match your eyes appropriately. The same is true if because of ill-fitting frames, the optical centers are placed somewhere other than over your pupils.

In either of these scenarios, your symptoms tend to be more vague than when the PD is made incorrectly. Your eyeglasses "just don't feel right," but your vision seems otherwise normal. If the optician hasn't already done so, your doctor needs to determine whether the frame sits unevenly on your face, and they should look at you from four different views.

The first is face-on, to see whether the frame is tilting and causing one lens to sit higher than the other. (For example, do you have one ear that's higher than the other, making the frame tilt?) If you wear a bifocal, frame tilt might cause the bifocal segment line to cross one pupil and create double vision.

The second view is to look from overhead, to see if one lens sits closer to your face than the other. This pushes one of the lenses farther from your eye, which gives that lens a different vertex distance. One eye's prescription will be less appropriate because the vertex distance will be off, and you'll be uncomfortable seeing with both eyes together. Your vision might be blurry or double.

The third view is your profile, to check for pantoscopic tilt. Too much frame tilt can distort your vision. This extra tilt actually changes your prescription because the optical centers of the lenses aren't where they're supposed to be.

The fourth view is again from overhead, to determine whether your frame has too much face form tilt and is wrapping around your face excessively. This tends to make the world look bowed in or out.

Generally, if the frame fit is different from the fit of your old eyeglasses, it can affect both your vision and your comfort with the new eyeglasses. *Always take your old eyeglasses with you when you return to your doctor to have the new glasses checked*. This way your doctor can consider how your old eyeglasses fit and try to readjust your new ones to match. Of course, if your old eyeglasses fit poorly but you adjusted to them, you don't necessarily want to have your new eyeglasses adjusted so that they fit as poorly as the old ones. However, you might have to compromise the fit of your new eyeglasses somewhat to improve your comfort. If your doctor is not comfortable readjusting your frame or doesn't have the equipment to do so, ask the doctor to write a note for the optician describing specific adjustments that need to be made.

Base-Curve Problems

If the base curve in your new eyeglasses is different from what you're used to, this can produce symptoms similar to those caused by too much face form tilt: the world will look curved or bowed. An incorrect base curve can affect your mobility: your new eyeglasses will make it difficult for you to negotiate curbs or steps while walking. If this is the problem with your new glasses, you may feel that the vision "just doesn't seem right" without being able to pinpoint your specific symptoms.

Like any eyeglass problem, base-curve problems are more common in higher prescriptions and are usually not experienced when the prescription is mild. If you can't adjust to the new eyeglasses, the optician will have to remake your lenses to match the base curve of your old pair.

Problems of Having a Different Prescription for Each Eye

When everything has been made correctly with your new eyeglasses but you still have complaints, the problem might relate to the prescription itself. That is, a prescription may simply be difficult to get used to with your eyes together, even if it's correct for either eye by itself. If the prescriptions for your two eyes are different, then you have a condition called *anisometropia*. (The symptoms of anisometropia are that one eye's image seems farther away or a different size than the other eye's image. Someone with this condition may also see double when viewing with both eyes together.)

When your eyes are different, the placement of the lenses over your pupils becomes critical for clear and comfortable vision. If, for example, your eyes sit evenly above the optical centers of the lenses and one lens is stronger, then that lens will have more induced prism at that eye's pupil than the other lens. This uneven induced prism will make your vision seem distorted, cause dizziness and discomfort, and create a doubling of the world so that you see two images, one on top of the other.

A more common problem with each eye having a different prescription is *image jump*. In a lined bifocal, as you move your eyes down to the line, the image will appear to "jump." When both eyes have the same prescription, the jump isn't really noticeable once you adapt to your eyeglasses. But when your eyes have *different* prescriptions, the jump is often greater in one eye than in the other, and thus more conspicuous. If your visual system isn't able to recover from this difference in jump, you may experience double vision when you read. Otherwise, you might describe your problem by saying that "the print swims, moves, or dances" on the page, or that you don't feel like your eyes are "working together for reading."

For these reasons, if you have a different prescription in each eye, you may not be able to wear a bifocal. If having two pairs of eyeglasses—one for distance and one for reading—is too inconvenient, a progressive addition lens might alleviate the symptoms of image jump that you had with a lined bifocal. Occasionally, symptoms of image jump can be relieved with a special type of prism called a *slab-off prism*. This is incorporated into one lens of a lined bifocal to counteract the difference in image jump created by different prescriptions. Contact lenses are another solution: they greatly reduce the effects of different prescriptions and offer an excellent alternative for your vision (see chapter 6).

Problems with Materials

Eyeglasses that have been measured and made correctly with an appropriate prescription still may not provide you with the vision that you were expecting. Keep in mind that there are many different materials and lens qualities available on the market today. Not all plastic lenses are created equal, and some lenses are clearer than others.

Plastic lenses are made of a material known as CR-39, which is exceptional for transmitting light without distortion and provides an excellent optical-quality image. The Food and Drug Administration requires that a lens manufacturer needs to use *at least* 50 percent of this material in a lens in order for that lens to be considered a “CR-39 lens.” Different manufacturers use different proportions of the material in their lenses. The finest plastic lenses are 100 percent CR-39; however, they also tend to be more expensive. If you’re looking for the least expensive prices, you may inadvertently be buying an inferior lens. The problem is that you never really know what you’re getting. In general, if the optician orders a stock lens from a major lens manufacturer rather than manufacturing lenses on site, there is less likely to be a problem. (Keep in mind that *manufacturing* lenses and *edging* lenses to be fit into a frame are two different processes.)

Lenses are also made of many materials other than CR-39. Newer plastic lens materials that are much thinner and lighter can be used to make your eyeglasses look and feel better. Many advertisements for these lenses have made eyeglass wearers aware of their availability. As always, some of these materials work better than others. The first such material to become available was polycarbonate. Originally these lenses were designed to be used in safety eyewear that required a high-impact-resistant lens. Because these lenses were so much lighter in weight than the high-index glass lenses in use at the time, they gained in popularity very quickly. Early on, however, it was discovered that these lenses didn't provide the same quality of image as did standard CR-39 lenses; to make matters worse, this shortcoming was much more noticeable when the prescription was stronger. So people who needed stronger prescriptions were more likely to spend more money for these lenses, only to be disappointed by their vision with the new eyeglasses. Newer polycarbonate materials apparently do not have this problem, but as with CR-39, not all optical laboratories use lenses of the same quality. Over the years high-index lenses that are made of plastic materials other than polycarbonate have become available. While these materials are not totally free of problems, in general they provide better vision than polycarbonate.

Lens coatings are sometimes the source of complaints with a new pair of eyeglasses. The most common lens coating used today is an "antireflective" coating, which reduces the amount of light reflecting off the lens surface and thus decreases glare. When properly applied, an antireflective coating can improve vision. But a poor-quality antireflective coating will leave noticeable ripples in the lenses and thus distort vision.

Other Things That Can Go Wrong

Finally, some things that go wrong with eyeglasses revolve around the wearer. Here are three things you can do to help avoid these problems.

First, be careful when you choose a new frame. The optician should be skilled at helping you find the best fit for your face and prescription, but sometimes—how can I put this diplomatically?—a sale becomes more important than offering the best advice. You should also be careful when purchasing your glasses online. If your frame is too large, it may create a distorted view of the world and affect your ability to navigate while wearing your eyeglasses. If the frame extends past the side of your face on either side, it can create glare from light reflecting off the back surface of the lenses.

Second, be careful to describe your vision needs to your doctor. This is of utmost importance. Your doctor can prescribe eyeglasses based on the average person's needs but can tailor your prescription to fit how *you* use your eyes during the day. The biggest problem with bifocal prescriptions, in particular, is determining a reading correction that allows you to read at the distance that *you* require. Every reading lens power focuses light at a given distance, and as the reading power increases, the reading distance gets shorter. We don't all necessarily have the same reading distance. Our reading distances either come from habit or are specific to a job or hobby. For example, if you sit all day with a computer monitor 24 inches away from you, and your doctor assumes that you like to read at 16 inches, then your eyeglasses won't be very helpful for the computer unless you move much closer to it.

The final thing you need to look at requires some introspection. We've all bought things—clothes, jewelry, and the like—that have gone over like a lead balloon with our friends and family. Many of us respond to this decided lack of enthusiasm by declining to wear that particular thing again. If for some reason you come to hate your new frames, then subconsciously you might not feel as if you see well. You may secretly be hoping that the eyeglasses can be returned. Try to be honest with yourself, the optician, and the doctor—because all of you will spend a lot of time trying to find out the source of your symptoms.

As a last word of advice, always have your doctor write a note for you to take back to the optician describing exactly what's wrong with your new eyeglasses. This helps you to communicate the problem to the optician effectively; it also adds more credence to the problem at hand. Without a note, the optician might just dismiss the problem and tell you that you don't really understand enough about eyeglasses to know what you're talking about.

Some Questions You May Have about Eyeglasses

Does it matter where I get my new eyeglasses?

In a perfect world, every optical shop, optician, optometrist, and ophthalmologist would treat you the same, radiating infinite concern that your new eyeglasses provide ideal vision, comfort, and looks—all, of course, at a reasonable price. Unfortunately, as in any profession, there are some among the spectacle purveyors who can be considered unscrupulous. Some chain stores are the epitome of professionalism; others illustrate in the worst possible way the principle of "caveat emptor" (let the buyer beware). The same can be said for some professional opticians. So the first thing to know is that the individuals you'll be dealing with—their knowledge and their ethics—matter much more than the location. In this regard, word of mouth and online reviews can be very helpful. Most likely, human nature being what it is, someone who has gotten lousy service will be more than happy to tell you all about it, and someone who has received excellent care from a particular eye doctor or optician will enjoy spreading that word as well.

There are several advantages to buying your eyeglasses at your doctor's office—if, of course, the price is fair. For one thing, you have the advantage of having your doctor available to recheck your prescription if something doesn't seem right. Also, if the new prescription needs to be changed, your doctor will probably not charge you for the second set of lenses. While some doctors tell their patients "old wives' tales" about "getting used to your new glasses" just to avoid remaking them, most doctors feel responsible for any lab work produced by their office. For them, this craftsmanship reflects the values of the office as a whole, and they'll do anything to make sure their patients are happy with their new eyeglasses.

Eyeglasses bought online or purchased at an optical store not affiliated with your eye doctor might be more convenient for you if the optician's shop is located where you can easily stop by for frame adjustments. However, if there's a problem, you'll find yourself traveling between the optician's and the doctor's offices, probably several times, until the problem is resolved. The "one-hour" opticians can be a lifesaver if you really have an emergency need for new eyeglasses. However, some of these establishments manufacture their own lenses, and the quality of materials may not provide you with the best vision possible.

Ultimately, you need to shop where you're comfortable or have had good references. If you know and trust your doctor, and the doctor's eyeglass prices are pretty much in line with prices elsewhere, it's probably worth getting your glasses made there for the service and quality of the eyeglasses. Remember, most people wear the same pair of glasses every day, usually for 2 years or more. No other piece of your wardrobe receives as much wear. It's probably worth a little more of your time, and sometimes your money, to make sure that you have the best possible vision, comfort, and looks with your eyeglasses. (In other words, it takes a reasonable length of time to make your glasses right the first time, and the people crafting your glasses should be watching the quality, not the clock.)

If I wear my eyeglasses all the time, will I become dependent on them?

No. Remember, your eyes are in a constant state of flux your whole life (see chapter 2). No matter what you do, you can't stop this process; your eyes are going to change anyway, with or without corrective lenses. All eyeglasses do is help us see better *through* these various unavoidable vision changes.

If you're just starting to need a reading prescription or bifocals and you try to put off getting eyeglasses "so that your eyes won't weaken further," you won't be doing yourself any favors—and you certainly won't be toughening up your eyes by straining them, as if they were stomach muscles you could whip into shape if only you did enough sit-ups. Instead, you'll find yourself putting up unnecessarily with blurred vision and headaches. As we age, our reading vision, in particular, falters; this trend increases with each passing year. So even if you don't wear your eyeglasses, your reading vision isn't going to get any better, and anyway, you'll still have more of a "dependency" on eyeglasses in the future. Everybody does. Why should you be blurry and uncomfortable in the meantime?

Conversely, if you don't wear your eyeglasses, your vision won't necessarily get *worse* because of eyestrain. After about the first 10 years of life, the critical years for the development of our vision, *not* wearing your eyeglasses has no effect on the outcome of your prescription. During those first 10 years, however, it's very important to provide the retina with the best possible image for vision development, and wearing eyeglasses, if they are needed, is an absolute must.

There's nothing wrong with being clear and comfortable; you're not giving in to weakness by seeing better. If it means wearing some form of corrective lens to achieve better vision, don't feel that you're harming yourself in doing so.

What does my prescription mean?

Your prescription is written in units called *diopters*. A "one-diopter lens" focuses light at 1 meter, or approximately 40 inches. The diopter designation on your prescription does not indicate what your visual acuity is. (For more on this, see chapter 4.) If, for example, you have a prescription for one diopter of nearsightedness, then you really don't see very well past the length of your arm; but the one-diopter designation doesn't indicate what your vision is without your eyeglasses. Eyeglass prescriptions change by a quarter of a diopter at a time. On average, your vision changes one line on the eye chart for every quarter diopter of prescription that you need. For someone with one diopter of nearsightedness, vision without eyeglasses is generally about four lines higher on an eye chart than the 20/20 line, or 20/50 vision.

Your prescription will sometimes include a designation for axis. The axis is the specific direction in which the correction for astigmatism is placed. Because astigmatism is an optical distortion that is caused by the eye, like an American football, having more curvature in one direction than in the other (see chapter 2), corrections for astigmatism always have a particular orientation.

If you are someone who needs to wear a bifocal, then your prescription will have a designation for *add* (see chapter 2). Your distance prescription will allow your eyes to focus appropriately on objects that are usually 20 feet away and beyond. The "add" describes the amount of reading correction that is added to the distance prescription in order to allow your eyes to focus at a reading (or near-working) distance.

How should I clean my new lenses?

Always begin by rinsing your lenses thoroughly with tap water. (Between cleanings, dust and debris settle on the lenses. Rubbing a lens with a cloth—your shirttail, for instance—actually grinds the dust and debris into the surface of the lens, creating fine scratches.)

After rinsing, spray them with a cleaner designed *especially for eyeglass lenses*—window cleaners often contain ammonia, which can damage lens coatings—or apply a small drop of a mild liquid dish detergent to each lens. Gently rub the cleaner into the lens with your thumb and forefinger and then rinse thoroughly with hot water. Hot water evaporates from the lens surface faster than cold water, making it easier to dry the lens. Finally, always use a soft paper towel or lint-free tissue to dry your glasses. Tissues with skin softeners and perfumes may smudge your freshly washed lenses, and cloth towels can scratch.

What is a "no-line" bifocal?

Actually, it's a little more complicated than it sounds. As discussed in this chapter, a bifocal is an eyeglass that does two jobs: the top part corrects your distance vision, and the bottom is used for reading. Traditionally, these two portions have been separated by a distinct line.

"No-line" bifocals come in two basic varieties. In the first, called a *blended bifocal*, the line is blended out, leaving a thin blurred zone between the distance- and near-lens portions. In the second and more popular kind, called a *progressive no-line bifocal*, there's a gradual progression between the distance and near prescriptions. The big advantage here is that instead of the wasted blurry space, there's a bonus zone for *intermediate vision* ("arm's-length" vision, such as the distance between you and a computer screen or a shelf at the grocery store).

I just bought new eyeglasses. Can I still get some use out of my old pair?

Sure. People do it all the time. Most of our patients keep at least one old pair of eyeglasses around the house as a spare or to wear when doing yard work or any other potentially lens-scratching activity. Some people have their old eyeglasses darkened with a tint by an optician and made into prescription sunglasses. There are many ways to give new life to an old frame. One of the best is to donate them to a "recycling" agency so that someone else can use them (see below).

Can I recycle my old eyeglasses?

Absolutely—and someone will thank you for it. Eyeglasses, both frames and lenses, are processed at regional centers, categorized by their lens prescription and style, and then sent to underprivileged areas in the United States and to underdeveloped countries and dispensed to those in need. Ask your eye doctor, local hospital, or community organizations (in the United States, the Lions Club has been particularly involved with this recycling project).

Can I do anything to alleviate computer-related eye problems?

If your long hours in front of the computer are hurting your eyes, you're certainly not alone. An estimated sixty-six million people in this country have computer-related vision problems: eyestrain, irritated eyes, blurred vision, even headaches.

But there are some things you can do. The easiest and most low-tech solution is simply to give those accommodation muscles (see chapter 2) a break every so often by looking across the room or out the window—the "20-20-20" rule (see chapter 3). Administering artificial teardrops several times a day may help. Progressive or "no-line" bifocals, or "computer lenses" (with an intermediate-distance prescription), may help ease the strain on your eyes. You might also ask your eye doctor about getting antireflective coatings or tints on your eyeglasses; these can break up the reflection of overhead lights and improve contrast of the screen. Also, many computer stores sell glare-cutting filters that sit over your screen or monitor. (Speaking of glare, if your computer sits directly in front of a bright window, you'll notice a big improvement if you either move the computer or keep the curtains drawn.) Finally, positioning your monitor slightly below eye level makes it easier for your eyes to converge (see chapter 2) on the screen.

My daughter sits too close to the television and my husband stares at his computer screen for hours. Will this damage their eyes?

This falls under the "reading in dim light" category of eye worries, and fortunately the answer is the same: no. No research has ever proven that TV screens or computer monitors harm the eye. However, watching any kind of screen, TV or computer, from the same vantage point for prolonged periods can cause eye fatigue and discomfort. (For tips on alleviating computer eyestrain, see the previous question.) As with any prolonged activity involving the eyes, take frequent breaks; look around the room every 15–30 minutes, to give your accommodation muscles a rest. Also, to avoid dry eyes, remember to blink frequently, and use supplemental artificial teardrops if needed. (For more on these, see chapter 14.)

What about those "dime-store" reading glasses? Are they any good?

Over-the-counter, or "dime-store," reading glasses are sold in many drugstores and grocery stores, as well as in specialty stores. These glasses come in varying strengths and are usually labeled with the same power system as prescribed reading glasses. Because they are inexpensive, many people who enjoy using them will purchase multiple pairs so that they can leave one at work, one by their favorite reading chair, and one on their nightstand and never have to worry about where they left their glasses.

Dime-store reading glasses can be an excellent alternative for someone with presbyopia who has little or no need for a distance prescription, or for someone who requires an additional reading prescription while wearing contact lenses. However, because both lenses in these types of glasses have the same effective power, they might not work well if one of your eyes needs a significantly different prescription from the other.

Additionally, these types of glasses are set up with optical centers that provide for an average PD, one that won't necessarily match your eyes. If you experience headaches, discomfort, print that swims or moves while you read, or double vision with your over-the-counter readers, then the optical centers are probably off with respect to your eyes.

Even if you do experience symptoms from wearing these glasses as a result of inappropriate power or PD, they will not harm your eyes. The symptoms will almost certainly go away when you stop wearing the glasses.

Can I get a prescription to help me see better than 20/20?

How well you see is dependent on the health of your eye. If your eye is not healthy enough to see 20/20, a prescription will not help you see any better. On the other hand, if you have a healthy eye with the potential to see 20/20 but give someone the wrong eyeglass prescription, you can certainly make them see worse than 20/20.

Chapter 6

CONTACT LENSES: EVERYTHING YOU NEED TO KNOW

For some people, glasses are a plain old nuisance. They slip down on your nose, get smudged, or, worse, get misplaced (for folks who rely on more than one pair of glasses, this can happen several times a day).

Thank goodness, then, for contact lenses. For the millions of people who wear them, contacts are the lenses of choice for several reasons. Many find contacts to be much simpler than glasses; once they're in for the day, it's easy to forget about them (except for adding the occasional rewetting drop). Also, they provide much better peripheral vision than glasses. Is this important? Absolutely. Better peripheral vision can help keep your eyes more relaxed when you're reading and focusing—and this, in turn, helps reduce fatigue and eyestrain. For sports and recreational activities, better peripheral vision can even boost your performance.

Also, a contact lens *moves with your eye*, so you're always looking through the *center* of the lens, the part of the lens that provides the best vision. In contrast, when you're wearing glasses and you glance to the side, sometimes your vision seems distorted. (This is because, due to the nature of many eyeglasses, the lens doesn't provide the same quality at its edges as it does in the center.)

If your prescription is strong, your glasses will actually change your perception of the size or relative distance of whatever you're seeing. Once you get used to your glasses, of course, you tend not to notice these things. But contacts give the world a more natural appearance. Putting the lens correction *on the eye itself* minimizes these size differences and often provides better visual acuity, which means you can read smaller letters on the eye chart. (For more on visual acuity, see chapter 4.)

Still, despite these and other advantages, contact lenses aren't ideal for everybody. Are they for you? This chapter may help you decide.

How Contact Lenses Came About: From Leonardo to Today

The notion of putting a corrective lens on the eye to achieve better vision is certainly nothing new. In fact, Leonardo da Vinci came up with this brilliant idea some 450 years ago. (Although no lenses were manufactured at that time, detailed drawings and descriptions were made.) A. E. Fick, a scientist in Zurich, manufactured the first contact lens in 1887 but soon found out that the human eye didn't like wearing lenses made of actual glass. It took a major innovation, in the 1940s, to produce the ancestors of the contact lenses we wear today: plastics. Those original lenses were made of a material called PMMA, which in fact was so well tolerated by the human eye that it's still used for hard contact lenses, for intraocular lens implants, and for orthopedic purposes.

Soft contact lenses didn't become available in this country until 1972, when Bausch and Lomb first introduced them to the American market. The original soft lenses tended to be more comfortable than the hard lenses available at the time, but because they were limited to just a few sizes, these lenses didn't fit many people. The big difference between hard and soft contact lenses was that the new soft lenses allowed oxygen to pass *through* them—not just *around* the lens, as with hard contacts. This made for a much healthier lens environment because it enabled the eye to "breathe" with a lens in place. Lack of oxygen to the cornea can lead to decreased vision from corneal swelling and epithelial cell damage.

Since 1972, contact lenses have changed and improved considerably. Now, lenses are designed to correct almost any vision problem and are available in special designs for extended wear, cosmetic changes (like eye color), and disposability.

Types of Contact Lenses

Hard versus Soft

Contact lenses come in an impressive variety of materials, sizes, shapes, thicknesses, and colors. In general, they're divided into two major categories: hard and soft.

Hard contacts have evolved significantly since their introduction in the 1940s. Initially their design improved as manufacturing techniques improved, but in the late 1970s came a major breakthrough: the development of hard contacts that "breathed" like soft lenses. We call these lenses *rigid gas-permeable contacts* (RGPs).

Gas-permeable contact lenses can be designed to fit onto the cornea, the front surface of the eye, or can be designed in a way that they do not touch the cornea at all, but rather rest on the conjunctiva and sclera, the white part of the eye. The latter is called a scleral contact lens and is usually prescribed for people with corneal diseases such as keratoconus or severe dry eye. Scleral contact lenses are large in diameter, whereas corneal gas-permeable lenses are small.

The RGP lenses are more flexible and fit better than earlier hard lenses, and they last longer (with respect to "wear and tear") and sometimes provide better vision than soft lenses. They're manufactured by computer-controlled lathes that can create any kind of surface needed to correct someone's vision. For example, if you have a high degree of astigmatism, an RGP lens can be ground with a curvature to match your cornea perfectly—providing a healthier, more comfortable fit, and vision that's usually superior to that offered by your glasses.

RGP lens materials also allow for bifocal segments to be added. In this sophisticated manufacturing process, a bifocal segment is fused into the lens; the result is similar to bifocal glasses that have a line (except this line is tiny, and it's within a lens placed on your eye; for more on this, read on). Because RGP lenses move significantly on the eye with a blink, these lenses can be fit to *translate* or move the bifocal segment up so that it sits in front of the pupil while you're looking down to read.

Another significant advantage to RGP lenses is that they can provide, in effect, a new cornea for people with a corneal problem that distorts vision. Because this lens maintains its shape on the eye—as opposed to molding itself to the eye, the way a soft lens does—it masks a corneal irregularity, helps correct the optical surface, and improves vision.

Soft contacts are referred to as *hydrogels* because they're made of a plastic material that holds water. By changing the amount of water that a lens holds, manufacturers can provide a broad assortment of materials for fitting. Water contents vary depending on the specific material; by changing the water content, lenses can be custom designed to fit specific needs. Silicone hydrogel contact lenses are a popular type of hydrogels that have a high water content and are very highly oxygen permeable. This material can be better for people with dry eye or problems related to reduced oxygen supply to the eye such as redness, discomfort, or blurry vision from contact lenses.

Soft contacts are available to correct myopia (nearsightedness), hyperopia (farsightedness), astigmatism, and even presbyopia (that unfortunate loss of ability to focus at near distances that gets worse after our midthirties). For years people with unusual prescriptions, astigmatism, or reading problems were told that they couldn't wear soft contact lenses. But now innovations in lens manufacturing allow for almost any prescription to be made into a soft lens. Computerization and automation of lathing and molding soft contact lenses have made for extremely accurate lens prescriptions.

Daily-Wear versus Extended-Wear

Daily-wear lenses are designed to be put in when you wake up and taken out before you go to sleep. This is very important. All daily-wear lenses are made to provide enough oxygen to the cornea for the eye to breathe while it's open. *No daily-wear lenses are appropriate for overnight wear.*

Extended wear lenses are designed for continuous overnight wear. (*Note:* Some people need extended-wear lenses for daily use because their eyes require a higher level of oxygen.) These lenses are made to provide enough oxygen so that the eye can breathe even while you're sleeping.

When they were first introduced in the late 1970s, extended-wear soft contacts were advertised as "thirty-day lenses." They're not called that anymore. Research in the early 1980s quickly discovered that very few people could tolerate keeping lenses in their eyes for a whole month at a time, and those hardy souls who tried wearing them that long often ended up with big problems—corneal edema (excess fluid and swelling in the cornea), corneal abrasions, and infections. Subsequent research found that after even 1 week of continuous wear, there was a significant buildup of bacteria on and in the lenses—so much so, actually, that it's been determined that most contact lenses shouldn't be worn for more than 1 week at a stretch. The Food and Drug Administration (FDA) and Federal Trade Commission (FTC) have even been closely monitoring the packaging and marketing of the wear-time recommendations by contact lens manufacturers. In general, though, overnight wear has been associated with high risks of complications, and so most practitioners will recommend against sleeping in contacts, even if they are approved for overnight wear. This means that the lenses themselves can be used for their approved time, but it is healthier if you take them out every night.

RGP extended wear didn't become available until the mid-

1980s. These lenses were approved for only 7-day wear, but they generally provided more oxygen than their soft-lens counterparts and were less prone to the nasty bacterial buildup. RGPs have higher oxygen permeability than soft contact lenses, which can reduce the number of complications to the cornea compared to hydrogels. This is especially true in the newer gas-permeable materials. However, overnight wear of extended-wear lenses is still not recommended owing to the increased risk of infection, as well as additional complications described below. While these materials with higher oxygen permeability are safer for patients, they cause more mucus and protein buildup on the surface of the lenses, which can lead to blurry vision or discomfort, and require more frequent and thorough cleaning and disinfecting of the lenses, which you will read more about shortly.

More current thinking with regard to extended-wear lenses centers around the phrase *flexible wear*—which isn't a particular type of contact lens but instead a concept of how these lenses should be worn. *Flexible wear* simply means that a lens material is fine for occasional overnight wear, and that you have the option of keeping your lenses in all night or taking them out before you go to sleep. You will read later in this chapter about the increasing popularity of daily disposable contact lenses, particularly because they are healthier for your eyes and usually more comfortable for people with dry eyes and allergic eye problems.

Disposable and Frequent-Replacement Contact Lenses

Like everything else, as technology has improved, soft contacts have also gotten more complicated. Now, in addition to the original lens packaging—where you bought a single pair of lenses, built to last for about 12–18 months—there are soft contacts that are packaged as disposable or frequent-replacement lenses.

Disposable extended-wear lenses, available since the late 1980s, are meant to be worn once—kept in your eyes for a day for some lenses or for a week at a time for other lenses—and then thrown away. Clinical studies in the 1980s found that many extended-wear lenses were more fragile than other kinds of contacts, more prone to wearing out or to being torn, which made this prospect too expensive for many people. In response to this, some lens manufacturers created entirely new production techniques and facilities to make lenses so reproducible, with so few defects, that large quantities of lenses could safely be dispensed at a very low cost per lens. In 1995, the first lens designed to be *disposed of daily* became available. If you have sensitivities to contact lens solutions or are prone to allergic reactions and infections due to contact lens coatings, or simply don't have time to clean your contacts, then daily-wear disposables might be the healthiest choice for your eyes.

Frequent-replacement lenses are designed to be removed, cleaned, and then worn again, but they need to be replaced often, at 2-week, 1-month, or 3-month intervals, depending on the brand and the individual wearer. These lenses are made for either daily use or extended wear. (However, any disposable, extended-wear lens can also be used as a daily-wear, frequent-replacement lens.) An important thing to remember is that although these lenses are replaced often, they must be cleaned and disinfected every time they are removed, if you intend to wear them again. Otherwise, there is a significant risk of an eye infection.

Getting Your Contact Lenses

Which Contact Lenses Are Right for You?

Your first step in deciding which lenses are right for you is a comprehensive eye exam, to determine what your prescription is and also to make sure that your eyes are healthy.

One of the most important parts of this evaluation is your health history. (For more on eye exams, see chapter 4.) Have you had any eye issues—such as dryness, chronic infections, or corneal dystrophy—that may interfere with contact lens wear? Do you have any functional problems with your eyes—a muscle imbalance, perhaps, or any trouble focusing? Do you have any general health problems? (Even though the problem may not be in your eye itself, some conditions may make wearing contact lenses more difficult, so be sure to tell your eye doctor *everything*, even if it doesn't seem important to you right now.) Are you taking any medications? (Some medications can dry out your eyes or otherwise interfere with contact lens wear.) Do you have any environmental allergies or sensitivities to preservatives? (These may also affect your comfort in contacts or your ability to use certain contact lens solutions.)

Another aspect of this evaluation is to determine whether your lifestyle—your work, habits, and hobbies—lends itself to contact lens wear. For example, are you active in sports? Do you work in a dry or dusty environment? Do you stare at a computer for a large portion of your day? Are you routinely exposed to any chemical fumes that may be absorbed into a contact lens? Are you a cigarette smoker? While none of these preclude your wearing contacts—many of us who stare at computers all day do just fine with our contacts, for instance—it's certainly smart to consider everything *before* you make this investment, not after the fact.

Finally, it's a good idea to clarify your goals and expectations with contact lenses. For example, if your goal is to wear contacts for competitive swimming, this may not be realistic because of the chemicals and bacteria found in swimming pools. If your goal is to use extended-wear soft contacts because you travel extensively on your job and don't want the hassle of taking contact lens solutions with you, this may be a fine idea, so long as your eyes can tolerate this type of lens. (The dehydrating environment in airplanes may complicate your plans.)

Getting the Right Fit

Contacts that don't fit right are about as useful as glasses that constantly slip down your nose; in other words, they're not much help. Good fit is essential because it lets the contacts do what they're designed to do: give you the best vision possible.

To ensure good fit, your eye doctor will begin by measuring the corneal curvature and diameter for each eye. This curvature measurement, taken with an instrument called a *keratometer*, helps determine the right curvature of the back surface of a contact lens, so that it can be custom fit to match your eye. The diameter of your cornea—important in determining what size lens to use—can be measured with a ruler, but often it's best to try on a *diagnostic contact lens* (a nonprescription sample) of a known size; then, the doctor can see how that lens fits by viewing it on your eye with something called a *biomicroscope*.

Your doctor will also take into account any surface irregularities on your eye that might hamper a good fit. Do you have any bumps or elevations on your conjunctiva (that clear layer over the "white" of your eye)? These may affect how your lenses move when you blink or may cause the edge of a lens to lift off a little. Is there any corneal disease? This may also affect how a contact lens would fit. And most importantly, might a contact lens aggravate any of these conditions?

When you blink, your contact lens should move up and down to circulate your tears on both sides of the lens. Good lubrication is very important; it helps keep your eyes and lenses from drying out. It also helps wash any debris, such as dust or even stray mascara, from your lenses and generally keeps the lens surface cleaner.

With this in mind, your eye doctor will also examine your eyelids. If you have a very large *interpalpebral aperture* (or "wide eyes," a large distance between your upper and lower lids), it may be difficult to fit you with RGP lenses, and you may need soft lenses, which are larger. If your lashes tend to turn inward and rub on the lens, this can affect both your vision and your comfort. Lids that don't move smoothly across an eye can affect lens movement and lead to discomfort, dryness, and blurred vision. Similarly, eyelids that are very tight may move a lens *too much*, while lids that sag or are loose may not move a lens enough.

Next, your tears—their quantity and quality—will be inspected. Your "tear profile" also helps determine the kind of lens material you'll need. Some people are more comfortable with soft contacts that hold high amounts of water; others don't make enough tears to maintain a soft lens and would do better with an RGP lens that doesn't absorb tears.

Next, the Test Drive

Once you've been examined for your prescription, measurements have been taken, and it's been determined that your eyes are indeed healthy enough to tolerate contact lenses, your eye doctor will probably place "trial contact lenses" in your eyes—choosing lenses that best match your specific needs—to make sure all these measurements and assessments have been made correctly. What will they feel like? If you are trial fit with a soft lens, you'll probably have some awareness that there is a lens in your eye, but it should be fairly comfortable within a few minutes. RGP lenses at first usually feel much more like a foreign body in your eye, but you typically adjust within about 15–20 minutes. *Note:* If either type of lens feels painful—like you have several eyelashes in your eye—then there's something wrong, and the lens should be removed, rinsed, and tried again.

Some lens designs take longer to settle on the eye than others. For instance, lenses that are designed to correct astigmatism and bifocal contact lenses usually need to sit on your eye for 15–20 minutes before the fit can be assessed. Some soft-lens materials are more volatile than others; they dry more easily on the eye. These lenses should also be allowed a longer settling time, so that the doctor can see whether this material is likely to tighten on your eye as it dries.

Once the trial lens has had time to settle on your eye, the doctor can often double-check your prescription using handheld lenses. This generally gives you a sense of how well you should see with your "real" contacts (understandably, having your full prescription in a well-fitting contact lens should provide even *better* vision than what you'll see with the trial contact demonstration).

Where to Purchase Your Contact Lenses

Now it's time to get your "real" contacts. After all the fitting determinations have been made, your new lenses will be ordered (or set aside, if the doctor already has them in stock). If you're being fitted for contacts for the first time, or being refitted because of problems with a previous lens design, then you should buy your new lenses from your doctor or "lens fitter" (some states allow opticians to fit contact lenses). Purchasing a new set of contacts online is not like buying a book or even cosmetics. Once they are delivered, if you don't like them—or, worse, they don't feel right—who are you going to call? Pushing through the discomfort can lead to other problems.

Contact lens prescriptions are much more complex than eyeglass prescriptions. Eyeglass prescriptions just specify the power of the lens. Contact lens prescriptions specify a power, curvature, diameter, thickness, material, tint, and edge configuration. And we can't stress this point enough: because contacts are worn *on the eye*, they automatically become a health consideration for your eye. If you choose to shop elsewhere for your lenses, careful fitting and follow-up care must be done before your doctor can give you a written prescription and the go-ahead. Think about it: You can't reasonably expect your doctor to see you for an initial contact lens fitting and then write a prescription for you to get your first lenses elsewhere or online because if that prescription is not correct or the fit is just not right, as mentioned above, there can be serious complications for your eyes. Sometimes it takes a follow-up visit for the doctor to ascertain that a lens needs to be modified to improve your vision or comfort.

Wearing Your New Contact Lenses

Once you have your contacts, either the doctor or a trained contact lens technician will show you what to do: how to put the lenses in and take them out, plus how to clean and care for them. You'll also be given a wearing schedule—a plan that tells you how many hours at a time to leave your lenses in your eyes—so that you can get used to them gradually. (It's like starting an exercise program: you can't just start out at full throttle; you have to build up to it.)

Contacts do take a little getting used to. The cornea has to adjust to receiving slightly less oxygen from outside air (this doesn't harm your cornea in any way). Your tear-making system has to gear up production so that it can maintain a contact lens as well as your eye. *Therefore, follow the schedule faithfully*. If you try to wear your lenses all day right away, you'll likely find yourself right back in the doctor's office the next day with painful red eyes. (It won't make you feel any better to recognize that you should have known better.)

Before you leave the office with new lenses, your doctor will probably want to check the fit and also make sure that your vision is what it should be. (*Note:* Your vision may be slightly blurry at first; this is perfectly normal because your eyes are adapting.) If it's determined that the fit looks healthy and that your vision is adequate, then you'll be set up for your first follow-up visit. (Depending on your specific needs, that visit may be scheduled from 24 hours to 2 weeks after this one.)

The follow-up visit is very important. It means far more than just seeing that you're comfortable and making sure that your vision is okay. The big reason to go is this: *contact lens complications, if caught early, are almost always reversible*.

The doctor needs to check the integrity and health of your eye at every follow-up visit. A typical follow-up schedule for a first-time daily-lens wearer might be visits at 1 week, 1 month, and 6 months, and then a full examination at 1 year. Someone with extended-wear contacts might return within 24–48 hours, at 1 week, 1 month, 3 months, and 6 months, and then at 1 year for a full examination. If you seem particularly likely to develop complications with extended-wear lenses, your doctor may want to see you every 3 months—or more often, if necessary—even if you've been wearing lenses for years.

Taking Care of Your Contact Lenses

Solutions

To help launch you into the new world of contact lenses, your doctor or lens technician will probably give you a "starter kit": various bottles of solutions, or "lens care systems." These have been fully tested, under the watchful control of the FDA, to make sure that the solutions work well with each other and that they'll both clean and disinfect your lenses.

Whether you wear soft, hard, or RGP lenses, the basic steps are the same, and they're fairly simple: when you take the lens out of your eye overnight, it needs to be cleaned, rinsed, and stored in a disinfecting solution. Some of the soft-lens solution terms that you need to be familiar with are *multipurpose solutions*, *hydrogen peroxide–based systems*, *saline*, *daily* or *surfactant cleaners*, and *enzymatic protein removers*.

Multipurpose Solutions

In the 1990s, multipurpose solutions, featuring chemical disinfectants plus a cleaner, came on the market. The chemicals are designed to be mild enough to be tolerated directly in the eye, so the solution can be used for both rinsing the lenses and disinfecting them. These solutions are convenient, which is their biggest selling point. But any cleaner—no matter how mild—has the potential to cause eye irritation, and the more chemicals, the greater this potential. These systems, however, seem to cause problems only for about 5–15 percent of the people who use them, depending on the brand of solution.

Multipurpose solutions don't always make the most effective cleaners or disinfectants. Because the ingredients have to be mild enough to be tolerated by the eye, they don't always do as thorough a job of maintaining a contact lens over the long run as other solutions. However, they are an excellent means of lens care when lenses are made for frequent replacement, especially if you replace your lenses at least once a month. Often a frequent-replacement lens can be fully maintained with multipurpose solutions—which means you won't have to bother with weekly enzyme cleaners. (Because everyone's tear composition, environment, and wearing habits are unique, there are some people who can successfully maintain a pair of contacts for its typical 12- to 18-month life with *only* a multipurpose solution.)

Multipurpose solutions are the most common solutions used today by soft contact lens wearers. Although these solutions offer all-in-one lens care, which is very appealing for most of us who have busy lives and packed schedules, please beware of the risk of infection. Be sure to always use fresh solution every time you use multipurpose solutions to clean, rinse, disinfect, and store your soft lenses. Never use old solution in your case for any of these steps, and always clean your contact lens case completely after each storage. "Topping off" solution in your case by adding fresh solution to old solution or not completely cleaning the contact lens case where you store your lenses will increase your chance of an eye infection.

Hydrogen Peroxide–Based Systems

Peroxide oxidative disinfectants: A significant advance in chemical contact lens disinfectants came in the early 1980s, with the development of peroxide oxidative–based systems. These are based on a 3 percent hydrogen peroxide solution—the same strength as the hydrogen peroxide you can buy in the drugstore. Hydrogen peroxide is a great disinfectant and, unlike multipurpose solutions, is preservative-free, but it is slightly acidic; if you accidentally got some in your eyes, it would burn, would turn your eyes red, and may temporarily cloud your vision.

To avoid this, peroxide oxidative disinfection systems have a built-in "neutralization mechanism" that oxidizes hydrogen peroxide, breaking it down to its basic components, oxygen and water. The specifics vary, depending on your particular system. One company, for example, uses a catalytic disk, made of plastic that's been coated with a very thin layer of platinum. This disk is left overnight in the lens case, where it takes about 6 hours to break down the hydrogen peroxide. Another company's solution uses a tablet that contains catalase, an enzyme that also occurs naturally in the body and that breaks down hydrogen peroxide completely.

These peroxide oxidative–based systems are often recommended for people who have an allergy to ingredients in multipurpose solutions that causes redness and eye irritation. Often combined with a lens cleaner (see below), these systems clean, disinfect, and store your soft lenses preservative-free, without potentially residual eye-irritating chemicals. Even when—as inevitably happens in bathrooms full of similar-looking bottles of solutions—people put the hydrogen peroxide disinfectant directly into their eye, there's no harm done beyond some temporary stinging and redness. (If this should happen to you, immediately wash your eye with copious amounts of saline and call your doctor.)

Saline is a rinsing solution, made up of water and 0.9 percent salt—much like your tears. It does not disinfect your soft contact lenses and should only be used after cleaning and disinfecting with a care system like a multipurpose solution or hydrogen peroxide–based system. It is easy to confuse saline solution for multipurpose solution, so be sure to check the packaging when you are shopping for either.

Note: If you use tap water instead of saline, you will contaminate your lenses with bacteria and other microorganisms that can cause severe corneal infection. Saline can be preserved with a chemical to keep it sterile for a longer shelf life. (Some people are sensitive to these preservatives, however, and need to use an unpreserved solution.) *Any time you need to rinse a lens, or temporarily store a lens in a case, use saline*. Homemade saline, a contact lens solution that is no longer popular, was made with a recipe of salt tablets and distilled water and carried a high risk of infection because of the potential for growth of microorganisms in the water. One particularly dangerous microorganism commonly found in tap water, lake water, well water, and other water sources, acanthamoeba, can cause a potentially incurable eye infection. The Centers for Disease Control and Prevention recommends that contacts should never be rinsed or stored in water and should be removed before showering, swimming, or using a hot tub.

Never use tap water to clean a contact lens case. Instead, you should rinse your contact lens case with a multipurpose solution, wipe it dry with a tissue, and then place it upside down to air-dry. As an additional precaution to protect you from a contact lens–related eye infection, it is recommended that you replace your contact lens case at least every 3 months.

Daily or Surfactant Cleaner

Daily cleaners are to be used whenever a lens is left out overnight. (If you take your contacts out every day, you'll need to clean them every day.) If you have extended- or flexible-wear contacts, you'll need to use the daily cleaner whenever you choose not to sleep with your lenses in. This cleaner is a *surfactant*, or soap, that cleans debris and other filmy coatings off the lenses. Daily cleaners help disinfect by killing any bacteria that stick to the surface of your lens, and this in turn helps your overnight storage solution do a better job of killing the remaining bacteria.

Protein coatings that also accumulate on the lenses cling so tenaciously that a daily cleaner just isn't powerful enough to get rid of them. *Enzymatic protein removers* contain enzymes that "eat away" the proteins without damaging the lenses. (For some people, protein builds up so heavily that it's necessary to clean the lenses with enzymes several times a week.) This usually involves either soaking the lenses separately, in a solution of saline mixed with an enzyme tablet (which fizzes like a tiny Alka-Seltzer), or adding the enzyme tablet to the disinfection cycle.

Caring for Soft Contact Lenses

You should always wash your hands and dry them completely with a clean or disposable towel before inserting, removing, or caring for your contact lenses. Some people find that using "contact lens rewetting drops" prior to removing the lens can make removal easier; it can also decrease the risk of either tearing your lens or scratching your eye in the process.

Cleaning and Rinsing

Once you've removed the lens, place it in the palm of your hand concave side up—so that the lens forms a small bowl—and rinse with saline to keep it from drying out. Add several drops of cleaner and gently scrub the lens in your palm by rubbing your finger back and forth over it. Rubbing back and forth will help remove any protein or bacteria buildup on the surfaces of the lens. However, rubbing the lens in a circular motion can increase the chance of ripping or tearing it. After scrubbing the lens, move it to your other palm and rinse it thoroughly with saline. If you don't rinse thoroughly, the soap and coatings will reattach themselves to the lens surface, just as dish detergent does on dishes that are scrubbed but not rinsed. If you have a "multipurpose" lens solution, in which the cleaner is mixed with the rinsing solution (see below), you can scrub and rinse in the same palm. You should always clean your lenses before disinfecting them.

Disinfecting

Disinfection is the process of killing bacteria on the lens surface and within the lens itself. Wearing a sterile lens reduces your risk of developing an eye infection. (Because soft lenses are porous enough to allow water to pass through, bacteria can infiltrate them as well.) This partially explains the increased popularity of daily disposable soft lenses. Disinfection systems are described above, and you should consult with your eye doctor about the best system or combination of systems recommended specifically for you.

Caring for Hard and RGP Contact Lenses

The concepts in cleaning hard and RGP contact lenses are the same as for soft contact lenses, but the solutions used are very different.

The first step after removing your lenses is to clean each one thoroughly, on both sides, with an RGP cleaner in the palm of your hand. Use a finger that's softer than the index finger on the tip, such as your ring finger or pinkie, to reduce the risk of scratching your lens. If you try to clean an RGP lens between your thumb and forefinger, the lens will be more likely to warp because of the extreme pressure from your finger.

After thoroughly scrubbing your lens, rinse it with sterile saline. Be sure that the saline solution is not too cold (it might shatter the lens) or too hot (it might warp the lens), and—this is essential—

be sure to close the sink drain. You should not use tap water instead of saline to rinse the cleaner off your RGP lenses for various reasons, including an increased risk for infection. You should also never use tap water to insert a lens into your eye. And NEVER wet your contact with your saliva before placing it in your eye. This is like bathing your eye in a septic tank—enough said.

After cleaning and rinsing your lenses, soak them in a case filled with an RGP soaking solution. This solution has preservatives to disinfect the surface of your lenses and make them safe to wear the next day. In fact, you'll probably use the same bottle of soaking solution to wet your lenses when you insert them the next day. The solution refreshes the lens surface to make it more "wettable" with your tears; with every blink, your tears should coat the lens surface smoothly. When a lens is not "wettable," your tears will bead up on the lens surface, just like rainwater on a freshly waxed car. *Note:* Always clean your lenses at night. If you clean a lens in the morning after a night of soaking, you'll undo all the good that the soaking did. Your lens will lose its surface "wettability" until it's soaked again for a few more hours. (If you happen to be wearing your lens at the time, this means that the soaking will take place *in your eye* for the first few hours. As a result, until the lens is properly wettable again, it will feel very dry or seem foggy.)

In general, for any type of contact lens, always use fresh solutions for cleaning and disinfection. Empty out your lens case after you insert your lenses. Rinse the case with saline or a multipurpose contact lens cleaner, wipe it dry with a tissue, and let it air-dry to kill any bacteria remaining in the case. Bacteria need moisture to survive, so air-drying the case will ensure that you're placing your lenses in a sterile environment the next time you clean them. A solution that is reused will not be as effective and can possibly lead to an eye infection.

Replacing Your Contact Lenses

Maybe your prescription changed, or you lost or tore a lens, or your lenses just wore out. Maybe you want to keep a spare pair of lenses handy, in case of an emergency. Maybe you wear tinted lenses, and you want several different colors. Whatever the reason, it's inevitable: at some point, you will need to replace one or both lenses.

So, where will you go to do this? There used to be just one choice: your eye doctor. But these days there are so many alternatives that you can actually shop around. (Believe me, your doctor is well aware of this and as a result will probably offer competitive prices.) Although most doctors don't have the buying power of a major lens retailer or discount mail-order business, they can usually come close to the best prices you can find elsewhere.

Why should you buy from your doctor if you can save a few dollars and get the exact same lens from someplace else? With soft contacts the reason is simply that no contact lens manufacturer ever produces lenses with a zero defect rate, for either a doctor or a major retailer. Your doctor, however, will be better equipped to troubleshoot a contact lens problem than the retail outlet or mail-order house, as well as make sure that the problem is with the lens and not with your eye. It's not uncommon, for instance, to receive a lens that's marked correctly on the package but doesn't perform as it should. It might not be clear for your vision or fit like your old lens. Occasionally lenses are received with a small defect in the material itself that affects how you see or how the lens feels.

Some RGP lenses also turn out not to have been made to your doctor's specifications and must be returned to the lab. Also, every lab has its own manufacturing technique; these may vary slightly, and this could alter the fit of even a "brand-name" lens. Say your doctor orders your first lens from one lab, and you replace it with a lens from another lab. Although the lens material and specifications may be exactly the same, the lens still may not fit or perform exactly as your original lens did. Not only can this affect your vision and comfort, but it can also harm your eye. If you do shop around for your RGP lenses, make sure that your new lens supplier gets in touch with your doctor's lab for your exact specifications and tolerances.

The mail-order contact business is advertised everywhere. You've probably seen the commercials and read the ads, in which a spokesmodel suggests that you can now buy lenses using a convenient toll-free number for up to "60 percent less." Such ads may be misleading. To start with, no lens manufacturer has ever set a "manufacturer's suggested retail price" for contacts. If you look hard enough, you'll probably come across a greedy doctor somewhere who overcharges for lenses so exorbitantly that the mail-order company's price is indeed 60 percent less. But this is not the norm. And it's not the whole story, either. Some mail-order companies may want to sell you a "membership fee," which adds to the cost of each "discount" lens; they also charge a pretty penny for shipping and handling, and these hidden costs often make the lens price *equal to or more than* the price your doctor charges. Mail-order companies are in the business to sell lenses and make a profit. Most doctors, in contrast, sell lenses to their patients as a service and charge only a nominal markup to cover any office expenses associated with ordering lenses. Reputable eye doctors make their living caring for eyes, not selling lenses. And if you like the convenience of ordering your lenses online, most eye doctors now offer this option too, along with their professional care of your eyes.

Complications: When Something's Not Right with Your Contact Lenses

Dry Eyes

This is an extremely common problem; in fact, dry eyes are probably the largest impediment to successful contact lens wear. Unfortunately, as the eye gets older, it makes fewer tears. In addition, medications such as hormonal supplements, diuretics, antidepressants, and isotretinoins for acne can make the eyes dry. Many people who have worn contact lenses for years, with no problems at all, suddenly find themselves unable to tolerate their lenses.

However, the key may simply be finding the right lens material for your eyes. It may take trying several different lens designs and materials before you and your doctor can find the least-drying contact lens for your eyes.

Tears are more complicated than you might imagine (see chapter 14). They've got three major layers, for one thing. The innermost, called the *mucin layer*, is produced by goblet cells on the conjunctiva. (For more on the eye's anatomy, see chapter 1.) Mucin is viscous; it enables tears to cover the eye more evenly. The huge middle layer (which takes up about 90 percent of each tear), mostly water, is produced by the lacrimal glands that sit just above and outside your eyes. Outermost is an oily layer, produced by a row of Meibomian glands along the margin of each eyelid; the coat of oil helps keep tears from evaporating too quickly.

A soft contact lens contains water, and so soft contact lenses must absorb tears in order to stay soft. After the lenses have been in your eyes for about 15 minutes, their water content is actually made up of your tears. If your eyes are dry because of poor tear *quality*—that is, if you have plenty of tears, but they lack mucins or oils—then a *higher-water-containing* lens will probably keep more tears on your eyes and, as a result, be less drying. If, however, your eyes are dry because of poor tear *quantity*—if, in other words, your tears are perfectly fine, but there just aren't enough of them to go around—then a *lower-water-containing* lens will usually cause less dryness because it won't have to absorb as much tear volume to maintain itself. Finally, if you have both poor-quality and poor-quantity tears, you'll most likely have problems wearing soft contacts at all—but RGP materials may work well for you.

Corneal Edema

As I've discussed in previous chapters, we see because light passes through the "window" of the cornea and focuses on the retina. The innermost portion of the cornea is constantly in contact with the aqueous humor, the fluid within the eye, but this fluid is never allowed to build up. Tiny efficient "pumps" continuously force it out, to keep the cornea clear (see chapter 12). These pumps run on oxygen; most of it comes from the environment, but extra oxygen also comes from blood vessels around the cornea and under the eyelid.

A contact lens has the potential to decrease the supply of oxygen to the cornea, and this can cause the pump mechanism to slow down. In turn, fluid begins to seep into the cornea—a swelling called *edema*—causing it to become cloudy. This can happen if a lens is too tight, if it's too thick, or if it's worn too long.

Signs of trouble: You'll probably first notice symptoms when you take out your contacts and put on your glasses: your vision will look hazy. If this haziness disappears within the first 10–15 minutes, the edema is probably not very significant. However, the haziness can persist for days or even months, depending on how much edema is present. If the edema is left untreated, small water bubbles will eventually form in the cornea. Your cornea is like skin, in that the surface layer constantly replenishes itself; cells formed below the surface rise and eventually slough off. When edema is present, these bubbles float, along with the rest of the cells, right to the top.

When they reach the surface of the cornea, they burst, leaving tiny defects that act and feel like abrasions. If you accumulate enough of these abrasions, in addition to the hazy vision you will have red and painful eyes.

Treatment: Your doctor can prescribe drops or ointments to reduce the edema and heal the abrasions. Corneal edema almost always resolves with treatment and discontinuing wear of the lens that's causing the trouble.

Corneal Neovascularization

Neovascularization is the growth of new blood vessels. As discussed above, the cornea needs oxygen to maintain its clarity; oxygen also supports a protective barrier that keeps blood vessels out of the cornea. If the cornea is oxygen starved, blood vessels invite themselves in, taking upon themselves the matter of "turning up" the oxygen flow. Unfortunately, these vessels also scar the cornea.

Treatment: If this condition is caught early, neovascularization can be reversed simply by removing the offending contacts and either switching to a better-fitting, more oxygen-permeable lens or discontinuing lens wear for a time. But when these blood vessels spread unchecked like ivy, right into the center of the cornea, they can cause big trouble: a significant loss in vision that can be treated only by corneal transplant.

Because there really aren't any early warning signs or symptoms of corneal neovascularization—that is, until it's too late to reverse—routine examinations with your doctor are essential, so that your doctor can make sure your cornea is as healthy as it should be.

Giant Papillary Conjunctivitis

Giant papillary conjunctivitis (GPC) is an allergy that's caused by an autoimmune reaction to your own protein coatings, the ones that build up on poorly cleaned contact lenses. Who's at risk? You are, if you don't use a protein cleaner with your soft lenses, or if you don't do a very good job cleaning any type of contact lens.

On any typical day of wearing your contacts, your upper lid travels about 300 yards—the equivalent of three football fields—over the surface of your lens. The upper lid therefore has the most interaction with protein coatings and is the best indicator of GPC: its inside surface becomes swollen and red and produces large amounts of mucins that coat your contact lens with a film that clouds your vision when the contacts are worn.

Signs of trouble: One common early symptom is an itch that gets worse when you remove the lens (when your upper lid comes in direct contact with your cornea). Also, as more mucins are produced, the lenses begin to appear foggy while you're wearing them. Sometimes—because with each blink your swollen upper lids grab the sticky, coated contact lenses more vigorously than usual—they even slide off the center of your cornea. Lenses also tend to wear out much more quickly than normal with GPC. Many lenses designed to last a year will wear out in as little as 1–2 months. Often someone with this problem will replace many lenses in a short period of time before finally going to the eye doctor and having the problem checked out.

Treatment for GPC has varied over the years, but a common remedy is to stop wearing contacts for at least 2 weeks, to give the lids a chance to recover. (Often this alone is enough to treat the problem, without the need for any additional medications.) If your GPC is severe, or if you still have symptoms after you stop wearing your lenses, your doctor may prescribe anti-allergy and/or anti-inflammatory eye drops. Over-the-counter artificial tear supplements can also help.

Because GPC is an allergy, if you start using the same contact lenses after this 2-week breather, your symptoms will probably come back; the proteins will accumulate again and produce a new allergic reaction. Therefore, if you want to keep wearing contacts once the GPC has resolved, you'll most likely need to switch to another kind of lens. In the past, someone with GPC either moved to a more "deposit-resistant" soft contact lens—and a much more rigorous cleaning regimen, including more frequent enzyme cleaning—or switched to a gas-permeable lens. But in recent years it's been found that wearing disposable or frequent-replacement contact lenses also reduces the problem dramatically. Because there's so little buildup of protein on a new contact lens, replacing your lenses daily, or at least every 2 weeks, keeps the lenses free enough of proteins that GPC usually doesn't return.

Infections and Corneal Ulcers

Everybody gets eye infections, whether we wear contacts or not. We all have bacteria around our eyes; most of the time our tears keep them in check, but occasionally those bacteria can take over. A well-fitting, well-tended contact lens does not cause eye infections, but it can make any infection worse; the warm, moist space between the lens and your cornea can act as an incubator for bacteria and allow them to flourish.

A corneal ulcer is a severe eye infection. It can be extremely painful—and potentially disastrous when it comes to your sight. An ulcer can permanently scar your cornea and cloud your vision if that scar is over your pupil.

Who's at risk? Mostly it's people who often sleep with their contacts in. A common scenario is this: Say you have a small corneal abrasion, from debris that got trapped under your lens. If you take out your lens for the night, the abrasion will have a chance to heal, and you'll wake up with no ill effects. But if you sleep with the contact lens in, the bacteria that grow between the lens and your eye can work their way into the abrasion and cause a corneal infection.

If you suspect that you have an infection—your eye is red, with a discharge, or is uncomfortable in any way or is sensitive to light—remove your lens immediately and call your eye doctor. Getting medical attention in time usually means that your eye will heal completely and that you can start wearing your contacts again as soon as your eye recovers. If your eye doctor feels that antibiotic eye drops will be needed to eradicate your corneal ulcer infection, the sooner you start these antibiotics, the better.

If your infection turns out to be bacterial, then your usual methods of cleaning and disinfecting your contacts will probably be enough to save your lenses and enable you to wear them again. But if your infection was caused by a virus, disinfection alone may not be enough to remove the contamination, and the lens may need to be replaced.

Limbal Stem Cell Dysfunction

The *limbus* is the juncture of the conjunctiva and the cornea, at the edge of the white and the clear parts of the front of the eye. At the limbus are stem cells—cells that can change as needed and renew themselves—that work to continuously populate the clear "skin" cells of the cornea. If the limbus is damaged or dysfunctional, then irregular limbal stem cells can start to populate the cornea, leading to decreased vision and possibly scarring. Although upward of 9 or 10 percent of soft contact lens wearers can develop some mild limbal stem cell dysfunction (the contact lens constantly rubs on the limbus), it usually does not cause long-term problems. However, it is important to have regular checks with your doctor to ensure that you are not developing this problem. If caught early, it can usually be reversed by simply stopping contact lens use for a while. Over the long term, a change in the type of contact lens may be necessary.

Tight-Lens Syndrome

Tight shoes can cause debilitating foot problems. A too-tight shirt collar can hamper your breathing and produce symptoms that mimic a heart attack. Well, your eye doesn't respond well to tight-fitting garments, either. When a soft contact lens is too tight, it can cause problems ranging from mild discomfort to serious, vision-threatening complications. The trouble is that a tight lens doesn't make room for your tears to flow underneath the lens and refresh the cornea. Instead, tears tend to pool under the lens and stagnate—like a fetid pond, a perfect breeding ground for nasty bacteria. As the bacteria proliferate, they ooze toxins that create cloudy patches in your cornea, called *corneal infiltrates*, and cause infections.

A soft lens that's too tight also smothers the cornea, leaving it constantly oxygen starved. The chronic lack of oxygen (as discussed above) in turn makes the cornea more susceptible to edema (swelling) and neovascularization (the growth of new blood vessels within the cornea).

Tight-lens syndrome can happen with any kind of soft contact lens—even disposable lenses that are thrown away every day. If the lenses don't fit properly, it doesn't matter how long you leave them in or whether you take them out every night; you're still harming your eye.

Signs of trouble: Warning symptoms include foggy vision, fluctuating vision (your vision gets better or worse with a blink), dryness, irritation, and redness. Often, redness is noticeable around the entire cornea, but it can appear in isolated patches as well. If the edges of your lens bear down on blood vessels running through your conjunctiva, this can cause tiny hemorrhages to appear around the edges of your contacts. Also, you can almost always see a distinct stamp of the lens left on the eye after you take out the lens, just as you can trace the outline of painful shoes after you take them off your feet. (However, some people can see such an impression even if their lenses fit appropriately.)

An RGP lens that's too tight can cause similar symptoms, but because it doesn't cover the entire cornea, as a soft lens does, the symptoms can take longer to express themselves. A tight RGP lens can actually stick to your cornea, making it difficult to remove, and will probably leave a contact-shaped indentation in the cornea afterward. If, after you remove your RGP lens, your vision is foggy and distorted with your glasses—and it doesn't return to normal within 10–15 minutes after you take out your contacts—your lens may be too tight.

A tight-fitting lens doesn't necessarily mean that your lens fitter did a poor job of fitting your eye. Contact lenses can tighten on their own after they're worn for a few hours, especially if your eyes are dry. Thus, it's important that you have your lenses in for a few hours before you return for any follow-up visit, so that your eye doctor can get an accurate idea of how your contact lenses really fit. (Of course, if your lenses are too uncomfortable to wear for even a few hours, then don't harm yourself just to demonstrate your level of discomfort.)

Reactions to Contact Lens Solutions

First, read the label. No matter how a solution is packaged, before you buy it, make sure it doesn't contain any chemical or preservative that you've reacted to before. Many manufacturers label their solutions as being "for sensitive eyes," but even some of these contain preservatives—milder, less sensitizing ones, but preservatives all the same—and you may still react to them. Thus, if you need an "unpreserved" solution, make sure the bottle is labeled that way.

Signs of trouble: Sensitivities to preservatives can range from stinging, burning, and redness to full-blown allergic reactions that can cause tremendous itching and swelling and may even harm the cornea. These reactions occasionally require treatment but almost always go away when use of that preservative is discontinued.

Two preservatives known to cause problems for many people are thimerosal and chlorhexidine. Thimerosal produces allergic reactions in more than 40 percent of the people who use it; these reactions can develop even after years of use. Chlorhexidine can be toxic to the cornea and can cause significant redness, burning, and irritation. Polyaminopropyl biguanide (also known as Dymed), a milder version of chlorhexidine introduced in the early 1990s, has decreased this problem tremendously. Still, some people have reactions to this chemical as well (symptoms are similar to those caused by chlorhexidine).

You can avoid some major eye reactions simply by making sure you're putting the right solution in your eye. Mistakes happen more often than you might think, and it's no laughing matter. Accidentally putting in contact lens cleaner instead of the rewetting drops you thought you had picked up can cause severe chemical burns, painful red eyes, and cloudy vision that lasts for days or even weeks. Some cleaners contain abrasives that will scratch your cornea; others contain alcohol, which can strip off the surface of your cornea. Occasionally someone mistakes disinfectant for saline, rinses a lens with a disinfectant, and inserts it. This can also cause a significant chemical burn.

Treatment for all of these reactions always starts with removing the offending chemical or preservative. You'll have to stop wearing your lenses until your eye heals completely, rid your old lenses of every last trace of the chemicals, or replace your lenses altogether. If your symptoms are severe enough, you may also be prescribed a medication. Because your symptoms can be vague, when you seek treatment make a list of every solution you've been using, or take your solutions along with you, to help your doctor or lens fitter pinpoint the problem.

Of course, one big remedy for solution sensitivities is disposable contact lenses. If you throw them away after every use, you'll never have to worry about reactions caused by cleaners and disinfectants.

Torn or Damaged Contacts

A torn or damaged lens can irritate your eye, causing symptoms of redness, pain, discharge, watering, and blurred or distorted vision that may not clear up right away when you take out your lens. It may also injure your cornea—in which case you might still feel like the lens is in your eye even when it's not—or even lead to infection. So if you have persistent redness, pain, or discharge, see your doctor and get your eyes (and contacts) checked.

No matter whether your lens is hard or soft, if it's torn, warped, broken, or simply worn out, it will have to be replaced. Once they're damaged, lenses can't be fixed.

Itching, Burning, and Redness

It's simple: itching, burning, and redness all indicate that there is something wrong with either your contact lenses or your eyes. If the symptoms go away when you take out your lens, this could indicate a problem with the fit of the lens, the lens itself, or the solutions that you're using, and your doctor or lens fitter should scrutinize your lens-wearing and lens-cleaning habits to figure out what needs to be changed. If your symptoms persist after you remove your lenses, this could suggest an infection, allergic reaction, or abrasion. In any event, you should seek medical attention.

Problems with Extended-Wear Lenses

Extended wear (wearing a contact lens overnight) magnifies the risk of any of the complications I've discussed above. Think about it: The lens is in your eye 24 hours a day. Your eye never gets a break; there's no downtime. This can cause serious eye infections and complications from lack of oxygen to the cornea.

We're not all cut out for extended-wear contacts. Some of us require more oxygen in our eyes, just as some of us need more sleep to refresh us or more heat to feel comfortable in the winter. Maybe you can do well with extended wear. Or maybe your eyes have such a high demand for oxygen that you need an extended-wear lens just for daily wear.

In any event, you can dramatically reduce your risk of extended-wear complications by just using a little common sense. The most important thing to do, before you decide to sleep with your contacts in, is to take a good look at your eyes. If they're red, irritated, or significantly dry before bedtime, then the answer should be pretty obvious: Don't sleep with your lenses. Take them out. Give your eyes a breather.

If you wake up with any symptoms of redness, persistent blurred vision, discomfort, discharge, or pain, the answer should be equally clear: Take out your lenses immediately. If the symptoms go away, see your eye doctor or lens fitter to make sure the lens fits properly. If your symptoms don't go away, again, seek medical attention promptly. Don't wait for a problem to become serious, and please don't potentially make your problem more serious by continuing to wear your lens—keep it out until you are examined.

Some Questions You May Have about Contact Lenses

Can I wear contact lenses if I have astigmatism?

Sure. Statistically, about 40 percent of potential contact lens wearers could benefit from correcting astigmatism with contact lenses. If you've read chapter 2, you know that astigmatism is considered a "refractive error," like nearsightedness or farsightedness. In a perfect eye, light enters through the cornea at the front of the eye and is focused to a precise point on the retina at the back of the eye. But with astigmatism, this focusing is skewed. Instead of being focused to a sharp *point* of light onto the retina, the light gets stretched out almost into a *line*; as a result, your view of the world is stretched in one direction and blurred. Eye doctors compensate for your astigmatism by prescribing lenses that have the *opposite* curvature of your eye; these lenses counterbalance the way your eyes focus light. *Note:* Astigmatism does not reflect the health of your eye and should not be considered an impediment to contact lens wear.

The original hard lenses could correct mild to moderate degrees of astigmatism, but they weren't very helpful for people with more significant astigmatism. Today highly precise RGP lenses, made by computer-driven lathes, can correct any degree of astigmatism.

The early soft contacts couldn't do much to correct astigmatism. By 1980, as technology improved, several soft-lens designs incorporated corrections for astigmatism. And today many lens designs do a fine job of correcting astigmatism. However, there are still some practitioners out there who tell patients that they can't wear contact lenses because they have astigmatism. This is not true. If you've been told that astigmatism prevents you from wearing contact lenses, take your business to a more enlightened establishment.

Am I too old to wear contact lenses?

Not unless you think you are. There's no age limit on wearing contacts; plenty of patients enjoy their contact lenses well into their nineties. Actually, the only real limiting factor is the state of your general health. Arthritis can make it more difficult to insert and remove lenses, for instance. Dry eyes are more prevalent as we get older and can make lens wearing difficult—but certainly not impossible. Certain diseases (thyroid disease, collagen vascular disease, corneal dystrophies) and some medications (hormone replacement therapy and diuretics, for example) can cause problems for contact lens wear. But by all means, if you're interested in contacts, talk to your eye doctor.

How can I see to clean my contact lenses more easily, once they're removed?

Place your lenses in a temporary case, put on your glasses, and then clean your contacts.

What happens if I leave my contact lenses out of their case and they dry out?

A soft contact lens will shrink considerably when it gets dry; it will also become brittle and fragile. But if you place the lens—gently—in a case with some saline, the lens will immediately start soaking up moisture like a sponge. It will probably take a good soak of at least 30–60 minutes before the lens is fully hydrated. Then, just clean and disinfect the lens again before you put it in.

With RGP contacts, drying causes no damage to the lens itself. However, these lenses have a surface treatment to make the lens surface more "wettable" (which helps your tears coat the lens surface evenly every time you blink). When an RGP lens gets dried out, this temporarily interferes with the "wettability," and you'll need to soak the lens for about 4 hours to replenish it. If you try to insert the dried-out lens right away, before it's had time to recover, it will "soak" anyway—in your eye—and will feel dry and uncomfortable for those 4 hours until it's finally refreshed.

How long do contact lenses last?

Generally, soft contacts that are neither disposable nor frequent-replacement lenses last 12–18 months. This is based on an average wearing schedule of about 12–14 hours per day, 7 days a week. But if you wear your lenses longer—18 hours a day, for example—they might wear out sooner, in as little as 9–12 months. Even if you take the most meticulous care imaginable, the material will still wear out. Several things contribute to this. Just the act of rubbing your lenses itself tends to break down the lens surface over time. (However, if you *don't* scrub your lenses, they'll wear out even sooner because the coatings that accumulate will eventually form permanent, impossible-to-clean deposits on the lenses.) Every time you blink, you wear down the lens a little. Eventually the surface of the lens begins to erode and become dimpled, like the surface of a golf ball. Deposits start to form in those dimples, and they bind to the lens so tenaciously that they can't be cleaned off.

The life span of disposable lenses is based on your wearing schedule; they should be replaced every 1–30 days. By the end of their cycle, nearly all of these lenses show signs of wear, so even if your lenses *feel* fine, they should be replaced. If you wait until the lenses hurt before replacing them, you may wind up with one or more of the problems these types of lenses were designed to avoid (such as GPC and corneal oxygen deprivation).

Because of our increased awareness of infection with reusable contact lenses, and due to advances in our manufacturing technology, most contact lens wearers today use monthly, biweekly (every 2 weeks), or daily disposal contacts. The last in particular have been demonstrated to have a lower risk of eye infections and have become especially popular among people with dry eyes and allergies because of their increased comfort.

For RGP lenses, their life span depends very much on how you take care of them. If, with all good intentions, you rigorously clean your lenses between your thumb and forefinger, your lenses may actually warp within a few cleanings. If you're a careful cleaner (see above for tips on cleaning), these lenses can last for years. Your doctor or lens technician can even prolong the life of your lenses by polishing them to remove any fine surface scratches that may accumulate over time. Polishing can also remove any rough spots on the lens edge, which can cause irritation.

There has been some research to support the theory that RGP lenses eventually wear out like a soft lens; electron micrograph photos have shown tiny surface disruptions on aging RGP lenses. However, because these photos show a lens magnified up to one million times, there's some dispute as to whether these irregularities are clinically significant, and whether they actually reduce the life of your lenses.

What are those white bumps that I see on my soft contact lenses?

They're the deposits that inevitably form on a worn-out lens, a conglomeration of mucins, oils, debris, and protein. Every time you blink, you contribute a thin layer to these evolving deposits, like an oyster working on a pearl. Eventually the deposits get larger and larger, resulting in the sizable white bump you're seeing. And this means it's time to replace the lens.

How do I care for my contact lenses if I don't wear them every day?

If you use a chemical disinfection system with your soft lenses, such solutions can usually maintain a lens for long-term storage of up to 2 weeks, depending on the product. Hydrogen peroxide solutions can maintain your soft contacts for much longer storage periods—so long as there is nothing to neutralize the hydrogen peroxide (which means that you'd need to remove the neutralization mechanism before storing your lenses).

For soft-lens wearers, 1-day disposable lenses address this dilemma nicely. You can wear the lens once and throw it away, storing the rest of your lenses in a cool, dry place until you're ready for them.

With RGP lenses, most soaking solutions are fine for storage of up to 1–2 weeks. If you're storing an old pair to keep as an emergency backup for your current lenses, you'll want to store the lenses dry after a thorough cleaning, to ensure that the lenses don't get contaminated by sitting around in old solution. Be sure to soak your lenses for at least 4 hours before again trying to wear them.

If I wear bifocal eyeglasses, can I still wear contact lenses?

Absolutely. The primary problem here is that you're dealing with at least two different eyeglass prescriptions: your distance prescription doesn't work for reading, and you can't see far away with your reading prescription. Also, some people who wear bifocals need intermediate-distance vision (generally from 2 to 4 feet) prescriptions. (In glasses, this is handled either with progressive addition lenses or with trifocals. For more on this, see chapter 5.)

Any decision that you and your doctor or lens specialist make together will be a compromise; what you need to decide is whether that compromise is more suitable to your needs than the compromise of wearing glasses alone.

A good option—the one that probably provides the best vision—is to use contact lenses for your distance vision and to wear reading glasses over the contact lenses. If you have demanding visual needs, or if your work requires some eye protection at a close distance—if you're a dentist or auto mechanic, for instance—then this can be an excellent way to go. If you need trifocals, you can have your reading glasses made in a format that addresses both intermediate and close-up visual needs. (Of course, the compromise here is that you'll still need to put on glasses for part of the day.)

Another option sounds like a special effect in the movies. It's called *monovision*: using one eye for distance vision and the other for seeing close-up (generally, the distance contact goes in your dominant eye). This is not as taxing as it sounds, and it can be achieved with any kind of contact lens. Even if, for instance, you need custom-made lenses to correct an unusual astigmatism, the lenses can still be modified so that one eye sees distance and the other reads. (A prerequisite for monovision is that both of your eyes must have excellent vision, and each must work properly by itself.) Monovision is also a very popular option at cataract surgery when deciding what intraocular implant lens power to insert in each eye to increase the likelihood that a person will be less dependent on glasses after the operation.

Studies have shown that monovision is safe, in that it doesn't affect how you use your eyes together. Even people who have worn monovision contacts for years still have good *binocular* vision (using both eyes together) when they wear glasses. One caveat with monovision is that not everyone is a good candidate. Because monovision allows the two eyes to view two different distances, it causes the eyes not to work together as a team, or "dissociates" the two eyes. Therefore, a thorough evaluation of your eye muscles and of the natural resting position of your eyes should be done in order to ensure that you are a good candidate for monovision. Otherwise, if you are someone who has some degree of misalignment between your eyes, monovision can make it worse or lead to the feeling of having crossed eyes or double vision. Another concern of many patients who wear monovision contacts is a loss of depth perception. At a long distance, you perceive depth based on information that can be provided to either eye and is not dependent on how you use your eyes together. For example, when you see a car parked in front of a building, you know that the building is farther away than the car. You can see this with either eye by itself, just the same as you would with both eyes together; you don't see the car as being *in* the building when you close one eye. Other clues to depth are relative differences in shadowing, shading, coloring, and contrast.

A major advantage to monovision is that you can view up-close objects from any angle. Say you go to the grocery store and you're wearing bifocal glasses. You want to read a product label that's at or above eye level. Well, you probably can't without first taking the product off the shelf and holding it at the appropriate angle. With monovision, though, you just look up and read the label, just as you did before you had bifocals.

The compromise with monovision is that your vision is generally not as sharp as it is with your glasses. You lose what's referred to as *binocular enhancement*, the enhanced visual image you see when both eyes work together. For the most part this is a concern only under specific circumstances, such as driving at night—in which case you can resolve the problem by using driving glasses. (You wear them over your monovision contacts to offset the near-vision contact lens and bring that eye back to a distance prescription. The other side contains a nonprescription lens.)

Also, with monovision there can be a compromise to intermediate vision, if you're accustomed to wearing trifocals or progressive addition bifocals. Some people resolve this by replacing the near contact lens with a progressive addition bifocal contact lens that will provide good vision close-up but will extend your working distance to allow for good intermediate vision.

The last option is *bifocal or multifocal contact lenses* designed for people with presbyopia (the normal age-related decline in intermediate and near vision) to see clearly with contact lenses at a range of distances, from far to near. Bifocal or multifocal contact lenses come in both soft and RGP materials and can also be made of a hybrid of both lens materials in one lens. Whereas both contacts address the vision challenges created by presbyopia, bifocal contact lenses have two distinct prescriptions in the same lens, whereas multifocal contacts have a range of powers in each lens, similar to progressive eyeglass lenses (see chapter 5). Bifocal and multifocal contact lens designs address presbyopia in different ways but fall into two basic groups: simultaneous-vision designs and translating-vision or segmented designs.

A *simultaneous-vision lens* has both distance and near optics that focus light into the eye at the same time: when you're looking at a distance, your brain learns to ignore visual information from the up-close part of the contact lens, and vice versa. Simultaneous-vision designs are accomplished either by creating different distance and near zones within the lens or by varying the power of the lens from the center to the edge, either through concentric power rings in the lens or through a more gradual change in contact lens power from far to near with no visible lines in the lenses. (This is akin to the way progressive bifocal eyeglasses vary the power from top to bottom.) Many of these lens designs provide 20/20 vision, but the *quality* of that vision may be reduced from the loss of contrast, and the things you see might not seem sharp or well-defined. One advantage, as with monovision contacts, is that you can read up-close objects at any angle. The compromise is that although you use both eyes together, the vision is still not always as good as it is with your glasses.

A *translating-vision* or *segmented bifocal contact lens* works like traditional bifocal glasses: there's a tiny line that separates the distance prescription at the top from the reading segment at the bottom. (A built-in stabilization system makes sure that the lens always sits the right way in your eye so that the distance part is always at the top.) When you glance down, the lens should move, or "translate," up, placing the reading area in front of your pupil so that you can see up close. Soft translating bifocal contact lenses tend not to work well because they generally can't move enough to bring the near optics where you want them, in front of your pupil.

The best of these translating-vision designs are made with RGP materials; they can provide excellent vision that can match or even surpass your glasses. However, they also have the same limitations as standard bifocal glasses. When you glance down at the floor, it's blurry; to see anything clearly up close, you have to hold the object down at a certain angle, just as you would with glasses. So if you work at a computer and your monitor sits at eye level, for example, you won't be able to use the near optics of your contact lens to see the computer monitor. If you can't adjust your work area, then this lens design might prove more of a hassle than a help.

Why does my contact lens just stick to my finger whenever I try to put it in? Why won't it stay on my eye?

No matter what kind of contact lens you have, when you insert it, the inside surface—the side that rests on your eye—should be wet enough to "pull" the lens onto your eye. This works because fluid is naturally drawn to fluid; a wet lens naturally wants to stick to your wet eye. But if your finger is too wet, there's too much "fluid attraction," and the lens sticks to your finger instead of your eye.

When you're putting in soft contacts, make sure that only the *bottom* of the lens (not the edge) is resting on your finger. Next, open your eyelids wide enough to provide a clear shot at your eye, so that the lens won't be waylaid by your lashes. Don't poke your eye, and don't press so hard that you just push the lens back onto your finger. Simply get the lens within striking distance—close enough that it can "work off" of your finger and onto your eye. If you can't get the hang of it, go back to your eye doctor or lens fitter for a refresher lesson. After all, the contact can't help you much if it stays on your finger.

How can I tell if my contact lens is inside out?

It's *almost* impossible to turn an RGP lens inside out. However, it can be done. You'll know something's not right because your lens will look almost flat, and if you can put it on your eye, it probably won't stay on. If you manage to turn the lens right side out again, it will most likely be too warped to wear, and you'll need to get a new one.

If you have soft contacts and aren't sure if a lens is inside out, look at the lens, invert it, and look at it again. (Often it's difficult to tell by just looking at the lens one way; by comparing both views, you'll have a more accurate assessment.) If the lens is as it should be, right side out, the edges will point up and the lens will form a bowl. If it's inside out, the edges will point more out to the sides than up to the skies, and the lens will appear "flared," like a champagne glass.

A second way to tell is to place the lens in the crease of your palm and gently cup your hand so that it starts to fold the lens. If the edges roll into each other, like a taco shell or clam shell, the lens is right side out. If the edges start to fold *back*, away from the center, the lens is inside out.

If you place an inside-out soft contact lens on your eye, your vision might still be clear. However, you will feel uncomfortable, and you'll probably feel that the lens is going to fall out. If you have this sensation, try removing the lens, inverting it, rinsing with saline, and reinserting it. If the lens feels fine, you've solved the problem. If it feels worse, it's likely that you had inserted the lens right side out the first time, and that either you had some debris on the lens that altered the fit or there's a nick or tear in the lens. If you can't get it to fit so that it feels right, let your eye doctor or lens fitter take a look at it.

Can I wear my contact lenses if I have hay fever? Can I use allergy eye drops with my contact lenses?

It depends on your symptoms. If hay fever for you means irritated, dry, and itchy eyes, then you might not be able to wear contact lenses during allergy season; the lenses might make your eyes feel drier and increase your itching. Also, some allergy medications can make the problem worse by drying out your eyes even more, making contact lenses uncomfortable.

However, if you get relief from one of the many allergy eye drops available, you might still be able to wear your contact lenses during allergy season. *Note:* These drops should not be inserted while your contact lenses are in your eyes. Soft contacts, especially, will soak up the drops and keep the medication and preservatives concentrated on your eye much longer than is safe, and this may harm the cornea. If you use the drops 10–15 minutes before inserting your contacts, the drop should have provided its relief and dissipated, and your lenses should be safe to insert.

How can I tell if my contact lens is worn out?

There is not one specific symptom that will tell you that your lenses are worn out. The most common symptom is that your lenses will feel drier than usual, and you may not be able to wear them comfortably for as long as you used to. Often the dryness is so significant that there's no relief, even with rewetting drops.

Quantity of vision—how many letters you can read on a chart—is occasionally poorer with a worn-out lens, but usually it's the *quality* of vision that people notice first. Worn-out lenses provide less contrast; nothing looks crisp.

Many people find that they need to increase their use of cleaners when the lenses are wearing out. For instance, you might need to remove the lens in the middle of the day and clean it with your daily cleaner. Regular enzyme cleaning won't seem to have the same benefit when a lens is worn out, and you might need to increase the frequency of this cleaning regimen as well.

For RGP lenses the symptoms may be similar, but often the lens can be polished and effectively refurbished. A soft contact lens that is worn out should be replaced.

If you're not sure whether your lens is worn out, see your doctor or lens fitter. Unfortunately, many people simply replace their lenses without having anyone take a look at their eyes—which is fine, unless there's another problem that needs to be addressed. Say, for example, you have a contact lens allergy (not hay fever, but a reaction to your contacts; see above). Your symptoms may be similar to those you'll have with a worn-out lens, and not treating the symptoms may be harmful—and cause you to throw out a good pair of lenses because you thought they were worn out.

Why do I have a red streak on my cheek after I insert my contact lenses?

Most likely you're sensitive to the preservative sorbic acid (also called potassium sorbate). This is the preservative that has traditionally been used in solutions labeled "for sensitive eyes," and while it *is* much less sensitizing than any of its predecessors, sorbic acid still causes reactions in as many as 5 percent of those who use it. But even if you are sensitive to this preservative, you still may not have any symptoms in your eyes, or you may experience only mild stinging. You can test yourself by placing several drops of a contact lens solution containing sorbic acid on the back of your hand and checking for any skin redness.

Why have my soft contact lenses discolored?

Soft contacts can discolor when they wear out. However, the culprit is usually a preservative in your contact lens solution. If you tend not to stick with one particular brand but buy "whatever's on special," and as a consequence mix various solutions containing different preservatives, these preservatives can interact. This can discolor your lenses, usually turning them yellow, red, brown, green, or gray.

Can hairspray "gunk up" my contact lenses?

Yes. Over time the sticky protein in hairspray can indeed build up on contact lenses and shorten their life span. So try not to use hairspray after inserting your contacts (or even to insert them in the same room after using hairspray because the stuff can linger in the air for several minutes). Similarly, it's a good idea to use water-based mascara, hypoallergenic or "sensitive-eye" makeup remover, oil-free moisturizers, and soaps that aren't lanolin based (such as Neutrogena in the bar form).

Can my contact lens get lost behind my eye?

No. Your eye is very well sealed off by several safeguards, including your sclera (the "white" of your eye), conjunctiva (the clear layer over the sclera), and eyelids. There is one, smooth, continuous flow of tissue from the margin of your lower eyelid, across the eye, and to the margin of the upper eyelid (see chapter 1). If your contact lens goes where it's not supposed to in your eye—above your cornea, for instance—it will just stay there, under your eyelid, until you get it out.

What is orthokeratology?

This is a method of fitting a rigid contact lens to the eye that is flatter than the curvature of your cornea. The lens effectively flattens the eye while you wear it; then, when the lens is removed, the cornea remains flattened. (Because the lens is curved less than the cornea, it won't be too tight.) If someone is nearsighted, flattening the cornea reduces the degree of myopia, or nearsightedness. In theory this means that after you remove the lens, you'll be able to see without *any* correction. (However, the flattening may not be even on the cornea, in which case your vision can appear distorted when you remove the lens.) Once the desired effect has been achieved, contact lenses must be worn for at least a few hours every day, or worn overnight while sleeping, to maintain a flattened cornea. If you stop wearing the lenses, the cornea should simply return to its original shape without damage to the eye, and you won't be any worse off than you were before.

This method of vision correction, said to lie somewhere between contact lenses and refractive surgery (see chapter 7), varies in effectiveness, and often the results are only short-lived. The safety and efficacy of molding the cornea remain controversial.

Are colored contact lenses safe to use?

While having an array of cosmetic contact lenses to change your eye color to match your outfit, or just to have a different look for the day, seems as simple as changing your earrings or hairstyle, please be careful. Although you can buy cosmetic contact lenses on the internet or elsewhere without a prescription, as required by the FDA, there are many reports of people going blind from infections due to the improper fit or care of these lenses. Cosmetic contact lenses are medical devices, and you should make sure that they are worn under the supervision of an eye care specialist. In fact, if you buy contact lenses through an illegal vendor, your eye doctor will likely report the distributor for illegal sale of a medical device. To help keep your eyes safe when wearing these special lenses, you should also pay attention to the contact lens wearing instructions and precautions that you've learned about in this chapter.

But beyond changing your eye color, how would you like to have the eyes of a lizard or mirrored contacts like an alien? Well, in many cases, these special effect custom-colored contact lenses worn by actors and actresses in the movies or on television are hand-painted and carefully fitted for them under the supervision of an eye doctor. Special effect custom-colored contact lenses have very limited wear time, and if worn too much, they can cause severe corneal abrasions, leading to eye infections and worse.

Many people want to buy contact lenses as part of getting dressed up for Halloween. The FDA cautions against buying contact lenses from unauthorized dealers on the web or in specialty shops; they have put together a helpful list of recommendations for consumers: https://www.fda.gov/consumers/consumer-updates/colored-and-decorative-contact-lenses-prescription-must.

One important use of these uniquely crafted, custom-colored contact lenses is as a prosthetic lens to camouflage a disfigured eye from a birth defect or eye trauma and help create a natural look for people. When hand-painted to match the color and dimensions of the other eye, these prosthetic custom-colored contact lenses can be life changing.

I have a scar on my cornea from a childhood accident. Due to this scar, my cornea is distorted and irregular. Eyeglasses don't help me see clearly. Is there a special contact lens option that might give me better vision?

Scleral lenses may be for you. These are specially designed contact lenses that primarily rest on the white of your eye (the sclera) and vault over your irregular cornea, creating a tear-filled space between your cornea and the contact lens. Like a cover or clear window over the front of the eye, this rigid contact lens bridges over a defective corneal surface and acts somewhat like a new cornea, potentially improving vision and comfort in a variety of people afflicted with eye problems such as severe dry eyes, keratoconus, aniridia (no iris), complications after LASIK or corneal surgery, corneal burns, and a variety of other diseases and injuries to the eye surface. Scleral lens development dates back to the 1880s, when they were initially made using blown glass. For decades, these lenses were difficult for patients to use and very uncomfortable. Scleral lens design has come a long way since those early days. Today, scleral lenses are made of a highly oxygen-permeable material and custom fit to your eye using digital imaging. Further innovations to improve fitting are being explored using 3D software. So, if you have trouble with your vision from a problem with your eye surface, caused by either illness or trauma, don't give up hope. Look into scleral lenses (no pun intended).

Chapter 7

REFRACTIVE SURGERY: IS THIS A GOOD OPTION FOR YOU?

Life without glasses or contact lenses—wouldn't it be wonderful? If only there were some way to correct vision permanently, to fix the problem that made us need glasses or contacts in the first place. It's an intriguing thought, one that has fascinated doctors and patients alike for years. Is it possible? Yes, it's called *refractive surgery*. Is it perfect? No. Is it for you? Maybe.

If you decide to undergo refractive surgery, it's imperative that you go into it—pardon the pun—with your eyes wide open. Refractive surgery will most likely reduce your prescription, yes. But there's absolutely no way to guarantee that it will provide you with even the same quality of vision that you had before surgery with your glasses or contact lenses. You may wind up needing something—glasses or contacts—afterward, to fine-tune your vision, and you'll still face presbyopia later in life. If you wear bifocals, you still may need glasses or contacts to help you see up close, maybe not right away but sometime in the future. If your potential surgeon leads you to believe otherwise, find another doctor.

A Little Background

The idea behind refractive surgery is, as its name suggests, to adjust the way your eyes refract, or bend, light, by changing the shape of the cornea (the front surface of your eye; for more on refraction and how the cornea works, see chapter 2). This was first attempted in 1885, by a Norwegian surgeon named Dr. H. Schiötz, in a procedure we now call *astigmatic keratotomy* (AK). The patient's trouble was severe astigmatism (a focusing problem, in which the eye doesn't refract light evenly; see chapter 2), a result of previous cataract surgery. Dr. Schiötz decided to make an incision in the patient's cornea to flatten it and thus counterbalance the astigmatism. The operation was successful, and refractive surgery was born.

It wasn't until the 1940s, however, that refractive surgery expanded beyond astigmatism. The first procedures to reduce myopia, or nearsightedness, were done by a Tokyo eye surgeon named Tsutomu Sato. He found that if incisions were placed radially—like the numbers on a clock face—around the corneal surface, the cornea would flatten uniformly, and as a result nearsightedness would improve (figures 7.1 and 7.2). Unfortunately, Dr. Sato took a good idea and went too far with it, trying to do too much at once. He attempted to reshape the cornea from both the front and the back, and instead of seeing better, his patients actually wound up with worse vision than they'd had before.

Dr. Sato's theories were put aside until the early 1970s, when Dr. S. N. Fyodorov, of the Soviet Union, evolved a more prudent approach that improved myopia with significantly less harm to the cornea. A few years later Dr. Fyodorov's procedure, called *radial keratotomy* (RK), found its way to the United States. At first there was a flurry of interest. But many patients who underwent this procedure found that not only was their vision *not* fully corrected but sometimes it also wound up being so distorted that even glasses couldn't help. For some of these people, hard contact lenses saved the day, providing a smooth optical surface on the cornea and making adequate vision possible again. RK had other limitations as well, in that it couldn't fully correct severe cases of myopia (and thus help the patients who needed the procedure most). As a result of these drawbacks, RK's popularity faded in the 1980s. But the procedure was given new life in the early 1990s, as equipment and surgical techniques improved dramatically.

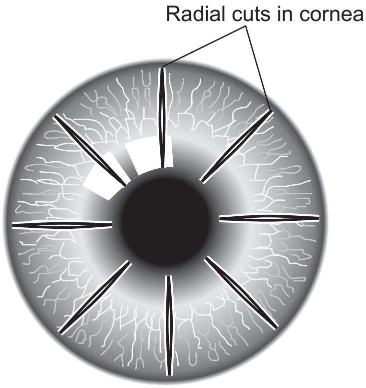

Figure 7.1. Radial cuts in cornea for a radial keratotomy

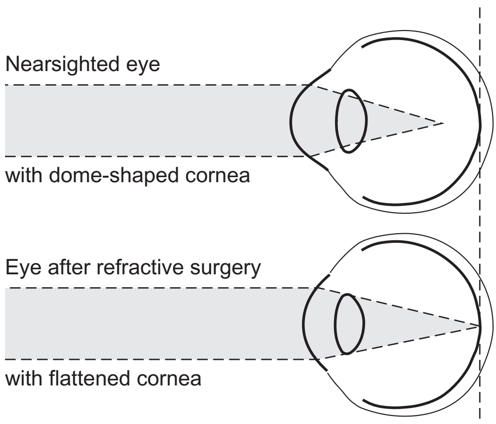

Figure 7.2. Nearsighted eye before and after radial keratotomy

Although these cornea-shaping operations themselves were less than flawless, doctors knew that the basic ideas behind them were sound, and they kept exploring new techniques and refining procedures. One of these new techniques, developed in the 1980s, was called *epikeratophakia*. Epikeratophakia involved removing a section of cornea, freezing it, lathing it into a new shape, and then reinserting the newly curved section back into the cornea. Because of the complexity of this procedure, there were too many things that could (and did) go wrong, and it was considered too risky for elective surgery. (Actually, this technique proved most successful as a means of correcting vision in babies after the removal of congenital cataracts.)

By the late 1980s, lasers had come on the scene, designed for *photoablation*—selectively vaporizing the tissue at the center of the cornea, thereby sculpting the eye into a new shape. This technology gave rise to several other surgical procedures. The first, *photorefractive keratectomy* (PRK), is performed by a highly sophisticated computer-driven piece of machinery called an *excimer laser*. The computer, reading a topographical map of the cornea, selectively reshapes the cornea by telling the laser precisely which bits of tissue to remove from the corneal stroma, after the corneal epithelium is removed. Unlike RK, PRK can correct not only for myopia and astigmatism but also for hyperopia. *Laser-assisted in situ keratomileusis* (LASIK; also known as *laser automated lamellar keratoplasty*, or *laser ALK*) also uses an excimer laser to vaporize tissue in the cornea, but this technique can correct more severe cases of myopia than PRK; it can also correct some astigmatism and moderate cases of farsightedness. Today, due to enhanced instrumentation and techniques, LASIK has evolved to become the procedure of choice for people looking to improve the way their eyes focus without glasses. According to the American Academy of Ophthalmology website, “More than 90 percent of people who have LASIK achieve somewhere between 20/20 and 20/40 vision without glasses or contact lenses.” If you are among the many people who do not like wearing glasses or contacts and who would be willing to accept less than perfect 20/20 vision after the procedure, LASIK refractive surgery may be for you.

Making the Decision to Have Refractive Surgery

Realistic Expectations

So, today it's surgically possible to correct myopia, astigmatism, and, to a lesser degree, hyperopia. But don't be dazzled by hype or unrealistic expectations: *none of these techniques are guaranteed to provide perfect vision or to prevent you from ever needing glasses or contacts again*. You're still going to get older, and so are your eyes; nothing can change that. And because presbyopia—the trouble focusing close-up that sneaks up on all of us eventually—is inevitable, *and because it's a problem with the lens and ciliary muscles, not the cornea*, refractive surgery on the cornea won't do anything to prevent it, and you may still wind up needing a reading prescription. If you're moderately nearsighted and wear glasses for distance vision only, you'll have a trade-off: instead of needing glasses to see across the street, you may eventually need them for reading. And if you spend your days in front of a computer, you may end up wearing glasses *more* than you did before surgery.

But I Don't Want to Wear Eyeglasses

We hear you. Refractive surgery, like wearing contact lenses or readjusting your vision with an implant lens at the time of cataract surgery (see chapter 8), does not guarantee that you will no longer need glasses. Remember monovision, the visual arrangement discussed in chapter 6? Monovision, in its most basic sense, is where one eye focuses at distance and the other eye focuses for reading to correct for presbyopia. Does this thought make you feel dizzy? Well, actually the AAO says that in the United States this is the "technique used most frequently for the nonspectacle correction of presbyopia." Most people have a dominant eye for distance, and if you haven't already discovered which is your dominant eye, your eye doctor can pretty easily find it for you. Therefore, when setting up a person's two eyes for monovision, we adjust their dominant eye vision to see distance without glasses. This can be done using a contact lens, refractive surgery, or even lens surgery, such as when we do cataract surgery. The other eye, the nondominant eye, is then adjusted for either reading up close (*monovision*) or reading at an intermediate distance such as the computer screen, car dashboard, or items on a shelf at the grocery store (*mini-monovision*). It is imperative that you have a long discussion with your eye doctor about the best setup for you, maybe even trying this arrangement with contact lenses before committing to this visual arrangement with refractive or lens surgery. Monovision or mini-monovision can be a great alternative to always searching for your misplaced reading glasses when you need to see something up close, but it is not for everyone. The best candidates are those people over 40 years old who were nearsighted all their life and who, as presbyopia descends on them, are starting to notice that they have trouble reading through their distance glasses or contact lenses. Monovision or mini-monovision may be accompanied by some loss of distance vision and stereopsis, as well as some glare and halos at night in the eye adjusted for near vision. Glasses can usually be prescribed for those times when monovision may be less than ideal, such as when reading a book in bed or driving at night, but overall, many monovision and mini-monovision patients are very happy just being less dependent on eyeglasses.

By the way, Babe Ruth, the famous baseball home run king, actually was reported by Gerald B. Kara, MD, of New York City, an ophthalmologist who examined the slugger later in life, to have good vision in only one eye, his right eye (20/15). Although Dr. Kara's observation has been questioned, he said that Ruth's other eye, his nondominant left eye, had poor sight from birth and never had more than 20/200 vision. Since Babe Ruth was a left-handed batter, if this observation is true, he seems to have done amazingly well tracking pitches with only his right eye. So, if having one good eye for distance was good enough for the "Sultan of Swat," it should be good enough for most of us too, right?

LASIK

How Is LASIK Performed?

LASIK evolved from a procedure called *automated lamellar keratoplasty* (ALK), in which tissue from the central cornea was removed to reduce myopia. In ALK, the surgeon creates a flap in the epithelium (the top layer of the cornea) and carefully lifts it to the side. Then, the surgeon removes a section of stroma (the tissue just beneath the epithelium) to reshape the cornea. The flap is then replaced and allowed to heal.

Although the idea behind ALK seems sound, in practice the operation's success rate proved disappointing; because it is so complex, there is much room for error. Surgeons sought to improve the technique with high-precision lasers, which brings us to LASIK, or laser ALK.

The LASIK procedure is basically the same as ALK, except that tissue is vaporized, or photoablated, instead of cut out. It's much less painful than RK or PRK (see below) because corneal nerves are not left exposed, and the original corneal epithelium is preserved—so you don't need to grow a new layer of cells over your cornea. Thus, it takes less time for your eyes to heal.

Performed while you lie flat on your back under a surgical device called an excimer laser, LASIK is done as an outpatient in a surgical suite. The eye is numbed with topical anesthetic eye drops, a lid speculum is placed between the eyelids to keep them open, and a special suction ring is then positioned on the eye to keep it from moving and properly orient the cornea for the procedure. (Frankly, this all sounds a lot worse than it is.) With the suction ring in place and the eye fixed in position, an automated microsurgical device, using either a laser or a blade, creates a centrally hinged flap of corneal tissue. This corneal flap is lifted and folded back on itself. The excimer laser is aimed at the exposed corneal surface that was beneath the flap, and using carefully calibrated preprogrammed settings unique for your eye measurements, the laser sculpts the corneal tissue. After laser sculpting is finished, the flap is placed back into its original position, and in less than 5 minutes, the corneal flap naturally reattaches to the corneal tissue.

Recovery: You'll still need to use antibiotic and anti-inflammatory eye drops, but for a shorter time than with RK or PRK. Recovery time is about 3–6 months until side effects resolve, your vision stabilizes, and you can begin to fully appreciate your visual results.

What's Considered Effective?

In most surgical studies assessing the benefits and risks of refractive surgery, a successful refractive surgical result is *uncorrected vision of 20/40 or better*. This is the minimal level of vision required by most states in granting a driver's license without a restriction for glasses or contact lenses. So basically, with 20/40 vision you could see well enough to drive a car. However, for most of us, seeing at a level less than 20/20 is not ideal; we don't feel that our vision is as clear as it should be. And some refractive surgery patients, even those with results considered to be "successful," still need glasses at least part-time, or they may even come to need glasses years after the procedure to improve their vision at certain times, like driving at night. (Most of these people, however, feel that this is less of a compromise than wearing glasses full-time.)

Potential LASIK Complications

Your doctor has probably told you this, but it's worth repeating: *with any type of eye surgery, there is a risk of loss of vision*.

Since it was first approved by the Food and Drug Administration in 1998, LASIK has been found to have far fewer complications than earlier refractive surgery techniques like RK, but there are a few. Infection and inflammation are always possible since LASIK is a surgical procedure, but these problems can usually be successfully addressed with medications. The primary symptoms after LASIK are pain, hazy vision, halos around lights, difficulty with night vision, and glare. As with RK, these symptoms usually go away within a few days to months; however, haze, halos, and glare can persist beyond the usual 6 months after surgery. Since LASIK alters tissue in the central cornea, visually significant scarring can develop, which may persist in this area indefinitely. In addition, the flap created during surgery never totally heals as well as an uncut cornea. So, if you get poked in the eye playing basketball, the flap can be moved or even lost.

Refractive surgery, when it's most successful, will give you the best vision soon after the surgery is performed, although sometimes a second refractive surgery, called a retreatment or enhancement, may be needed to get you closer to your preferred final vision. But whether or not you have the surgery, the vision you have today is not the vision you'll have 10 years from now. Surgery to your cornea won't affect what happens to the *rest* of your eye (the lens in particular), which will keep right on changing over your lifetime—and, therefore, so will your vision.

Alternative Refractive Surgery Procedures

Although LASIK is the most popular refractive surgical procedure today, it is not for everyone. Please consult the FDA website for a list of those people who should not consider LASIK, or who should instead consider one of several alternative refractive surgical procedures. These alternative procedures can also be used in combination with each other, as well as in addition to LASIK. Some of the more popular ones are listed below and range from correcting vision by reshaping the cornea to operations that surgically remove the normal, healthy lens of the eye and replace it with an artificial implant (basically, cataract surgery before the lens develops a visually significant cataract).

Wavefront-Guided LASIK

In wavefront-guided LASIK, the excimer laser is programmed for sculpting the corneal tissue under the corneal flap based on the unique and individual corneal contour of the patient, rather than on the patient's eyeglass prescription, as in conventional LASIK. The added precision of wavefront-guided LASIK often achieves visual results beyond that achieved with conventional LASIK, and even better than with glasses and contacts, as well as reduced side effects.

LASEK and epi-LASIK

LASEK and epi-LASIK are variations of LASIK. Instead of using a laser to create a corneal flap like in LASIK, LASEK uses a handheld trephine and epi-LASIK uses a special microkeratome. The LASEK trephine is like a circular cookie cutter, and it is used to create a small flap in the central corneal surface. The epi-LASIK microkeratome is specially designed to shave off a very thin sheet of the outer corneal tissue. Once the outer corneal surface is moved aside by either technique, the corneal tissue beneath is sculpted using a laser like in LASIK. With both LASEK and epi-LASIK, the corneal surface takes about 4 days to heal, often requiring a bandage contact lens to improve comfort and promote healing.

Photorefractive Keratectomy

PRK is very similar to LASEK and epi-LASIK, but instead of carefully cutting and temporarily displacing a small portion of the outer corneal surface to expose underlying corneal tissue for laser sculpting and then replacing the displaced corneal surface, in PRK the outer epithelium is just removed and allowed to regrow on its own after sculpting. Think of a cookie jar. In LASEK and epi-LASIK the cookie jar lid is removed, you take a cookie, and the lid is replaced. In a PRK cookie jar, the lid is removed, you take a cookie, and the lid is never replaced; instead, you wait for it to grow back. Okay, not the best analogy, but I think you get the point. Whether PRK or LASIK is the best procedure for you is a discussion that you will need to have with your doctor. Both are very effective refractive surgical procedures with low risk, but they have pros and cons.

Small Incision Lenticule Extraction (SMILE)

This procedure involves using a laser to cut a thin sliver of a layer of the cornea, which is then removed through a tiny incision on the side of the cornea. It's almost like ALK, but without making a flap. This way, the surface of the eye is barely touched, so it's relatively painless, and there is no risk of future damage to a flap as in LASIK.

Conductive Keratoplasty

Conductive keratoplasty (CK) is used primarily to correct mild to moderate farsightedness (hyperopia) in people over 40. Unlike with LASIK, CK is noninvasive and uses heat rather than a laser. A tiny heat probe releasing small amounts of radio frequency energy is applied to the outer corneal surface in a predetermined pattern. These heated spots induce shrinkage of the peripheral cornea, resulting in increased curvature of the central cornea and correction of farsightedness. For some people, CK is not permanent and will only temporarily correct their vision.

Phakic Intraocular Lenses

Just when you thought you had heard everything about how we can correct vision, here is something even harder to believe: placing a contact lens not on the eye but inside the eye. The phakic intraocular lenses (IOLs) are designed for people who are very nearsighted or very farsighted but who cannot safely have corneal-based refractive surgery. "Phakic" means that the person's natural lens is still in their eye. In this procedure, an implantable contact or collamer lens (ICL), a type of IOL, is surgically placed in front of the eye's natural lens—a contact lens inserted into the eye. When properly positioned, this ICL procedure can provide good visual correction, but of course, as with any surgical procedure, complications can occur.

Refractive Lens Exchange (Clear Lens Extraction)

When an ophthalmologist performs cataract surgery, the natural lens in the eye has become cloudy and causes impaired vision and focusing. A cataract surgeon then enters the eye, removes the cloudy lens, and replaces the eye's natural lens with an artificial IOL—well, not exactly that simply, but you get the idea. This IOL is shaped similarly to the eye's natural lens (not like the ICL discussed above) and, when placed into the eye, refocuses the vision again. Depending on the strength of IOL chosen for the patient, it can also improve a person's vision without glasses. You probably already see where we are going with this discussion. Suppose a person is very nearsighted or very farsighted but doesn't have a cataract yet; can we still remove their natural lens and put in an IOL that would improve their vision without glasses? This procedure is called refractive or clear lens exchange, and the answer is yes, but it's a qualified yes. So far, the FDA has not approved refractive lens exchange, but ophthalmologists legally may choose to perform this procedure as an "off-label" use. Additionally, since your ophthalmologist would be operating on a healthy eye, make sure that you are fully aware of all the potential complications of the surgery. This is particularly important if you are very nearsighted, in which case there is a high risk for retinal detachment after cataract surgery and thus potentially permanent loss of vision.

Orthokeratology (a Corneal Refractive Therapy)

Orthokeratology (sometimes shortened to "Ortho K") is a nonsurgical technique used to lessen nearsightedness by flattening the cornea with contact lenses worn overnight. As discussed at the end of chapter 6, overnight wear of rigid gas-permeable contact lenses designed to be flatter than the natural curvature of your cornea will flatten your cornea. When removed during the day, your cornea will be flatter and you will be less nearsighted. This effect is only temporary and requires continuous nighttime wear of the RGP lens (sounds like wearing braces or a retainer for your teeth, right?). This technique is popular with highly motivated nearsighted individuals who do not want to have refractive surgery and who also don't want to or cannot wear contact lenses during the day. Like with any technique that will alter your biologically given shape, orthokeratology has been associated with complications such as induced astigmatism, visual aberrations, recurrent corneal erosions, and corneal infections. The FDA stipulates that orthokeratology can only be performed by eye care professionals trained and certified in this technique.

Part III

THE BIG PROBLEMS FOR AGING EYES

Chapter 8

CATARACTS

It's probably cataracts. My friend's aunt had cataracts, and so did her husband. I'm the right age for it, and I'm having problems with my eyes—cataracts, that's it. I bet I need surgery.

Well, you may. Then again, you may not—depending on whether you do indeed have cataracts. Although cataracts are probably the most talked-about eye problem today and a major reason for visits to an eye doctor as we get older, they're also—right up there with astigmatism—among the most misunderstood disorders of the eye.

Difficulty reading for prolonged periods of time, excessive tearing, occasional feelings of having something in your eye, double vision in both eyes, pain in or around the eye, intermittent spots or floaters in your vision—these are *not* typical symptoms of cataract development. (Of course, if you're having *any* troublesome eye symptoms—whether you think the diagnosis is cataracts or not—you should seek medical attention.)

Instead, cataracts more commonly cause problems with distance vision, blurred vision (that doesn't change with blinking), frequent changes in eyeglass prescriptions, and poor night vision; they can also cause glare, make it appear that there's a halo around lights, and make it necessary for the person to use ever-brighter lights to see to read. My goal with this chapter is to help you better understand cataracts—their development, symptoms, and treatment—and to help give you realistic expectations about what their surgical removal *can* and *cannot* achieve.

The first thing you need to know is that if you have developed cataracts, you couldn't have picked a better time to do it. Not long ago cataracts were removed through large incisions in the eye. These surgical wounds were closed with thick sutures that caused

WHAT ARE THE SYMPTOMS OF CATARACTS?

Symptoms associated with cataracts include:

- Impaired distance vision
- Blurred vision (that doesn't change with blinking)
- Frequent changes in eyeglass prescriptions
- Poor night vision
- Glare
- Appearance of a halo around lights
- Need for ever-brighter lights for reading
- Double vision in one eye

a lot of pain and swelling. Also, intraocular implant lenses were in their infancy just 50–60 years ago; before this, cataract patients had to wear thick cataract glasses or extended-wear contact lenses. Today, thanks to great surgical advances, things are dramatically different. Most people with cataracts who need surgery undergo the modern *phacoemulsification* procedure, which enables surgeons to remove the cataract through a tiny incision in the eye. Complications are fewer, and recovery time is quicker. Now more than 99 percent of patients who undergo cataract surgery receive a permanent implant lens for better focusing power and sight.

What Is a Cataract?

A *cataract* is an opacity or haziness that develops in the eye's lens. For most people a cataract simply develops as part of the normal aging process. *All* people over age 65 have at least some degree of cataract development; although this aging process usually affects both eyes at the same time, it can progress at different rates. Just because you've never been told that you have a cataract doesn't mean that you *don't* have some degree of cataract development in your eyes. Cataracts are somewhat like gray hair and wrinkled skin in this regard: everyone eventually gets some of these changes, but we really don't take notice or make mention of them until someone has a lot of gray hair or wrinkled skin (and ideally even then we'd hold back, to be polite). Similarly, most eye doctors feel that cataracts are hardly worth mentioning at the beginning. However, rest assured that we become acutely interested in them as they progress and begin to affect vision.

Many people ask whether a cataract is actually a film, like the skim on fresh milk, or maybe a sheet of algae on a pond, growing on the eye's surface. Actually, it is not. A cataract occurs in the lens (figure 8.1), which is deeper within the eye. (The cornea is the clear outer surface of the eye, the "window" through which light must pass. Although there are conditions that cause whitening or clouding of the cornea, these aren't cataracts.) The lens is located inside the eyeball, within a membranous "bag." (Because it sits behind the iris, it's not easily seen without special instruments, and without first dilating the pupil.) So even if your eye *looks* clear in the mirror, this doesn't necessarily mean that you don't have a cataract.

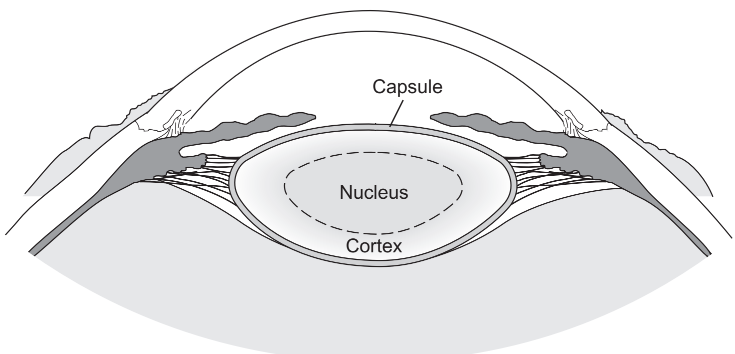

Figure 8.1. The parts of the lens

Types of Cataracts and Their Symptoms

The typical cataract that occurs with age is called a *nuclear sclerotic cataract* (figure 8.2). The name refers to the center, or nucleus, of the lens. As the normal lens ages, the nucleus enlarges, and its protein structure starts to change. The lens gradually loses its clear appearance and becomes a yellowish or greenish color. Over time, as the nuclear cataract progresses, the lens can actually turn brown. (This is what eye doctors mean when we use words like *clouding* or *haziness* to describe cataracts.) People with nuclear sclerotic cataracts typically have trouble seeing at a distance. Many stop driving at night because of poor vision and because car headlights appear blurred. They also find that the quality and brightness of light become very important for seeing. They have trouble in dim light and must increase the wattage of light bulbs at home to help them read and get around the house better at night. They often read best in bright sunlight, unless glare becomes a problem; in that case, hazy days may bring more comfort and better vision.

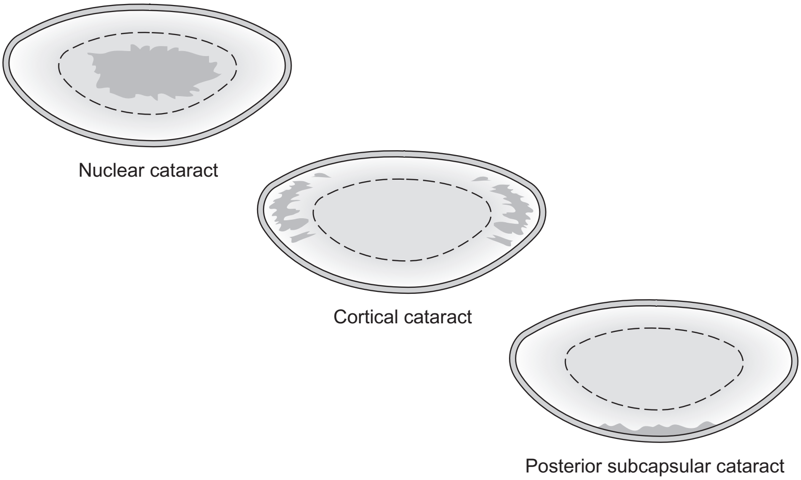

Figure 8.2. Types of cataracts

The two other main age-related types of cataract are (1) *cortical changes* and (2) *posterior subcapsular lens changes* (figure 8.2). Cortical changes occur in the outer layer, or lens cortex; they're the result of chemical imbalances that cause local disruption of the lens fibers and fluid to be drawn into the outer cortex. This excess fluid has an adverse effect on lens fibers—think of waterlogged carpet strands—causing a decrease in the clarity of the lens. (Interestingly, one of the dictionary's definitions of *cataract* is "a waterfall or great downpour.") Vacuoles and whitish, irregular lens areas and streaks caused by this flooding create problems with diffraction (how light is bent and focused; see chapter 5). People with cortical lens changes that fall within their visual axis frequently complain of glare from intense point sources of light, like street lights and car headlights, although this annoyance can occur less often with other types of cataract too. Nuclear and cortical lens changes usually happen slowly, and at a different pace in each eye.

Posterior subcapsular lens changes, on the other hand, can progress rapidly and tend to be much more advanced in one eye than the other. These are often known as *fast cataracts*. People with posterior subcapsular cataracts form an opaque, plaquelike cell growth on the back surface of the lens. This is different from the diffuse haziness of nuclear sclerotic cataracts or the focal fluid accumulation and distortion of cortical lens changes. This growth often occurs dead center in the lens, right in the path of central light rays that pass to the macula for reading vision. It can cause people to have more problems seeing close-up than at a distance, and as with cortical changes, it can cause a lot of discomfort from glare. Another common symptom is *monocular double vision* (double vision or a "ghost" image seen when looking through only one eye). When double vision occurs with both eyes open, but not in either eye alone, it's very rarely due to cataracts. (Double vision with both eyes open needs to be carefully evaluated by an eye doctor for eye muscle imbalances or other problems.) People with diabetes, people taking oral steroids, and people who have suffered eye trauma (or even head trauma not directly involving the eye) or who have undergone previous eye surgery are more prone to develop these cataracts. But posterior subcapsular cataracts can also occur in young, healthy people who don't have any of these risk factors. Because of their rapid onset and marked impairment of reading vision, these cataracts are often tremendously debilitating.

There are many other, rarer types of lens changes, including cholesterol cataracts, "sunflower" cataracts, phenothiazine cataracts, and congenital lens changes. But nuclear sclerotic lens changes—alone or in combination with cortical, posterior subcapsular, or other lens changes—are overwhelmingly the most common.

Symptoms Not Typical of Cataracts

A hazard of automatically blaming cataracts for many eye problems is that making this assumption—without the medical diagnosis to back it up—often delays the diagnosis of other eye diseases until it's too late for treatment. As mentioned above, cataracts usually cause problems with vision; on the other hand, they do *not* typically cause eye discomfort or pain, or any change in the appearance of the eye or the production of tears.

WHAT SYMPTOMS ARE NOT TYPICAL OF CATARACTS?

Symptoms unlikely to be associated with cataracts include:

- Eye discomfort
- Pain
- Redness
- Discharge
- Excess mucus
- Tearing
- Itching
- Irritation
- Aching in the eyeball

Cataracts are also not a major cause of feeling like you have tired eyes; as we get older, these symptoms are usually due to dry eyes or the need for new glasses or contacts. Also, a rapid deterioration in vision is usually not due to a cataract. (However, as always, there are a few exceptions to this rule, like some posterior subcapsular or cortical cataracts, and a careful examination by an eye doctor is necessary to determine the true cause of deteriorating eyesight.) Likewise, cataracts usually aren't to blame for a sudden loss of reading vision or lost side vision (two symptoms, by the way, that call for immediate professional attention).

Who's at Risk?

Among the risk factors associated with developing cataracts, age is by far the biggest. It's important to note here that most cataract lens changes are simply part of the *normal* aging process; theoretically, all of us will eventually experience some degree of cataract if we live long enough. And again, although everybody has at least some cataract lens changes by age 65, these usually aren't commented on by eye care specialists unless they appear to be affecting a person's vision or unless they can help explain symptoms such as glare, foggy vision, or difficulty with night driving. Many people, however, live their whole lives without ever having cataract problems that need treatment.

The Beaver Dam Eye Study, a large population-based study conducted in Wisconsin during the 1980s, found that visually significant cataracts were slightly more common in women than in men. Cataracts also have been found to be more common in people living in developing countries near the tropical belt than in people living in the United States, Asia, and Europe. Having diabetes, having a strong family history of visually significant cataracts, and taking certain medications (in particular, corticosteroids) also have been shown to increase someone's likelihood of developing cataracts. Smoking has also been shown to increase a person's risk of developing nuclear and posterior subcapsular, but not cortical, cataracts. The role of nutrition in cataract formation is not clear. Some studies have suggested that taking multivitamin supplements may protect against cataract development, but several large scientific studies (the Age-Related Eye Disease Studies 1 and 2) did not support these findings with the vitamins they studied.

Do sunglasses help? Advertisements for sunglasses have popularized the notion that sunlight and its associated UV rays can increase someone's risk of developing cataracts. Several scientific studies appear to support this claim; in particular, a study from the Johns Hopkins Hospital in the 1980s found that watermen on the Chesapeake Bay, who, by reason of their occupation, had increased exposure to the UVB radiation in sunlight, had over a threefold risk of developing cortical cataracts compared with those with much lower exposure. The exact role of sunlight and UV rays in lens changes and cataract development needs further study. However, because there's good evidence that the two are indeed linked, we recommend sunglasses for all our patients—especially those at risk for cataract development (including people with diabetes, as well as people on certain medications that make them more sensitive to the effects of light exposure).

Although most sunglasses provide adequate protection from UV radiation, you should look for labeling claiming "100 percent UVA and UVB filtering." The color of the sunglasses has little effect on their ability to protect your eyes. The tint should simply tone down the sun's brightness to a level that's comfortable for you. (The embedded chromophores in the lens that provide UV protection have little effect on the color or darkness of the sunglass.) Very dark gray lenses can decrease contrast, but gray is an acceptable color at lighter shades as well. Amber and brown lenses are popular because people find that they alter natural colors minimally. Green lenses, on the other hand, cause the most color distortion. Yellow lenses have been touted on midnight television commercials as great improvers of vision, especially outdoors. There is little scientific support for these claims, but hunters and other people who spend a lot of time outdoors have found them particularly comfortable. Polarized lenses have little effect on UV light, but they do cut glare substantially. Glare is a frequent complaint before and after cataract surgery, and polarized lenses may provide considerable comfort, especially for people who are exposed to a lot of reflected light (fishermen, boaters, and those who spend a lot of time driving on highways). Mirrored lenses, on the other hand, are purely cosmetic (especially if your goal is to look like a celebrity), have no true protective or comfort value, and may reflect unwanted UV rays onto the surrounding skin, causing sunburn.

Visual Impairment and Paradoxical Improvement from Cataracts

Like the lens in a camera that focuses light rays onto the film inside, the lens in the eye focuses light rays onto the retina. As cataracts develop over time, the lens becomes cloudy or hazy, allowing less light to reach the retina. The rays that do penetrate the lens can become distorted and scattered, accounting for such symptoms as blurred vision and halos around lights at night. Eventually this dimming of the lens reaches the point where stronger eyeglasses can no longer improve vision. This is because cataracts are not a *refractive* problem (one that can be corrected simply by changing your prescription); rather, cataracts are a problem *inside* the eye. The lens becomes cloudy, like a dirty window. No matter what kind of glasses you put up *outside* the eye, they can't focus light rays adequately through this hazy or dirty cataract window inside the eye. For your vision to get any better, the window will eventually need to be cleaned—or, as in the case of cataracts, removed.

One of the earliest signs of cataract development is called *second sight*. It's an amazing phenomenon. Some people actually stop needing their glasses as they get older (see chapter 2). Even though they may once have needed glasses for distance, now they can see just fine without them. Others who were always dependent on reading glasses may slowly discover that they read just as well without any glasses. So how, you may be wondering, if a cataract is a clouding of the lens in the eye, can this cause better vision? The answer is that in its earliest stages, the clouding is minimal and has little effect on decreasing light and distorting vision. But at this early stage, as the cataract begins to form, the change in the consistency of the lens can have an effect on someone's eyeglass prescription. These changes can alter the focus of light rays by the lens, so that people who were farsighted may gradually become nearsighted, and vice versa (though more often the former). This tendency toward nearsightedness as a cataract develops is called a *myopic shift*. Myopic shifts can have many other causes, such as certain medications (sulfa antibiotics, miotic eye drops), systemic disorders (diabetes), and other ocular conditions (ciliary muscle spasm). Nevertheless, people with large changes in their eyeglass prescription over 1 or 2 years, especially if there's a big difference between the two eyes, should be checked for cataract development. This change is occasionally the first clue that a cataract is developing, despite only minimal changes in the lens visible during an examination.

Can Cataracts Be Prevented?

Vitamins

As we discussed previously, age is the primary cause of cataracts—and as we all know only too well, there's not much we can do to stop or turn back the clock. However, it has been suggested by several investigators that nutrition plays a role in cataract development, and changes in nutrition and vitamin supplementation have been tried to slow cataract development. Specifically, antioxidants such as riboflavin, vitamins C and E, and carotenoids, as well as niacin, thiamine, and iron, may alter cataract development.

The effect of nutrition, specifically antioxidants, on cataract development has been investigated by the National Institutes of Health in two large clinical trials. As mentioned previously, these studies, known as the Age-Related Eye Disease Studies (AREDS and AREDS2), enrolled people nationwide with various stages of cataracts and macular degeneration. These people were assigned randomly to groups. Some groups took vitamin supplements containing copper, zinc, and an assortment of antioxidants (such as beta-carotene, lutein/zeaxanthin), whereas other groups took a sugar pill (placebo). Study participants were carefully followed for years to determine the effects of dietary supplementation on these age-related eye conditions.

Both AREDS studies did not find that supplements had a significant effect on the overall rates of progression to cataract surgery, although there was some evidence to suggest that dietary lutein/zeaxanthin ingestion may reduce cataract development. Don't rush out and raid the health food store. Vitamins aren't candy, and you may risk your health if you take high-powered nutritional supplements without medical supervision. If you want to take something, a multivitamin with zinc, copper, and antioxidants can't hurt, but please check with your general medical doctor or other health care provider before adding these or any supplements to your diet.

Sunglasses

It has also been suggested, as discussed above, that wearing sunglasses with UV filters may slow cataract development. UV rays penetrate the cornea and are absorbed by the human lens; laboratory animal and epidemiological studies suggest that exposure to sunlight and UV light may have an effect on cataract development. But whether (and how much) *ordinary* exposure to sunlight accelerates cataract development is uncertain. If you decide to use sunglasses—and this is probably a good idea—to cut down on light exposure when you're outside, you should purchase the darkest-tinted lenses that are comfortable for you and don't cause you problems with contrast, and look for UV coating that blocks 100 percent of UV rays. Wearing a hat with a brim can also contribute significantly to preventing the sun's rays from scorching your eyes.

Medications

Various medications, including aspirin, have been studied for their effect on cataract development. Aspirin appears to have a minimal effect, if any, on inhibiting cataract lens changes. Ongoing research is being conducted into delaying or reversing cataract development with a class of drugs called *aldose reductase inhibitors*, which have shown a beneficial effect in animal studies but not yet in humans. However, there are several medications that have been specifically designed and marketed as "anticataract drugs." These are much more popular outside the United States and include catalin, phacolysin (Lutrax, Quinax), and bendazac. However, buy them at your own risk. The usefulness of these drugs in retarding or reversing cataract development is not widely accepted, especially in light of today's excellent surgical results. That is, cataract surgery usually has such a good outcome that using unproven drug remedies seems not the best approach.

What Are My Treatment Options?

At first, the best treatment is education: having a good understanding of this problem and its effect on vision, and getting the most accurate eyeglass prescription possible, can help you cope with the often annoying consequences of cataract development. Improving the lighting at home with more and brighter lights (halogen or LED lights), positioning reading lamps over your shoulder or clipping lights to the page of a book for maximum illumination of the printed page, wearing sunglasses on bright sunny days to reduce glare, and limiting your night driving—all of these can be very helpful steps for people with early cataracts.

But also know that cataracts, like all age-related changes, will progress. There will come a point when stronger eyeglasses will no longer do the job, when the lens changes will impair your vision to a degree you find unacceptable, when you're no longer comfortable performing daily activities such as driving, reading, or even walking around in varied lighting conditions. At this point, cataract surgery becomes a treatment option that you need to consider.

Making the Decision to Have Cataract Surgery

As I've said before, the lens (and the cataract changes in it) sits in a "bag" inside the front part of your eye. When the lens becomes so hazy or opaque that a cataract operation is necessary, the lens must be removed from this bag. This is true for all kinds of cataracts, including the three most common types: nuclear, cortical, and posterior subcapsular (see figure 8.2). Cataract surgery usually involves opening the front of the bag, removing the lens, and leaving the back of the bag in place. An intraocular ("within the eye") implant lens is then inserted in place of the old lens, inside the old lens bag.

Who Needs Surgery?

Do you need surgery? A big part of the answer is that it's up to you; it depends on what you can tolerate and the degree of vision you consider necessary for a normal life. Surgical removal of cataract lenses is considered when people find that the visual impairment has progressed to the point where their normal activities are curtailed and stronger glasses aren't an option. An older person who doesn't move around very much has fewer visual needs and can better tolerate a more advanced cataract than a more active person, who may not be able to tolerate even an early cataract.

So, how active are you? This is an important question. And in answering it, by the way, don't sell yourself short—or let your doctor or well-meaning relatives talk you out of surgery—with a rationale such as, "Well, I'm in my seventies, I guess I should slow down anyway." Poppycock—it's your life, and the decision to undergo cataract surgery is an *individual* one; there are no strict rules to be applied here. There's also no age cutoff. Is the visual impairment interfering with your job, special interest, or hobby? Is it affecting your level of independence, as driving becomes a problem or you become afraid to leave the house because of trouble seeing?

Cataract surgery may also be performed for other reasons besides improving your vision. A dense cataract will obscure an eye doctor's view of the retina. This will make it difficult to follow conditions in the back of the eye such as glaucoma, diabetic retinopathy, and macular degeneration. Laser treatment of the retina is also difficult when there is a dense cataract. Very mature cataracts can lead to glaucoma or inflammation in the eye and should probably be removed.

Consideration must also be given to what you expect to achieve with the surgery. In most instances, cataract surgery is done to improve vision; in other words, you expect that your vision will be better than it was before the surgery, whether you need to wear glasses or not. *You should not undergo cataract surgery with the idea that you won't need to wear glasses anymore.* (Or because you hope cataract surgery will improve your golf game. It's the old joke: "Doctor, will I be able to play the piano after the operation?" "Yes," replies the doctor. "Great. I never knew how to play it before.")

When Should Surgery Be Performed?

This is another difficult question. Visual acuity, as measured with eye charts, varies from office to office and from one tester to another. The most common acuity measurements used today in the United States are the familiar "Snellen acuity" measurements of 20/20, 20/40, and so on. In general, someone whose visual acuity cannot be brought to better than 20/50 with eyeglasses should consider surgery. And this highlights the importance of a good refraction (glasses check) as a first step in any cataract evaluation. Only after a good refraction can you know if glasses will improve your vision or if your visual impairment needs further examination. This visual impairment must be judged to be consistent with the degree of cataract observed clinically and the health of the eye. Also, a careful eye examination must be performed to make sure that this visual impairment isn't due to other problems, such as corneal or retinal disease, or glaucoma. Fortunately, modern microsurgical techniques, which have much lower complication rates and allow for much faster visual recovery, make it no longer necessary to wait until cataracts are "ripe" before they can be removed.

When discussing such concepts as visual acuity and the level of impairment due to cataracts, it may be helpful to think of your vision in terms of a scale from 1 to 10. On this scale, 1 is the best vision you can have (about 20/20) and 10 is the worst. Right in the middle, at level 5, is 20/50 vision; at this point, cataracts are usually significantly affecting a person's activities. *Cataract surgery in most people can be expected to improve vision, with or without glasses after the operation, to a level below 5, and preferably to a 1, or approximately 20/20.*

Although 20/50 is generally the accepted level at which many eye surgeons feel comfortable recommending cataract surgery in an otherwise healthy eye, sometimes cataract surgery may be warranted in patients at lower levels on this scale. Cataracts causing severe impairment in someone's occupation or lifestyle due to reduced acuity, monocular double vision, distortion, or glare can prompt a surgeon and patient to decide to proceed with surgery in an eye at levels of 4 (20/40), 3 (20/30), or better. In fact, testing the eye for the effect of glare (glare testing) on your vision is often a useful way to see just how much difficulty you are having with headlights while driving at night and with glare on a bright, sunny day.

Note: Before undergoing any surgery, it's a good idea to *get a second opinion*. (In fact, some insurance plans require patients to get two opinions before undergoing any surgery for which the insurer will be asked to pay.) This is especially important if there's a possibility of insincere motives on the doctor's part or unrealistic expectations on yours.

Will the Surgery Actually Help?

This should go without saying, but cataract surgery shouldn't be performed unless your eye doctor believes there's a good chance that your vision will be improved by it. If the retina or the optic nerve isn't healthy, then removal of the cataract may not improve visual acuity to a reasonable enough level to justify surgery. (Imagine trying to focus light rays in a camera onto bad or exposed film. The lens can be as clear as possible, with the best focusing ability, but none of that will matter if the film is simply bad.)

Before performing cataract surgery, it's essential for the doctor to assess the health of the rest of your eye behind the cataract. This requires carefully going over your medical history, asking many questions about past vision problems, eye trauma, and eye disease. As mentioned above, any evaluation of an eye for cataracts should begin with a careful refraction (glasses check). A simple test of your eye's health behind the cataract can be to examine your reading vision. Because most cataracts affect your distance vision but not your near vision, seeing 20/50 on an eye chart at the end of an exam room but reading comfortably up close is usually a strong indication that your problem is a visually significant cataract. Your doctor also may use instruments such as a potential acuity meter (PAM) to test the health of your eye behind the cataract. In this test, a visual acuity chart—similar to the classic ones you see in an eye doctor's office—is projected *through the cataract* and focused onto the retina in the back of the eye, using two pencil-thin beams of light. If someone can see the chart *better* this way, then the retina is usually judged as healthy. If, on the other hand, the person does not see better with this test, then this implies that the retina or the optic nerve may not be healthy, and it's doubtful that removing the cataract would improve vision. (*Note:* Sometimes the PAM test can provide misleading results. Therefore, it should be done by doctors who have a great deal of experience using these instruments and interpreting their results.) Automated computerized visual field testing and optical coherence tomography, both discussed elsewhere in this book, are also potentially useful testing methods during an eye examination to help your doctor assess the health of your eye and visual system behind your cataract.

What about the Risks?

I've talked about the benefits of cataract surgery (improved vision); we also need to consider the risks. Many people hear from their friends how easy it was to have cataract surgery, and because the surgery is relatively safe these days, fewer people have heard about those who had complications. *But cataract surgery is an operation.* As with any operation, there are risks, and there is a recovery period.

One risk of cataract surgery is eye infection. Many surgeons give their patients antibiotics around the time of surgery, in theory to help lower this risk. Because cataract surgery is considered to be a minimally invasive procedure, typically systemic antibiotics are not needed prior to surgery. However, if you have any concerns because of another health issue, such as a preexisting artificial or damaged heart valve or a compromised immune system, you should consult with the specialist who helps manage this aspect of your health. On the other hand, using topical antibiotics before cataract surgery to lower the risk of a postoperative eye infection makes sense, but studies about this have not been conclusive. Because there is evidence that using antibiotic eye drops before surgery will lower bacterial counts on the eye's surface and even in the eye immediately after surgery, some patients may be given antibiotic eye drops before routine cataract surgery. However, preoperative topical antibiotic prophylaxis is more commonly used for patients who may be at higher risk for eye infections after surgery, such as those with diabetes, those with methicillin-resistant Staphylococcus aureus, or those who have had previous eye infections or surgery. Every precaution should also be taken when operating on a one-eyed patient, so preoperative antibiotics are always a good idea in these people too.

Another big concern is retinal detachment after cataract surgery. The retina is like wallpaper lining the back of the eye. If there's any weakness in the retina at the time of surgery, it can become detached, like peeling wallpaper, from the back of the eye. This is why people are examined frequently after the operation. Retinal detachment is especially a concern in very nearsighted (myopic) individuals who anatomically have a longer eyeball and are known to be prone to retinal detachments. Although all patients prior to cataract surgery should have a careful retinal evaluation, this is particularly important in highly myopic patients to look for potential areas of trouble and have these addressed before the operation. If a retinal detachment occurs after cataract surgery, it is repaired right away. (We have also seen patients sneeze their implants out of place, rub open their cataract wounds, and even fall on their eyes soon after cataract surgery. But don't panic. The quicker these issues are addressed, the better your chances are for still having better vision after your operation.)

The lens of the eye, as mentioned elsewhere, lies within a capsular bag that is attached to the eye by many fine, thin, hair-like support structures called zonules (see chapter 1). During cataract surgery, your surgeon carefully makes an opening through the anterior portion of the lens's capsular bag into the cataract lens, removes the cataract lens, and then places an artificial intraocular implant lens into the capsular bag to reestablish an eye's ability to focus. In the event that the capsular bag inadvertently breaks or tears during surgery, an infrequent occurrence, or the zonules supporting the capsular bag become loose or torn, the intraocular implant lens may not be able to be properly positioned within the capsular bag in the eye. A second surgery after the initial cataract surgery may be required to reposition the implant lens in the eye, perhaps even necessitating sewing it into position. A torn capsular bag or zonules are often also accompanied by the inability to remove the entire cataract lens at the time of surgery, so a retinal specialist may be needed to perform a vitrectomy and remove any remaining cataract lens material from the eye before positioning an intraocular implant lens. Despite requiring an unexpected second surgery so soon after the first surgery, modern microsurgical techniques today make it possible for a person, in most cases, to still expect an excellent visual outcome.

Many other complications are also possible, either during or after cataract surgery. Any surgeon who performs cataract surgery sees these complications, ranging from minor issues of healing to more serious issues like endophthalmitis (an infection in the eye); fortunately, complications are infrequent—on the order of 5–10 percent—but they do happen. This is where the experience and competence of your surgeon can make all the difference in the world. *Usually, if complications are recognized and treated early, the eye can still heal well after surgery and achieve improved vision—even if this requires a second surgery soon afterward.* If an infection gets out of control or a retina becomes very badly detached, however, there's a chance that the vision in the eye could end up worse than it was before the operation. In rare cases, people have lost an eye from cataract surgery. In extremely rare cases, people have had unforeseen reactions to anesthesia and have even died from it. *Fortunately, complications of all kinds are unusual, and most cataract surgery goes very well.* But it's worth repeating that cataract surgery, no matter what you've heard from friends, is not without some discomfort, and a good outcome is certainly not guaranteed.

How's Your Health in General?

Your overall health is another important consideration. Although today, with modern microsurgical techniques, cataract surgery is relatively safe, with few complications, there are still risks. People taking Coumadin, aspirin, and other blood-thinning medications may be at risk for excessive bleeding during the operation. Men who are on tamsulosin (Flomax) or related medications should alert their surgeons because these drugs can affect the muscle of the iris, leading to a "floppy" iris during surgery. Because it's necessary to lie flat during the operation for a period of time ranging from as little as 15 minutes to greater than an hour, someone with severe scoliosis, debilitating arthritis (especially in the cervical spine), or chronic obstructive pulmonary disease may have difficulty.

Also, a certain level of patient cooperation is necessary for cataract surgery. Today it has become standard to perform cataract surgery under local and not general anesthesia (in which the patient is "asleep"). Local anesthesia is safer and avoids the potential complications associated with general anesthesia; patients also recuperate faster after the operation and can go home the same day, with little drowsiness and few residual effects. At the start of most cataract operations, people are given an intravenous injection of a Valium-like drug to induce a "twilight sleep." While they're in this relaxed state, most patients also receive either topical anesthesia on the eye or injections of local anesthesia around the eye, to keep them from closing their eye or blinking during the procedure. These injections also block sight in the operated eye. Patients are awake during the operation but are so relaxed that they hardly notice what is going on around them; in fact, many people doze during cataract surgery. *But patients must make an effort to lie still and cooperate; sudden movements can have devastating visual consequences.* This is especially true for patients of doctors who choose to perform cataract surgery with only topical and intraocular anesthesia, without a peribulbar or retrobulbar block (see below). Combative patients, people with dementia, or others who are likely to have trouble keeping still for sustained periods may not be good candidates for cataract surgery, unless performed under general anesthesia.

Other Concerns You May Have

It's perfectly normal to be concerned before any surgery. You'll probably have a lot of questions: How much better will my vision be after the operation? What if something goes wrong? Could I be blinded? How long will it take after the operation for me to drive, get back to work, read, and resume my other normal activities? Will the other eye need cataract surgery in the near future?

The stakes are much higher for people who have only one working eye, since for them an unsuccessful operation can have a much graver outcome; the risks of surgery for these individuals become magnified and potentially devastating.

There's no master list of answers to these questions because everybody's situation differs slightly; in fact, there are as many sets of pre- and postoperative cataract surgery instructions as there are eye surgeons. But one standard applies in every case: You should feel free to raise your concerns and questions with your cataract surgeon and their staff before surgery, not only to ease your worries but also to establish realistic expectations regarding the procedure.

If your surgeon seems too concerned about how quickly they get you in and out at your eye exam and brags about how fast they can do your surgery, or if they flunked the bedside-manner course in medical school and either don't fully answer your questions and concerns or don't seem inclined to take the time to listen to you, you may want to seek a second opinion or consider going to a different surgeon altogether. You should also be comfortable with your surgeon's arrangements for your postoperative care. Today not all cataract surgeons follow their patients after surgery, instead sending patients back to their ophthalmologist or optometrist for postoperative management.

Cataract Surgery

Cataract surgery has progressed remarkably over the past 60 years. Not too long ago people routinely spent a week or two in the hospital recuperating from a cataract operation. At that time, the hazy cataract lens was removed using mainly manual techniques. Sandbags—how primitive it seems now—were placed around the patient's head in an attempt to prevent movement while the wound healed. The results of these procedures varied, and there were much higher rates of infection and inflammation following surgery than we see today. Furthermore, after cataract surgery many people had to wear thick cataract glasses that overmagnified and distorted their vision.

Welcome to the microsurgery revolution. Special microscopes, designed to give ophthalmologists a better view of the cataract and other eye structures during surgery, have enabled us to refine our surgical incisions and other delicate procedures performed inside the eye. As microsurgery has evolved, surgeons have developed many new instruments for use within the eye. New sutures, finer than human hair, and smaller cataract incisions (which oftentimes don't even need sutures) have also allowed for better wound closure following cataract surgery. This advance, along with improved implant lens designs, has also sped the patient's recovery, as well as helping maximize the chances for achieving good vision after the procedure.

Intraocular Lens Implants

The lens provides focusing power for the eye. When it's removed, as it is during cataract surgery, the eye loses its ability to focus properly. Hence the dilemma: how to fix one problem (getting rid of the hazy lens) without creating an even bigger one (removing someone's ability to focus incoming light rays, and therefore see in that eye, altogether).

Years ago, the most widely accepted options for correcting this lack of focusing power in the eye after cataract surgery were the thick cataract glasses or contact lenses mentioned above—both inadequate solutions. Many people found it difficult, if not impossible, to adjust to the distortion and magnification created by the thick glasses. And contacts weren't an ideal option because they were difficult to handle, especially for people with arthritis or a mild tremor; they also increased the risk of developing an eye infection.

Eye surgeons continued to search for a more acceptable option for returning focusing power to the eye, eventually artificially developing an intraocular implant lens, or IOL implant. This implant, which can be placed in the eye during cataract surgery, restores some of the eye's ability to focus after the old lens has been removed. Toric lenses for astigmatism and multifocal implants have addressed the issues of astigmatism and presbyopia, respectively. Both these lenses are called "premium implants" and are used to lessen your likelihood of wearing glasses after cataract surgery. Since the latter is considered a cosmetic concern, premium implants are usually not covered by insurance. But premium implants are not perfect. With any implant, you may still need a pair of normal reading glasses to provide more focusing power for close work, or even a bifocal prescription that will also fine-tune your distance vision. Although they don't create perfect vision, IOL implants have eliminated the magnification problems created by those thick cataract glasses of many years ago and have helped many people avoid the difficulties associated with the use of contact lenses. After cataract surgery, you can still wear contacts if you want to.

A Bit of Background

A complete history of intraocular implant lenses is beyond the scope of this text (and is in fact the subject of several books). But the story of their development is an interesting one. Dr. Harold Ridley, an English ophthalmologist working during World War II, is credited by most people as the person responsible for originating the idea of implant lenses in cataract surgery. During the war, he treated many Royal Air Force pilots who had been injured when their planes' cockpits shattered. In a number of these pilots, cockpit windshield fragments had penetrated the cornea and lodged in the anterior chamber of the eye. But surprisingly, Dr. Ridley noticed, these fragments were actually well tolerated by the eye. This gave him the idea that a prosthetic lens could be developed of similar material and placed in the eye after removal of a cataract.

As you might expect, early attempts to create implant lenses met with many problems and complications, since manufacturing techniques and materials were limited. Glass implants were too heavy and would not remain properly fixed in the eye. But over the years technology finally caught up with the idea, and newer implant designs were made of plastic—which, as with contact lenses, eventually became the material of choice. Surgeons tried various methods of getting these implants to stay put inside the eye—all met with varied success. After many years of study, we have found that it's best to place intraocular implant lenses *behind the iris* inside the old cataract bag, where they're better fixated and in a better position for the restoration of eyesight.

Just like hearing aides, implants have gotten smaller over the years as our technology and surgeons themselves have become more sophisticated. Now, thanks to better surgical instruments, it's possible to remove a cataract through narrower incisions—and the smaller the incision, the more rapidly someone will heal after cataract surgery. Also, these smaller wounds are less likely to induce unwanted astigmatism in the eye, a common problem after cataract surgery, and often are self-closing, eliminating the need for sutures. We continue to strive for ever-tinier incisions and implant lenses. Currently the trend is to make a 5-millimeter (or smaller) incision and use foldable (or injectable) implant lenses. But who knows what the future holds—perhaps a needle-sized incision and an injectable liquid implant that then hardens in the shape of the natural lens?

Advances in Anesthesia

Major surgical advances; new, highly sophisticated equipment; and an expanded spectrum of medications to decrease infection and inflammation after the operation have helped make cataract surgery a much safer and more effective procedure. Because of improved techniques, cataract surgery today is usually done under local anesthesia (instead of general anesthesia, which carries more risks). As noted earlier, you'll probably receive a relaxing medication, given by intravenous injection, before the procedure to make you sleepy. Then, you may be given injections of a local anesthetic around the eye to decrease sensation and movement (similar to the injections the dentist uses when working on your teeth). Patients are usually in a "twilight sleep" during surgery, aware but not caring; these injections also block your vision in that eye during cataract surgery. Many doctors today even choose to perform cataract surgery using only topical anesthetic eye drops and gel. This is supplemented with an intraocular anesthetic and requires a very cooperative patient to keep the eye from moving during surgery.

Improved techniques of closing the incision and new ways of controlling inflammation have done away with those prolonged hospital stays patients used to endure (remember the sandbags). In fact, most cataract surgery today is done on an outpatient basis: patients have their surgery and then go home the same day.

Before Surgery

The A-Scan Measurement

The A-scan measurement, an ultrasound measurement of the length of the eyeball, is an important calculation that must be performed before surgery to help determine—along with other measurements, such as your target postoperative prescription, corneal curvature readings, and the IOL constant—the appropriate power of the lens implant you'll be getting.

Unfortunately, this calculation is not always as accurate as we would like, especially in very nearsighted (very long eyeballs) or farsighted (very short eyeballs) people. Special implant lens power calculations have been developed for these extreme cases, as well as for post-LASIK patients, since LASIK also tends to make IOL power calculations unpredictable. Because the intraocular implant lens is a *gross* estimation of the power the eye needs to focus correctly, not infrequently glasses are necessary after a cataract operation to fine-tune vision.

Presurgical Testing

Even though cataract surgery is performed under local anesthesia, it's usually advisable to undergo presurgical tests to check for any medical conditions that might cause problems during surgery. The degree of presurgical testing required for your cataract surgery will depend on your medical history, as well as the specific requirements of the facility where your surgery will be performed. Presurgical testing usually includes a history and a physical, and additionally it may include an EKG, a chest X-ray, blood work, and a urinalysis. If you have multiple medical problems, it's probably a good idea to have these tests performed by your general medical doctor or other health care provider, or another specialist familiar with your medical history. (Otherwise, the testing can be done at the hospital or surgical center prior to the operation.)

Scheduling

Surgery dates are scheduled in coordination with the A-scan measurement and presurgical testing. Typically, surgeons begin working very early in the morning and continue doing operations until midafternoon; your surgery will probably be scheduled sometime between 7:30 a.m. and 3:00 p.m.

Preoperative Instructions

Preoperative instructions vary from surgeon to surgeon. Patients are generally asked not to eat or drink anything the night before surgery, from midnight onward. (This is a routine precaution before any type of anesthesia is given; it can vary greatly depending on the surgeon, the surgical center, and the specific anesthesia that will be used.) You'll probably be told to continue taking any medicines you normally take on a daily basis (but on the day of surgery to swallow them with only small sips of water). *Note:* Bring a list of your medications, as well as when you last took them, to the surgical center before the operation. Your surgeon may also want you to take antibiotic and nonsteroidal anti-inflammatory eye drops before the procedure.

If you take insulin, be sure to check with your primary care provider or endocrinologist about the doses you'll need on the morning of surgery. As previously mentioned, if you usually take prophylactic doses of oral antibiotics—to protect a damaged heart valve, for instance—before dental procedures, it's a good idea to check with your general medical doctor or other health care provider about taking these antibiotics before cataract surgery.

Aspirin and other anticoagulants such as Coumadin are known to interfere with blood clotting. Therefore, most doctors who use peribulbar or retrobulbar injections for anesthesia recommend that *all aspirin use be stopped before cataract surgery* because of the risk of bleeding near the eye or orbital hemorrhage (see below). With the rise in popularity of topical anesthesia for cataract surgery, these concerns have become much less common.

However, when desired, temporary discontinuation of aspirin and other anticoagulants prior to cataract surgery should be done only with the consent of the health care provider or specialist who put you on aspirin in the first place. Stopping Coumadin or other anticoagulation medication before cataract surgery is a trickier prospect because interrupting it for even a short period of time can put some patients at serious risk for a stroke. (In this case you and your eye surgeon, after a thorough discussion of the risks of being anticoagulated at the time of cataract surgery, may decide to continue your anticoagulation and go ahead with the operation, perhaps with topical anesthesia, where the risk of bleeding is very low.)

The Procedure Itself

Your surgery may be performed at a hospital, at an outpatient surgicenter, or in a surgical facility connected to your doctor's office. Wherever it is, you'll probably be asked to arrive early, sometimes as much as an hour and a half before the actual scheduled time of the operation, to allow plenty of time for preoperative preparation. (This usually includes a review of the presurgical testing results, interviews by nursing and anesthesia staff, and eye drops.) The regimen of preoperative eye drops varies, but it usually includes dilating drops such as tropicamide (Mydriacyl) and phenylephrine (Neo-Synephrine) and may also include an antibiotic and a corticosteroid and/or nonsteroidal anti-inflammatory medication. Anesthetic eye drops may be applied to *both* eyes—to numb the eye that will be operated on, and to make the other eye more comfortable during surgery. As a precaution, the eye for surgery should be clearly marked, usually above the eye with a skin marker or colorful sticker.

Patients often ask whether they'll need to remove their clothes for the procedure. This is a reasonable question; the answer varies depending on the surgical facility. Most likely you will get to keep your own clothes on from the waist down and wear a surgical gown or covering during the procedure over your upper body. This operating room "fashion" facilitates cardiac and blood pressure monitoring, as well as the placement of an intravenous line into your arm for medications. Human nature being what it is, it's a good idea to keep such personal articles as watches, rings, money, and wallets to a minimum (and preferably to leave nonessentials at home).

Note: A quick trip to the bathroom before surgery can be very important and help avoid an embarrassing situation. (But even if you take this precaution and still have to go, don't worry: if necessary, you can use a urinal or bedpan during the surgery.)

In the operating room, your eye and the region around it will be cleaned with an antibacterial and antiseptic solution. Sterile drapes and sheets will also be laid over and around the eye to lower the risk of infection. Oxygen is usually provided to the patient through a nose tube because it can be hard to breathe under the drapes. At most centers, patients' blood pressure, blood-oxygen levels, and cardiac rhythm are also monitored throughout the procedure.

We should note again that there is considerable variability among surgeons and centers regarding the procedures on the day of cataract surgery. But in general, all patients receive some degree of intravenous sedation to relax them, followed by topical aesthetic eye drops and gel on the eye or injections of local anesthesia around and behind the eye. As mentioned previously, patients who receive topical anesthesia drops and gel on the outside of the eye usually also receive the instillation of anesthesia to the inside of the eye. *Note:* The medication used is usually lidocaine or something similar—just like the lidocaine your dentist uses. So, if you've ever had any problems with local anesthesia in the dentist's chair, be sure to tell your surgeon.

Peribulbar and *retrobulbar anesthesia*, local injections of anesthetic next to or behind the eyeball, work by blocking the nerves leading to the muscles that control the movement of the eyeball and eyelid. These injections are performed with a thin needle that is usually inserted through the lower eyelid to a point next to (peribulbar) or behind (retrobulbar) the eyeball, where the ocular nerves and muscles nestle closely together. A peribulbar or retrobulbar injection is not without risk. Your doctor guides the needle without being able to see the structures around or behind the eye such as blood vessels, nerves, muscles, and—most important—the eyeball itself. Although eye surgeons and anesthesiologists perform the injection with great care and complications are rare, problems may occur and can include issues such as nicking a blood vessel (causing a retrobulbar hemorrhage), perforating the eyeball, or injuring the optic nerve. These complications can occur in even the most experienced hands and usually require postponing the planned cataract surgery until a later date. But the vast majority of these injections are performed each year without any complications at all. (However, because the risk of these complications, though small, is present, some surgeons advocate other anesthesia and surgical techniques that are associated with less risk. You need to discuss these anesthesia options with your eye surgeon and choose the procedure that will be best for you.)

After peribulbar or retrobulbar anesthesia, pressure is applied to the eyeball, either manually, by the doctor's finger, or using a special device or weight over the eyeball. This pressure on the eyeball serves two purposes. First, it encourages any bleeding—if a blood vessel was nicked or severed during the retrobulbar injection, for instance—to stop, and it maximizes clotting. Second, pressure on the eyeball decreases the pressure within the eye by displacing fluid from the eyeball into the systemic circulation. (And lower intraocular pressure decreases the risk of surgical complications.)

The atmosphere in the operating room probably won't be nearly as intense as it's usually portrayed in the movies and on TV; many patients are pleasantly surprised to find that the staff is congenial, with a warm, comforting attitude. Many patients worry that they won't be able to keep their eye open throughout the whole operation—that they'll accidentally blink and derail the procedure. As the old slogan goes, "Leave the driving to us." We'll keep your eyelids open, using a lid speculum or specially designed retraction device.

Now it's time to remove that cataract. After anesthesia, the eye area is cleaned in a sterile fashion, and a lid speculum is placed into the eye to open up and fix the eyelids so the eyeball is exposed. Next, two incisions are made. One incision is called a paracentesis and is basically a very small, strategically placed opening to allow the surgeon easy access into the eye for injections and surgical instruments. A larger incision is also made into the eyeball for the main event: cataract removal and insertion of the implant lens. Most main incisions are placed to the side of the eye, level with your ear, or somewhere in the upper half of the eyeball, relatively near where the cornea meets the sclera (the "white" of the eye); this area is known as the limbus of the eye. The length and specific placement of the main incision depend on which technique the surgeon will be using to remove your cataract. Smaller surgical incisions speed up recovery time; they're also less likely to cause postoperative astigmatism, an abnormal curvature of the corneal surface that is created as the wound heals. In the past, in intracapsular and extracapsular cataract surgery, where the lens of the eye was removed in one piece, the surgical incision was large, as long as 10–12 millimeters, or about half an inch. Today, phacoemulsification cataract surgery can be performed through a very small incision less than 5 millimeters wide, and is often performed through an incision less than half this length.

Intracapsular cataract extraction (ICCE), very popular many years ago, before modern microsurgical techniques were developed, is rarely performed these days. In an ICCE the lens is removed intact, complete with the surrounding capsular lens bag (figure 8.3). *Extracapsular cataract extraction* (ECCE) involves opening the capsular lens bag and removing the lens located within it (figure 8.4). The inner lens is extracted from the eye in one piece. Today, this technique is often reserved for very dense and firm cataracts that would be difficult to break up with phacoemulsification (figure 8.5).

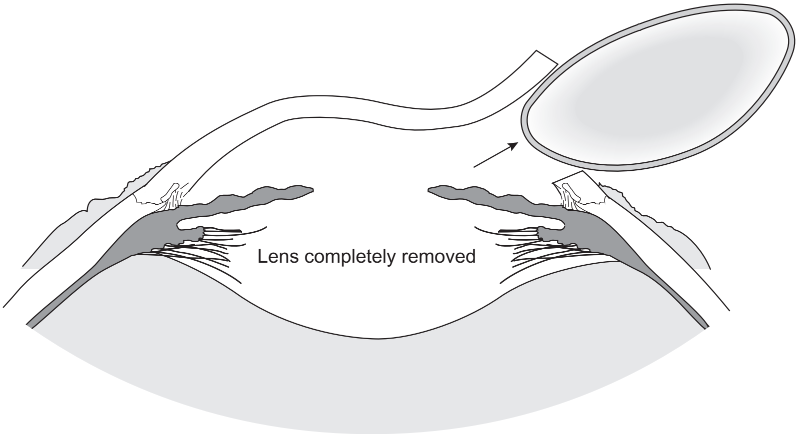

Figure 8.3. Intracapsular extraction

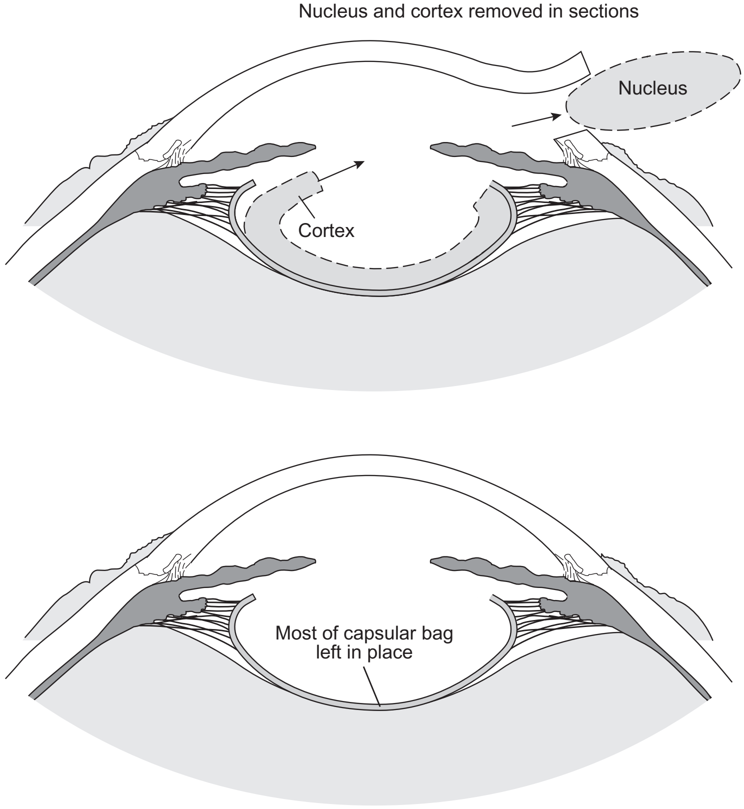

Figure 8.4. Extracapsular extraction

In *phacoemulsification cataract extraction*, as mentioned above, incisions can be much smaller (figure 8.6). In this very popular form of cataract surgery, the cataractous lens is broken up inside the eye with ultrasound waves emanating from a specially designed surgical instrument inserted through the incision. This instrument then vacuums up these small lens fragments as they're broken up. (The use of lasers for cataract surgery will be discussed later. At this time, lasers are *not* used to remove cataracts from the eye. Since a cataract is a solid structure, it must be removed, either in one piece or in fragments.)

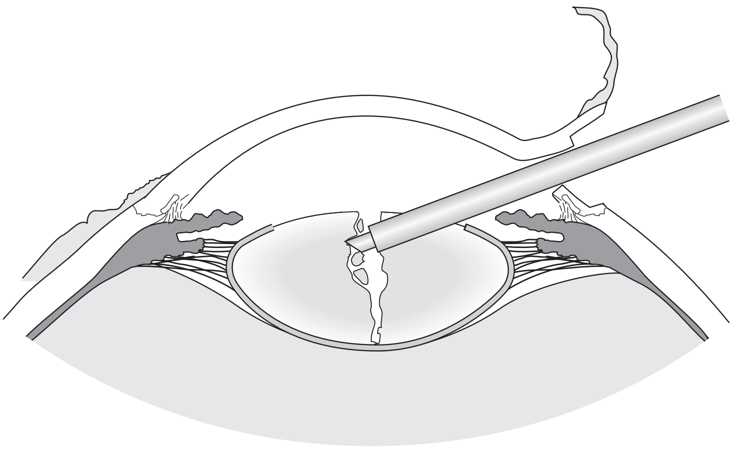

Figure 8.5. Phacoemulsification

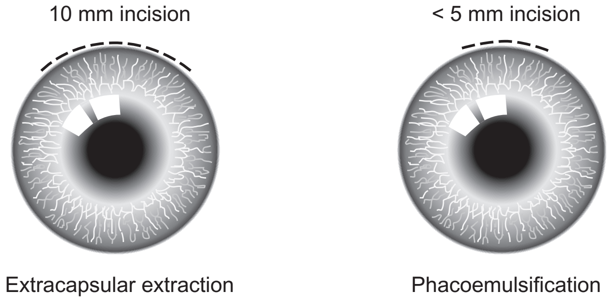

Figure 8.6. Incisions for extracapsular extraction and phacoemulsification

With extracapsular extraction and phacoemulsification, after the cataract is removed from the eye, it's often necessary to use an irrigation and aspiration technique to clean up any leftover fragments of the cataract. Although this technique can be performed manually, most surgeons prefer to use an automated system.

Now it's time to insert the intraocular implant lens. At this point in the procedure the incision is either large (approximately 10 millimeters) or, more typically these days, small. Foldable implant lenses can be inserted into the eye through incisions smaller than the width of a pencil eraser. Implant lenses are inserted into the capsular bag, the former home of the cataract lens, and a variety of functional implant designs are available for insertion, including toric implants, for astigmatism, and accommodating and multifocal implants, which attempt to return to the eye both distance and reading vision without the need for eyeglasses. Each patient must carefully weigh their expectations against the type of implant lens available to meet those expectations, as well as the potential problems and cost of the implant. (Once again, the style and size of the implant lens chosen for each patient vary, depending on a multitude of factors.)

Closure of the opening, or wound, was once a highly publicized issue in cataract surgery advertisements. Advertisements for "one-stitch" or "no-stitch" surgery, popularized by surgeons as the most modern, state-of-the-art approach to cataract surgery, at one time implied that the eye surgeons who used these techniques were a cut above all the rest (no pun intended). The truth is that the *majority* of eye surgeons today perform phacoemulsification and no-stitch surgery. Most small incision wounds don't need to be sutured, which helps patients recover faster. There's also less chance for unwanted postoperative astigmatism due to sutures being too tight or too loose. On the other hand, cataract procedures involving a larger surgical incision, rarely performed today, must be closed using many more sutures. Recuperation from these procedures is usually longer, with a greater chance for astigmatism.

At the end of surgery, you'll probably receive an antibiotic medication in the eye; then, a shield will be placed over it—sometimes even a light patch (especially if you received a retrobulbar block). You'll be taken to a recovery area where—finally—you can break your surgical fast. Eat, drink, and be merry, for the operation is over.

After Surgery

You'll be able to go home shortly after the operation, but somebody else must drive you because you'll still be drowsy. (Even if you think you're fully alert, have someone drive you anyway.) You'll probably need someone to drive you again for your first follow-up appointment, the next day because you will still have some residual anesthesia in your system and also will be getting adjusted to your new vision. Overall, most people don't find the surgery difficult; many patients report that it was painless and not nearly as taxing as they had expected.

You'll go back to your eye surgeon and/or your referring eye care provider for several postoperative visits. These are generally scheduled as follows: one on the day after surgery, another at 1 week, and then one 3–4 weeks afterward. You may need to be seen more frequently if you have any complications or an unusual postoperative course.

Rest and relaxation are the marching orders during the first 24 hours after cataract surgery. For most patients the evening of the operation usually includes some mild eye discomfort and headache, which can be treated with over-the-counter analgesics. Lingering postoperative drowsiness, an effect of the anesthesia, is not uncommon. (*Note:* Immediately report any severe pain, nausea, vomiting, or other unusual symptom to your eye surgeon.) The next day you'll go back to your surgeon and have the eye patch and shield removed (if you were given them after surgery). Many patients notice an immediate improvement in vision: lights are brighter, colors are more vivid, and even objects are better defined. Your vision will continue to improve gradually over the next several weeks.

The old restrictions—in which patients were warned not to lift or bend after cataract surgery—are becoming passé. Stories of patients dislodging implant lenses or tearing open their cataract wound as they bent over to tie their shoes or to brush their teeth now belong to cataract folklore. Today most cataract patients resume their normal activities—including reading, driving, and working—almost immediately after surgery. Recommendations regarding showering, bathing, and visiting the beauty parlor have also been changed. (However, it's a good idea to discuss these activities, as well as the resumption of golf, tennis, swimming, bowling, or gardening, with your doctor beforehand.) Common sense is usually your best guide to resuming normal activities after cataract surgery.

You'll probably want to wear some covering over the operated eye for 1–2 weeks after surgery, either your old eyeglasses or a lightly tinted pair of sunglasses. This will help protect the eye from an accidental finger (your own or a grandchild's), a foreign object, a bump on the eye, or other forms of trauma. At night you'll probably wear an eye shield for a short period of time after surgery to keep you from inadvertently rolling onto the operated eye or rubbing it during sleep. Antibiotic and anti-inflammatory eye drops are commonly prescribed after surgery to prevent eye infections and eliminate swelling and discomfort.

Complications

Complications can occur during any surgery, and it's no different for cataract surgery. Fortunately, the risk of complications is very low, but a very common one is when the bag that holds the lens tears or breaks during surgery. In these cases, sometimes a cleanup of the jelly (vitreous) that is coming from behind the lens in the back of the eye needs to be done (see chapter 1, figure 1.1), and if lens material has fallen back into the vitreous, this will require a retina surgeon to clean out the pieces.

Complications after cataract surgery are generally mild, but it's important for you to be aware of the warning signs.

Cystoid macular edema, a common problem, is a swelling that occurs in the retina after surgery. Fluid accumulates in small spaces in the area of the retina responsible for central or straight-ahead vision. This swelling can cause blurred vision during the weeks immediately following the operation. The edema usually goes away in 1–2 months without causing any damage to the retina or eye, but occasionally it can remain much longer and may require medical treatment. Diabetics are more at risk for this problem, and because of this, some surgeons will prophylactically prescribe a nonsteroidal eye drop before surgery to lessen the likelihood of this diabetic macular edema occurring after the operation.

Postoperative eye infection is another well-recognized complication of cataract surgery. The most severe form, which occurs in the eyeball, is called *endophthalmitis*. It is very difficult to treat, and the earlier it's diagnosed and treated, the better the chances for minimizing the damage from this potentially devastating complication. Endophthalmitis often causes the eye to become very red and painful, with an associated decrease in vision. It usually occurs within the first week after surgery. Although the problem isn't nearly as common today as it once was—thanks to sterile surgical techniques, plus the use of antibiotics—it's definitely something you should be aware of, so that you can seek treatment as soon as possible. Other, less serious postoperative infections such as bacterial conjunctivitis, allergic reactions to topical medications, and corneal swelling also may cause milder degrees of inflammation, discomfort, and alterations in vision.

Retinal detachment is another potentially serious postoperative complication. If there's any weakness in the retina at the time of cataract surgery, the retina can become loosened or detached by the procedure (see chapter 16). The tricky thing is that this may not happen immediately after surgery but may occur weeks or even months later. *If you've ever had cataract or any other form of eye surgery, contact your surgeon immediately if you notice the sudden onset of floaters, flashing lights, or a "curtain" that seems to be blocking part of your vision.* These may be signs of a retinal tear or detachment, and they should be evaluated immediately. The quicker this is discovered and treated, the better the chances for repair and a good visual outcome.

Other problems that may arise after cataract surgery include a marked *change in your eyeglass prescription*, making it difficult for you to adjust to your new vision after surgery. Healing can also lead to unwanted *astigmatism* in the eye (a complication that, fortunately, is much less common with smaller incisions). *Double vision* is also not uncommon, especially within the first 2 weeks after surgery. The brain has to get readjusted to the change in vision between the two eyes. When double vision persists or develops several weeks or months after the surgery, this may be due to a problem with one's ability to turn the images from each eye into a single picture. (This is best evaluated with special testing and may require a "prism" correction in your eyeglasses to help your eyes work together. For more on this, see chapter 2.) *Corneal swelling or damage*—much less common today with microsurgery—is another potential problem. This can lead to prolonged visual blurring after the surgery and, very rarely, may require a corneal transplant. Also, ptosis, or drooping of the eyelid, can occur after surgery from the use of the speculum to hold open the eye. Usually, this resolves on its own, but on rare occasions it does not, and sometimes the eyelid needs to be surgically lifted at a later time.

Other fairly common complications are *spontaneous anterior chamber bleeding* from the cataract wound and *recurrent postoperative inflammation*—both easily treated if promptly brought to the attention of the eye surgeon. Annoying *floaters* and *intermittent flashing* in the operated eye are also frequent postoperative complaints. These are related to a change in the vitreous dynamics in the back of the eye after surgery and should be brought to your eye doctor's attention, since they may be the first sign of a retinal tear or detachment (see chapter 16).

Although many patients worry about them, implants rarely slip out of place after surgery, and wounds very seldom leak, despite not being sutured closed. Again, we've come a long way from the days when these were common postoperative problems.

As potentially devastating as some complications can be after cataract surgery, if they're caught early and tended to properly, in most cases there's still an excellent chance that the eye can heal normally and you can have better vision than you had before surgery—even if you need a second surgery soon after the first to correct a particular intraoperative or postoperative problem. Unfortunately—although it doesn't happen often—there is a chance that if an infection gets out of control, a retina becomes badly detached, or a complication does not respond to treatment or management, you may end up with worse vision in the eye than you had before. Some patients have even lost their vision or their eye after cataract surgery. Although the local anesthesia we use today has significantly lower risks than general anesthesia, there have also been extremely rare instances in which patients have died during the procedure.

This is why, even though you may feel fine, your doctor will want to monitor you closely after the operation. It's also why after surgery you should call your doctor immediately at the first sign of unusual discomfort or a sudden change in vision. But again, for the vast majority of patients, serious complications are rare, and the benefits of clearer sight often far outweigh the risks of surgery.

How Will This Improve Your Life? Realistic Expectations

People have different expectations after cataract surgery, some realistic and others not. The vast majority of cataract surgeries are performed to clear up a person's vision or for a medical reason (such as improving the view to the back of the eye to help better monitor disease in the retina or optic nerve), and not to get rid of the need for eyeglasses. In fact, many people still need to wear glasses to fine-tune their vision after cataract surgery (see next section). Although we've all heard of people who swear they no longer need glasses after cataract surgery, most surgeons would agree that these fortunate souls are the exception rather than the rule. Your need for glasses after surgery depends a lot on the prior discussions you had with your eye surgeon. Before your surgery, if you told your surgeon that you like to read without your eyeglasses but don't mind wearing eyeglasses for seeing at a distance, an implant lens will be calculated and placed in your eye to target this result. On the other hand, if you prefer that your surgeon implant an intraocular lens to attempt to make you less dependent on eyeglasses to see at a distance, postoperatively you may need eyeglasses to read. If you asked for both distance and near vision without eyeglasses, a premium lens or monovision may be offered to you, but even still, neither will likely completely obviate the need for any eyeglasses. And there are those people who just want to see clearer after cataract surgery and don't care whether they still need eyeglasses. In fact, there are people who feel they look better in eyeglasses and don't want to give them up. Besides the discussion you have with your surgeon, the measurements and calculations made by your doctor before your surgery are also very important to help meet your expectations. Remember, implant lenses are artificial, and they're only so good at replacing the eye's focusing power. The more active you are, and the more you depend on good eyesight for activities such as driving and reading, the more likely you are to need corrective eyeglasses or contact lenses after surgery, perhaps even to just fine-tune your vision at certain times.

People who have had cataracts removed almost universally notice that colors are brighter and more vivid after the surgery. Since the cataract acts like a dirty window, removing it allows more light to pass to the back of the eye. (A particularly happy patient once returned after cataract surgery to tell me that she had been prepared to redo the wallpaper in her dining room. After the surgery, she realized that the wallpaper was fine, as bright and colorful as she remembered it being when she bought it; it had only seemed faded because of her cataract.) Night driving is easier, and so is reading, especially in dim light. Occasionally the increase in light makes people rely more on sunglasses when they go outside than they did before the operation.

Now that you have had one cataract removed, what should you do as the cataract in the other eye continues to advance? The criterion for surgery on the second eye is generally the same as that (discussed above) for the first eye and is dependent on how much the impaired vision from the cataract is impacting your lifestyle. However, a surgeon may operate on the second eye in other situations—for example, if someone has severe discomfort due to the visual imbalance resulting from the presence of a remaining cataract. This is particularly common when the cataract has been removed from a nondominant eye; suddenly the nondominant eye has better vision than the dominant eye, and the brain becomes “confused.” This conflict can cause visual discomfort until the cataract is removed from the dominant eye and binocular vision is restored.

No two operations are ever the same, and so it is with cataract surgery. Many people feel that the second operation took longer, hurt more, or otherwise did not go as well as the first. Rarely do they report that it was a better experience. But as with childbirth, recollections of the event fade with time, making a comparison very difficult. (*Note:* This applies to listening to friends’ experiences too. When it comes to cataract surgery, improved eyesight often seems to cloud the memory.) Be cautiously optimistic about the surgery, and you’ll have a better chance of being pleasantly surprised.

Getting Rid of Eyeglasses after Cataract Surgery—Fact or Myth?

Everyone who is about to undergo cataract surgery has different visual expectations. Of course, after surgery people want to see more clearly, read more comfortably, and get rid of visual disturbances such as glare and halos around lights. Seeing better is the reason behind cataract surgery, even if you still will need an eyeglass correction (or contact lenses) to achieve improved vision. But how about all your friends who said that they no longer needed glasses after cataract surgery? Are they being truthful, or are they exaggerating? Well, in most cases it might be a little bit of both.

It all starts with having a very frank and honest discussion with your cataract surgeon about your visual expectations after cataract surgery (see above). Do you care if you will need to wear glasses after your cataract surgery to "fine-tune" your visual result? Many people like how they look in glasses and really don't care if they will still be wearing them to maximize their vision after cataract surgery. Other people are not only looking to see better but also looking forward to becoming less dependent on glasses after their operation. Some people are even under the impression that they will never need glasses again after cataract surgery.

So be sure to speak with your cataract surgeon *before* your surgery. This discussion is extremely important if you are looking forward to *not* wearing glasses after cataract surgery, or at least becoming less dependent on them for certain tasks like driving, working on the computer, or reading a book. If that is the case, your surgeon will ask you if after surgery you would prefer to see at distance without glasses, or would prefer to be able to read without glasses, or would really like to do both. Your answer will help the surgeon decide on your target postoperative vision and where to aim their intraocular implant lens calculations to meet your expectations. People who want to see both at distance and near without glasses after cataract surgery present more of a challenge for surgeons. But don't worry, there are options for you, and as instrumentation, experience, and implant lens calculations improve, so does your surgeon's ability to meet your expectations.

It is beyond the scope of this book to go into an in-depth discussion of how a cataract surgeon can meet the expectations of people who want to have both distance and near vision without glasses after surgery. New preoperative measurement techniques and implant lens designs are being developed and tested to achieve this postoperative visual holy grail. In a broad sense, achieving both distance and near vision to make a person less dependent on glasses after cataract surgery can be achieved by carefully establishing the target vision for one or both eyes and then using either spherical or toric intraocular implant lenses (the latter for people with astigmatism) to hit that target.

Monovision (or mini-monovision; see chapters 6 and 7) has been a popular way of helping a person achieve both distance and reading vision following cataract surgery. As discussed in the contact lens chapter, with monovision a person's dominant eye can be targeted for distance vision without glasses and the person's nondominant eye can be calculated for reading vision, either at an intermediate range for things like the computer (mini-monovision) or for closer reading vision like reading in bed (monovision). Multifocal intraocular implant lenses are also an option to achieve postoperative distance and reading vision after cataract surgery. As mentioned previously, these "premium lenses" are like progressive eyeglasses, and through various designs, they incorporate multiple lens powers into the intraocular implant to enable the eye to achieve variable focusing from distance to near vision. Even if you have astigmatism (an eye shaped more like the different curves of an American football than the even and uniform curves of a basketball), toric lenses that correct for astigmatism can help you achieve the above-mentioned monovision and multifocal solutions to lessen your dependence on glasses after cataract surgery.

The "Second Cataract" behind the Implant Lens: Lasers in the Management of Cataracts

Lasers—highly sophisticated instruments that harness energy and release it on demand at a specific point—have greatly improved our ability to treat eye disease. A question we're regularly asked by patients contemplating cataract surgery is, "Do you do laser cataract surgery?" Well, we all do, yet we all don't. Confused? So are patients. Much of the bewilderment stems from marketing campaigns by ophthalmologists hoping to convey the idea that they're one step ahead of the competition. The bottom line is that all ophthalmologists basically perform the same cataract extraction operations with implantation of IOLs. So where do lasers come in?

Remember, we treat the cataract surgically by removing the hazy lens, most often with phacoemulsification, as described in detail above. But lasers don't work that way; we can't simply use a laser to cut a clear zone through the lens or remove it. As of writing this book, femtosecond lasers, due to their precision and reproducibility, have been advocated and are used by some surgeons in certain cutting and preparation steps prior to removal of the lens with phacoemulsification. This laser adds significant cost to the cataract procedure, and its benefit over traditional techniques is hotly debated in ophthalmology.

But we can still use other lasers to treat cataracts—kind of. Sometimes, with time, the back portion of the lens bag that was left in the eye, which is now located behind the intraocular implant lens, becomes very cloudy. This "second cataract," or opacified posterior capsule, can cause a gradual decrease in vision *even though the cataract has been removed*. In the past an eye surgeon needed to insert a needle into the eye to open this cloudy membrane. Ophthalmic scientists later developed lasers (YAG lasers) able to open these membranes with less risk than the needle technique. This outpatient procedure is virtually painless and usually provides immediate improvement in a patient's vision.

So this is how most eye surgeons these days explain it to patients who ask about laser cataract surgery: Cataract surgery requires removing the cataract lens from the eye, which lasers can't do. Lasers are used by some cataract surgeons for certain steps, but the benefit is debatable and the cost is high. On the other hand, a laser can be used later after cataract surgery, if necessary, when a cloudiness develops behind the implant lens.

Special Eyeglass Considerations after Cataract Surgery

Most people who have had cataract surgery eventually need some form of eyeglasses to maximize their distance or reading vision. As discussed previously, this has a lot to do with a person's own visual demands and level of activity.

No two patients are the same; everyone heals at a different rate, and each surgery may cause a different amount of postoperative swelling. Most patients get their "final" eyeglass prescription about 4–6 weeks after surgery. But as your eye continues to heal over the first year, your prescription may change again at 6 months to a year later; even after this, you may still require slight alterations in your prescription from time to time.

What kind of eyeglasses will you need after cataract surgery? Again, much depends on you. Important considerations include the style of glasses you wore before the operation, your particular visual needs after surgery, and how much you want to spend. Bifocals, trifocals, and no-line progressive lenses are popular options because these are usually what patients wore before surgery, and they continue to provide corrected vision at various distances after surgery. Occasionally patients require only single-vision distance or reading glasses after cataract surgery. Some patients are even fortunate enough to be able to use inexpensive premade drugstore reading glasses. Contact lenses can even be worn after cataract surgery if you have worn them before or are interested in trying them (see chapter 6).

Similarly, the choice of various eyeglass lens options is largely up to you. Options include antireflective lenses, polarized lenses, photochromic lenses (which change color when you move from a light area—like outside—to a darker area, and vice versa), and other tinted lenses. Many people experience visual discomfort from bright sunlight and indoor light; antireflective coatings on lenses can reduce the glare and dazzle of lights, especially at night. (These lenses have also been helpful for people who play indoor tennis, where the lighting is often poor.) UV protection in the intraocular implant lens or glasses after cataract surgery is felt to be important to protect the retina once the natural lens has been removed. (For more on lens options, see chapter 5.)

Some Questions You May Have about Cataracts

Do cataracts need to be "ripe" before they can be removed?

Although many years ago it was necessary for cataracts to mature to a certain stage before a patient could have cataract surgery, this is not true today. Modern microsurgical techniques, because of lower complication rates, have made it possible to remove cataracts at earlier stages of development based on the level of visual problems they are causing, not on their degree of maturity.

What is phacoemulsification cataract surgery?

Phacoemulsification is an advanced cataract-removing technique that uses ultrasound waves to shatter the cataract in the eye. Suction is then used to remove the lens fragments, making room for an implant lens. The tiny incision used in this technique either seals itself closed or requires only one stitch thinner than a strand of human hair. Most people recuperate quickly from this procedure and are able to resume their normal activities within a few days.

How can I find a good cataract surgeon?

Perhaps a better thought is "how to find a good doctor" because a good cataract surgeon will have all the characteristics of a good doctor plus excellent surgical skills. In this case, *good* implies a skilled medical and surgical ophthalmologist who is caring and able to communicate well with patients. Whether you're looking for a general medical doctor or other health care provider, dentist, or eye doctor, finding the right one for *you* can be the most important step.

Frankly, the ideal way to find the right eye doctor is probably not the Yellow Pages. Many doctors are also a little suspicious of their colleagues who overzealously promote themselves in newspaper, television, and radio advertisements. On the other hand, relatives and friends who have had cataracts or cataract surgery are usually excellent sources for referrals. If your eye doctor is not the person who will be doing your cataract surgery, ask them for a referral. Talk to your other health care providers too about the eye surgeons in your area. If you want to check out potential eye surgeons online, you may want to access the dedicated search page "Find an Ophthalmologist" available through the largest professional society for eye surgeons in the United States: the American Academy of Ophthalmology (https://secure.aao.org/aao/find-ophthalmologist).

When evaluating potential surgeons online, it's helpful to consider the following:

1. Board certification status
2. Prior training
3. Years in practice and surgical volume
4. Surgery is performed at an accredited surgical facility
5. Online ratings and comments can be helpful but may not be accurate

Finally, make an appointment to meet the eye surgeon, in order to make an informed decision. Ask to speak with some of the surgeon's other patients with cataracts or who have had cataract surgery. Ask how often the doctor performs cataract surgery. *This is* *extremely important*. You don't want someone who does this procedure only occasionally; you want someone who has performed this surgery for many years. Specifically, find out whether they perform phacoemulsification, as well as whether you are a candidate for this technique. Make sure that you're comfortable with the surgeon's postoperative care arrangement.

Remember, you have only one pair of eyes. And although cataract surgery is fairly safe these days, not all cataract surgeons are equal. A poorly performed or complicated surgery can cause you problems for the rest of your life.

I'm in a managed care program. Will my program cover cataract surgery?

Cataract surgery is one of the most commonly covered health insurance services. The bottom line is that it costs insurance companies, as well as state and national health insurance programs like Medicare, a lot of money each year. As managed health care becomes more popular, there may be increased pressure on doctors and hospitals to perform fewer cataract surgeries at lower levels of reimbursement. There has even been talk of only covering surgery on one eye. The choice of surgeon, facility, and time of the operation may also change from a patient-doctor decision to a health insurance company decision. It is important to be aware of your health insurance coverage concerning your eye care, especially cataract surgery. Being informed about your options as a patient will help you get the care you desire when it comes time for cataract surgery.

If I have cataract surgery on one eye, how long do I have to wait to have the second eye done? Can't I have both eyes fixed at once?

Anyone who would benefit from cataract surgery on both eyes usually has two separate surgery dates. The time between operations usually averages about 2 weeks. Doctors may advise someone to have both cataracts operated on at the same time. One thing to consider, though, is that for some people it can be helpful to leave one eye unoperated, to make it easier for them to see to get around after the operation. In addition, any complications during or after surgery may change your surgeon's approach when it comes time to operate on the other eye. And finally, depending on your experience with the first operation, you may decide you don't even want to have the other eye done right away, if at all.

Can cataracts grow back after cataract surgery?

No, because the lens has been removed, and an artificial one has been implanted in its place. Occasionally, however, a cloudy film can develop *behind* the implant lens (see above). Ophthalmologists use state-of-the-art laser surgery to remove this cloudy film, thereby restoring the person's vision.

Chapter 9

GLAUCOMA, THE "SILENT THIEF"

It's often called the silent thief of vision.

One of the most troubling conditions to affect the eye, glaucoma indeed sneaks in, with the stealth of a master prowler. It rarely causes warning symptoms and yet is the second leading cause of blindness globally (following cataracts)—theoretically accounting for about 12 percent of blindness in the world. An estimated 2 out of every 100 people—nearly 2.2 million people in the United States—over age 40 have glaucoma. And it is estimated that half of those with glaucoma don't know that they have it. Understandably, detecting and managing glaucoma is of major concern to eye doctors.

It is not a simple disease. In most cases glaucoma is instead a *collection* of eye problems that damage the optic nerve and lead to characteristic patterns of visual field loss. Its onset is furtive, usually very gradual over several years; during this time, people seldom have any symptoms to alert them of the visual damage being caused by glaucoma. And although elevated eye pressure is one of the primary risk factors associated with developing glaucoma, it is not present in all cases of this insidious disease process (more on this unusual form of glaucoma, sometimes called *normal-tension* or *low-tension glaucoma*, later in this chapter). Furthermore, whether a person has elevated eye pressures or not, most people who develop glaucoma can't feel it. Even the loss of peripheral vision, one of the first signs of trouble, is so subtle that for many people it's virtually unnoticeable.

One form of the disease, called *acute closed-angle glaucoma*, in which the pressure in the eye rises rapidly owing to mechanical blockage of the flow of fluid out of the eye, does cause acute eye pain. This condition hits suddenly and is *an ophthalmic emergency that requires immediate treatment*. But it's also pretty rare.

The more common form of glaucoma is called *open-angle glaucoma*. This is our old nemesis, the silent thief. Open-angle glaucoma can advance undetected for years; during this time, in typical cases, constantly elevated eye pressure can cause irreversible vision loss by severely damaging the nerve fibers that pass through the optic nerve in the back of the eye. The nerve fibers most frequently damaged by this are those that make peripheral vision possible. Losing enough peripheral vision can, over time, lead to tunnel vision, in which people can see only when they're looking directly ahead. In people with very advanced cases of glaucoma, this loss of vision can deteriorate into total blindness.

What's your best protection against the potentially devastating consequences of glaucoma? Because its onset is so insidious, don't trust yourself to notice early symptoms; chances are, you won't. But your eye doctor will. *This means that regular eye exams are essential. Only by monitoring the eyes regularly can glaucoma be detected early and managed well.*

What Happens to the Eyes in Glaucoma

Think of the eye as a balloon. Inside the eye there's a fine balance between the outer atmospheric pressure and the eye's own internal pressure. This balance helps maintain the shape of the eye, or the balloon. Too much or too little internal pressure can easily change this balance.

Like a balloon, the eye is basically hollow, but it has an inner core that maintains its shape. This core is made up of two separate compartments, one filled with fluid and another filled with jelly. The front compartment, or cavity, of the eye is filled with a fluid called aqueous. Within this watery cavity (the aqueous cavity) are two areas, the *anterior chamber* and the *posterior chamber*, both of which are located in front of the lens. Behind the lens, the rear cavity (the vitreous cavity) holds a jellylike substance called vitreous (figure 9.1).

Together, the aqueous and vitreous cavities help maintain the eye's shape. While the vitreous, like jelly, is relatively inert and stable, the aqueous has a dynamic turnover with constant production of new fluid entering the eye and drainage of old fluid out—much like what happens in a storm drain. The big problem in many people with glaucoma—the elevated pressure that damages the optic nerve—is caused when there's an issue with the drainage. In keeping with our image of a storm drain, imagine the drain clogged by leaves, and the poor drainage—and water backup—that results.

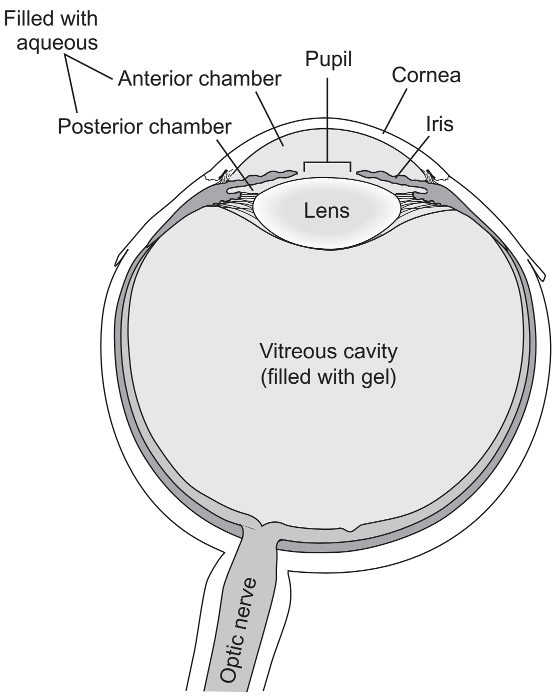

Figure 9.1. Fluid and gel cavities in the eye: the vitreous cavity is filled with gel, and the anterior and posterior chambers are filled with aqueous (fluid)

Now for a little anatomy. The anterior chamber of the eye, which contains most of the aqueous fluid, is bordered by the back surface of the cornea and the front surface of the iris. The posterior chamber, which also contains aqueous fluid, is bordered by the back surface of the iris and the front surface of the lens.

The fluid itself is made by the ciliary body, eye tissue located near the root of the iris in the posterior chamber. It's then pumped into the posterior chamber, where it circulates through the pupillary space and into the anterior chamber of the eye. The fluid drains out from the anterior chamber—and this is critical—*at an angle*, where the cornea and iris meet. (This is called the anterior chamber angle.) As it leaves the eye through this angle, the aqueous fluid passes through a filter of connective tissue called the *trabecular meshwork*.

The trabecular meshwork encircles the eye like a ring on a finger. Normally the anterior chamber angle is wide open, presenting a straight shot to the trabecular meshwork, and the clear aqueous fluid freely exits the eye. It filters out through the trabecular meshwork into an aqueduct called *Schlemm canal* (figure 9.2). Schlemm canal transports the fluid through a network of aqueous veins. The aqueous is then gradually absorbed into the blood supply by vessels in the conjunctiva.

It's not a terribly complicated drainage system, but it has plenty of places where trouble can occur. When the flow of aqueous is interfered with somewhere along the route—from its beginnings, at the ciliary body, to the trabecular meshwork and Schlemm canal—the fluid backs up. Then, pressure within the eye—picture an overfilled water balloon—begins to rise. This is the elevated pressure that can damage the optic nerve and gradually lead to nerve death and loss of peripheral vision—if, that is, the pressure is not lowered by treatment.

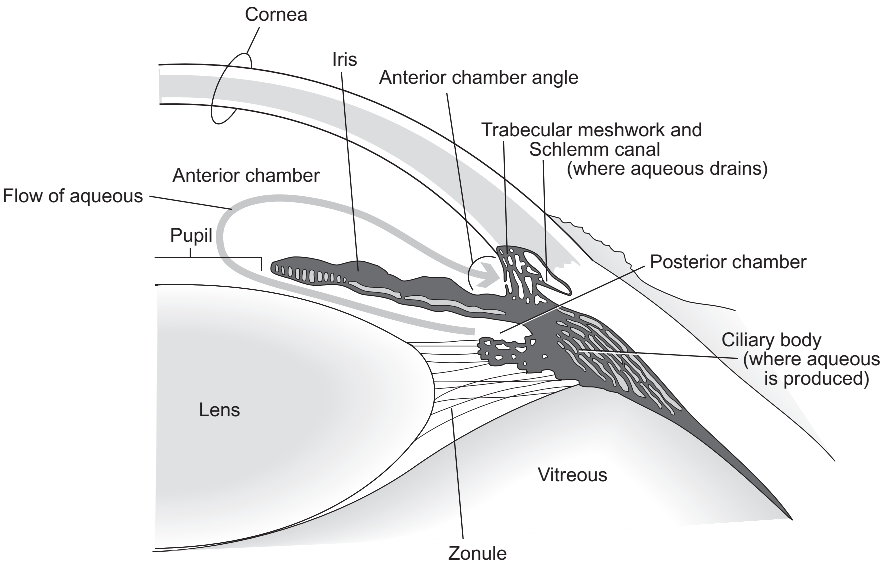

Figure 9.2. The path of fluid movement in the eye: aqueous flows from the ciliary body to the trabecular meshwork and Schlemm canal, where it drains from the eye

Types of Glaucoma

The type of glaucoma—there are two basic forms—depends on the specific configuration of the eye's anterior chamber angle (see above) in a person with optic nerve changes characteristic for glaucoma. Closed-angle glaucoma (also called *narrow-angle glaucoma* or *angle-closure glaucoma*) results when the fluid's access to the trabecular meshwork in the angle is physically blocked by the root of the iris. The more common condition, open-angle glaucoma, happens when, despite an open drain in the anterior chamber angle, a person develops optic nerve damage characteristic of glaucoma. *Note:* Unfortunately, it's possible for someone to develop a combination of both types of glaucoma in the same eye.

Closed-Angle Glaucoma

The problem with closed-angle glaucoma is an obstruction in the drainage of aqueous fluid due to a narrowing in the angle of the anterior chamber (figure 9.3). This anatomical defect can best be seen during a comprehensive eye examination with a technique known as *gonioscopy*, using a specially designed contact lens with angled mirrors to observe the anterior chamber angle. In people with a narrowed anterior chamber angle, the iris appears to crowd this area, limiting aqueous access to the trabecular meshwork. The angle obstruction can occur suddenly (acute closed-angle) or over a long period of time (chronic closed-angle).

Farsighted people, who have smaller eyeballs to begin with, are more prone to developing closed-angle glaucoma; as you might imagine, in a smaller eye it's easier for the iris to block the anterior chamber angle. The prevalence of closed-angle glaucoma has also

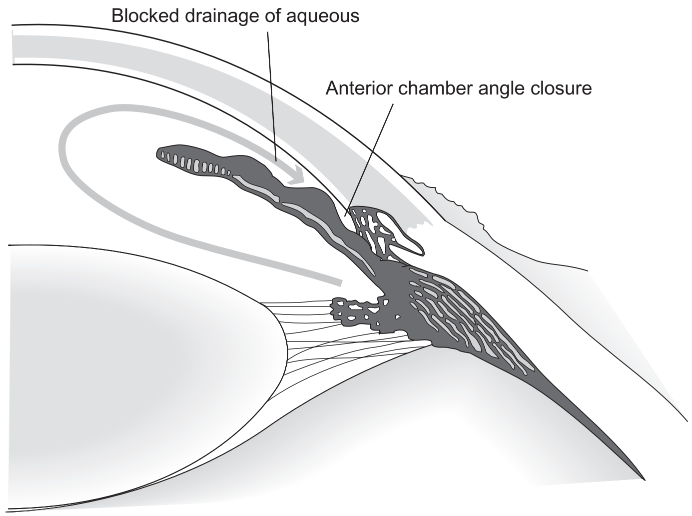

Figure 9.3. Closed-angle glaucoma: drainage of aqueous is blocked by narrowing or closure of the anterior chamber angle

been found to be higher in Asian countries. A survey of a Chinese population showed that the risk of closed-angle glaucoma was six times higher in people with any family history compared to those people in the population without any family members with closed-angle glaucoma.

Also, some people were just born with narrow anterior chamber angles; although most of them have normal eye pressures, their risk of acute closed-angle glaucoma is higher. And for these people, even normal activities can bring on an attack—watching a movie in a darkened theater, for example, which causes the pupil to dilate mildly, displacing the iris into the narrow anterior chamber angle. Or trouble can be incited by certain dilating eye drops or oral medications such as allergy and cold medications, antidepressants, and some urological drugs, which can affect the position of the iris and lead to a precarious further narrowing of this angle. If this narrowing becomes extreme enough to block or close a significant portion of the anterior chamber angle, the eye pressure will rise. This will develop into a harmful cycle of increased angle blockage and higher eye pressure. Eventually, when the eye pressure rises to very high levels, the person will have a painful, red eye. Most people also experience nausea, vomiting, and a severe headache during an attack of acute closed-angle glaucoma. Again, the consequences of an acute angle-closure attack can be devastating. *This is a medical emergency and must be treated immediately and aggressively to preserve vision*.

The primary goal of emergency treatment is to lower the pressure in the eye. This may involve eye drops, pills, and occasionally intravenous or intramuscular injections. In the acute stages of an attack, it may also be necessary to operate with laser surgery or incisional surgery if medical treatment fails to lower the eye pressure.

Laser or surgical treatment makes a hole in the iris so that the fluid can escape from behind the iris. This procedure, called a *peripheral iridotomy* (opening a hole in the iris with a laser) or *peripheral iridectomy* (surgical removal of iris tissue to form a hole in the iris), creates an opening for runoff in the periphery of the iris, improving the flow of aqueous fluid from the posterior chamber into the anterior chamber. The iridotomy or iridectomy is, in effect, a shortcut, allowing aqueous fluid to bypass the narrowed approach to the trabecular meshwork.

Peripheral iridotomies and iridectomies are often recommended as a means of prevention against these attacks. For example, the procedure is recommended in the second eye of someone who has suffered through an attack in one eye already. (Preventive, or prophylactic, peripheral iridotomies and iridectomies are discussed later in this chapter.)

Closed-angle glaucoma can also develop more chronically over time with or without an obvious identifiable cause such as an unusually "ripe" and enlarged cataract, abnormal blood vessel growth in the eye, eye inflammation, past eye trauma, or even eye tumors. The anterior chamber angle gradually seals closed to a point where the pressure builds up in the eyes. This chronic closure of the angle is less painful than the acute variety, but it can be just as visually devastating.

Open-Angle Glaucoma

Open-angle glaucoma—by far the more common form of glaucoma—is a chronic, slowly progressive optic nerve disease causing damage to the optic nerve and resulting in characteristic patterns of visual field loss (figure 9.4). Risk factors include elevated eye pressure, advanced age, race, a thin central cornea, and a family history of glaucoma. Although elevated eye pressure is not seen in all cases of open-angle glaucoma, it is a major risk factor, and when present, the site of trouble is considered to be the filter, or trabecular meshwork, leading into Schlemm canal. There's no single anatomical problem causing the drainage block, as in closed-angle glaucoma. Instead, in many conditions that can lead to open-angle glaucoma,

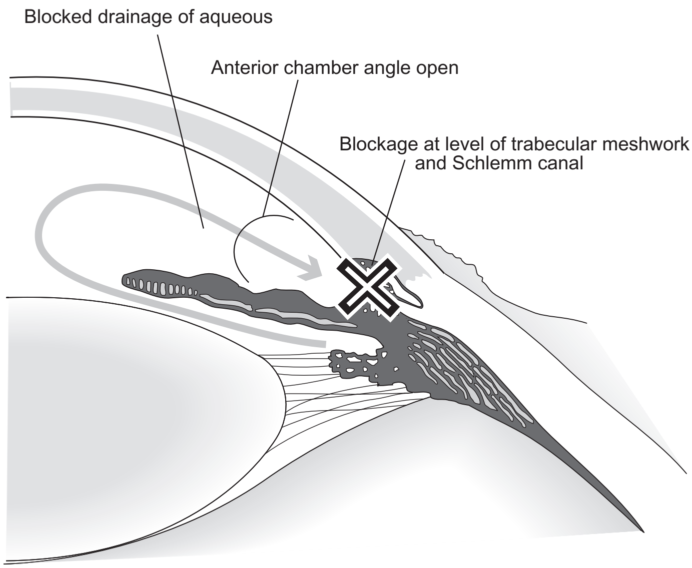

Figure 9.4. Open-angle glaucoma: drainage of aqueous is blocked at level of trabecular meshwork

the trabecular meshwork is clogged or obstructed. What are some of the things that can go wrong and lead to open-angle glaucoma? For one, inflammation in the anterior portion of the eye, such as *iritis*, can temporarily clog the trabecular meshwork with inflammatory cells. Also, bleeding, or *hyphema*, a separate problem in the anterior chamber, can lead to elevated eye pressure through a similar mechanism. In hyphema, red blood cells collect in and on the trabecular meshwork, impeding the outflow of aqueous fluid.

In *pigment dispersion syndrome*, another form of open-angle glaucoma, pigment granules from the iris drop off into the aqueous-filled anterior chamber, especially during exercise or other exertion. These pigment cells are jiggled loose from the surface of the iris and flow with the aqueous to the trabecular meshwork filter in the anterior chamber angle. The trabecular meshwork can eventually become clogged with these cells; this impedes further aqueous drainage and leads to temporary elevations in eye pressure. People with this condition may experience dull pain in their eyes and see halos around lights after exercise or vigorous exertion. Pigmentary glaucoma is three times more common in men than women. It is especially seen in men between the ages of 20 and 50 years old who are mildly to moderately nearsighted.

Pseudoexfoliative glaucoma, yet another form of open-angle glaucoma, happens when the trabecular meshwork becomes clogged with cells that flake off, like dandruff, in the anterior chamber of the eye. This dandruff-like material accounts for more than 50 percent of open-angle glaucoma cases in Scandinavian countries. The glaucoma resulting from pseudoexfoliation can be difficult to treat with a worse overall prognosis when compared to most other forms of open-angle glaucoma. Additionally, pseudoexfoliation can weaken the zonular supports around the lens of the eye, potentially adding an increased risk for complications during eye surgery such as cataract extraction.

The most common form of open-angle glaucoma is *primary open-angle glaucoma*. In this case the use of the word *primary* means that doctors are not certain what's causing the blockage at the trabecular meshwork. They know it's *not*, however, due to a narrowed anterior chamber angle (thus, by default, it's a form of open-angle glaucoma). Nor is it caused by a recognizable cell or substance clogging the trabecular meshwork, as in the forms of open-angle glaucoma mentioned above. Some researchers believe that the pressure elevation in primary open-angle glaucoma may be due to a change in the structural integrity of the trabecular meshwork. Others have suggested that a problem exists with the drainage through Schlemm canal.

Whatever the exact mechanism, the changes in the trabecular meshwork seen in this form of glaucoma have also been observed in older people who do *not* have glaucoma. Therefore, open-angle glaucoma cannot simply be understood as a clogged trabecular meshwork in the eye, leading to elevated eye pressure that damages the optic nerve. Many other factors such as age, race, and family history also play a role in this optic nerve disease process and complicate our understanding of glaucoma. This is why many ophthalmologists, in moments of frustration when trying to control difficult cases of glaucoma, have declared that this disorder is an aging process that is often as tough to treat as wrinkling skin. *This is not true*. We have many successful ways of controlling glaucoma, as we will soon discuss.

Normal-Tension (Low-Tension) Glaucoma

Normal eye pressure is usually considered to be 21 millimeters of mercury (mm Hg) or less. Some people have normal pressures within the eye but nevertheless have progressive optic disc and visual field changes similar to those observed in people with primary open-angle glaucoma (which, as noted above, is usually due to elevated eye pressures). When someone develops glaucoma despite having normal eye pressures, that person is said to have *normal-tension glaucoma* or *low-tension glaucoma*. This diagnosis is made only after other ocular or systemic problems that can damage the optic nerve and cause visual field loss are ruled out. These include a period of past elevated eye pressure (in this case, even though the ocular pressure has returned to normal, there is residual optic nerve damage), daily fluctuations of eye pressures in and out of the "normal" range, and a past episode of very low blood pressure as the result of severe blood loss or myocardial infarction. Some ophthalmologists even question whether normal-tension glaucoma represents a distinct optic nerve disease entity or whether it is simply a form of primary open-angle glaucoma with eye pressures in the normal range. Supporters of the latter theory believe that the term *normal-tension glaucoma* should no longer be used to describe this entity. I choose to use the term *normal-tension glaucoma* in this book as a way to highlight the importance of getting comprehensive eye exams and not just a screening of eye pressure, which is often offered at health fairs and free screening events.

It is believed that many people have *undiagnosed* normal-tension glaucoma. Eye doctors often miss diagnosing this disorder because the person has normal intraocular pressure (IOP) during an eye examination. This is why the doctor must carefully evaluate the eye for other signs of glaucoma, such as significant optic disc changes and visual field loss. Many glaucoma screening programs at health fairs and senior centers also rely heavily on the IOP readings to screen large numbers of people for glaucoma, so (obviously) they often miss picking up normal-tension glaucoma.

What's causing optic nerve damage in people with normal-tension glaucoma despite eye pressures in the normal range? Unfortunately, we don't yet know the answer to this question. Perhaps *normal eye pressure* is a relative term, since some people can tolerate IOPs of 24 mm Hg for years without developing optic nerve damage. For other people an IOP of even 16 mm Hg may be too high, causing damage to their optic nerve and visual field loss. It has also long been speculated that this increased susceptibility may be related to a poor blood supply to the optic nerve. Or there may be a defect in the support tissues of the optic nerve that makes the nerve more likely to be damaged at lower eye pressures.

The treatment of normal-tension glaucoma, as in other forms of glaucoma, is directed at lowering the eye pressure as much as possible, first medically and later with lasers and/or surgery, if necessary. Patients are also thoroughly evaluated medically to make sure they do not have an underlying anemia or other condition that can directly or indirectly affect the optic nerve. A brain scan is sometimes part of this workup to evaluate the health of the optic nerve behind the eyeball.

We still know little about what makes one person's optic nerve susceptible and another person's resistant to changes in eye pressure. Normal-tension glaucoma underscores this problem, as well as the complex nature of glaucoma.

Diagnosing Glaucoma

Measuring Pressure within the Eye

Although today we recognize that glaucoma can occur in eyes with "normal" eye pressure, the relationship between elevated eye pressure and visual field loss was recognized centuries ago, though at that time physicians were unable to measure eye pressure accurately. For many years the accepted method of estimating the pressure in the eyeball was simply to feel, or "ballot," the eye with one's fingers. Eye doctors of the eighteenth and early nineteenth centuries prided themselves on their ability to judge eye pressure simply "by feel." So confident were they, in fact, that they scoffed at the development of more objective methods to measure pressure.

But eventually eye doctors were won over by the sensitivity of measurements made through *tonometry*, a noninvasive way to measure pressure within the eye. Over the years many tonometry techniques have been developed, all of them measuring how much force is required to indent or flatten the cornea. This measurement, in turn, allows the ophthalmologist to estimate the pressure in the eye.

Many tonometers use weights or specially designed contact tips, which are placed on the eye or cornea. The *Goldmann contact tonometer*, or "blue light" test—many people are familiar with this from eye examinations—is generally accepted to be the "gold standard" for measuring eye pressure. This is an *applanation tonometry system*, in which a circular tip is placed on an anesthetized cornea. A scale measures the amount of pressure in millimeters of mercury required to cause a specific degree of corneal flattening. Fluorescein (orange) dye and a cobalt blue filtered light are used to help illuminate the tip as it comes in contact with the eye. Many patients are fearful of tonometry, or the "glaucoma test." Most are squeamish about having someone touching their eyes (in applanation tonometry, it's often necessary for the examiner to hold open the patient's eyelids). Others are afraid because they remember some negative past experiences with tonometry techniques, particularly the frightening and sudden loud click associated with some "air-puff" tonometers.

Although it's difficult to define normal eye pressure—since what's "normal" varies from person to person—it is generally accepted that the "average" IOP of individuals without glaucoma is around 16 mm Hg. In the general population, however, there appear to be more people with pressure readings above 16 mm Hg than would be expected on a purely statistical basis. Therefore, it is only when someone's pressures reach above 20 or 21 mm Hg that ophthalmologists may consider additional tests to diagnose or rule out a diagnosis of glaucoma.

Anyone with IOPs above 21 mm Hg is considered to have elevated IOP. Many people with elevated IOP never go on to develop glaucoma, but they must be carefully monitored for early signs of it. Some people have eye pressures of 24 mm Hg for their entire lives and do not develop any signs of glaucoma, while other people with this pressure develop severe glaucoma. Even more perplexing are those patients with *low* eye pressure (see above) who develop glaucoma, which suggests, again, that glaucoma is caused by other factors besides elevated eye pressure. And although IOP does appear to be a very important factor, IOP readings by themselves are inadequate predictors of glaucoma.

To make things still more complicated, although IOPs are usually highest in the early morning, they can fluctuate *day to day* and even *hour to hour*. They can be affected by such variables as age, gender, race, the presence of myopia, a family history of glaucoma, medications (for example, steroids and antihistamines), and certain systemic disorders (such as eye disease related to a thyroid disorder). The risk of developing glaucoma in people with diabetes, hypertension, or high blood pressure has been studied, but results are inconclusive, so the jury is still out.

The Effects of Elevated Eye Pressure in Glaucoma

Let's take a moment to review the machinery of the eye. First, of course, light rays enter the eye. They strike the retina, where they induce chemical reactions in specialized cells called rods and cones. (For more on the eye's anatomy, see chapter 1.) These cells then send impulses to the brain via nerve fibers—tiny telegraph lines, if you will, conveying essential information. The mass of all of these nerve fibers—approximately one million in all—forms the optic nerve, way at the back of the eye. The optic nerve's job is to transmit all of this information to the brain, where it's translated into images that make sense. The exact area where these fibers come together at the back of the eye, before exiting the eyeball, is called the *optic nerve head* or *disc*. Within this optic disc, major retinal blood vessels enter and exit the inner part of the eyeball.

What does all this have to do with glaucoma? IOP elevations—such as those found in the majority of people with glaucoma—cause structural damage to these nerve fibers at the optic disc. Exactly *why* these fibers are so susceptible to damage here is not well understood. In normal aging, these fibers appear to diminish gradually anyway, but in people with elevated eye pressures and glaucoma, this loss is accelerated.

These one million nerve fibers are somewhat loosely organized. The fibers responsible for central vision are generally located on the temporal side of the optic disc (the side nearest the temples). The ones responsible for peripheral vision are mainly found at the top, bottom, and nasal side of the disc, and it is theorized that these are the first to be damaged by elevated eye pressure. Unfortunately, these peripheral fibers can be damaged before any loss in visual field can be noticed by the patient or discovered in an eye exam. When this loss of peripheral vision is detectable, the structural change that eye doctors see on the disc looks as if someone has excavated, or scooped out, part of the normally flat optic disc, making it resemble a cup (see figure 9.5).

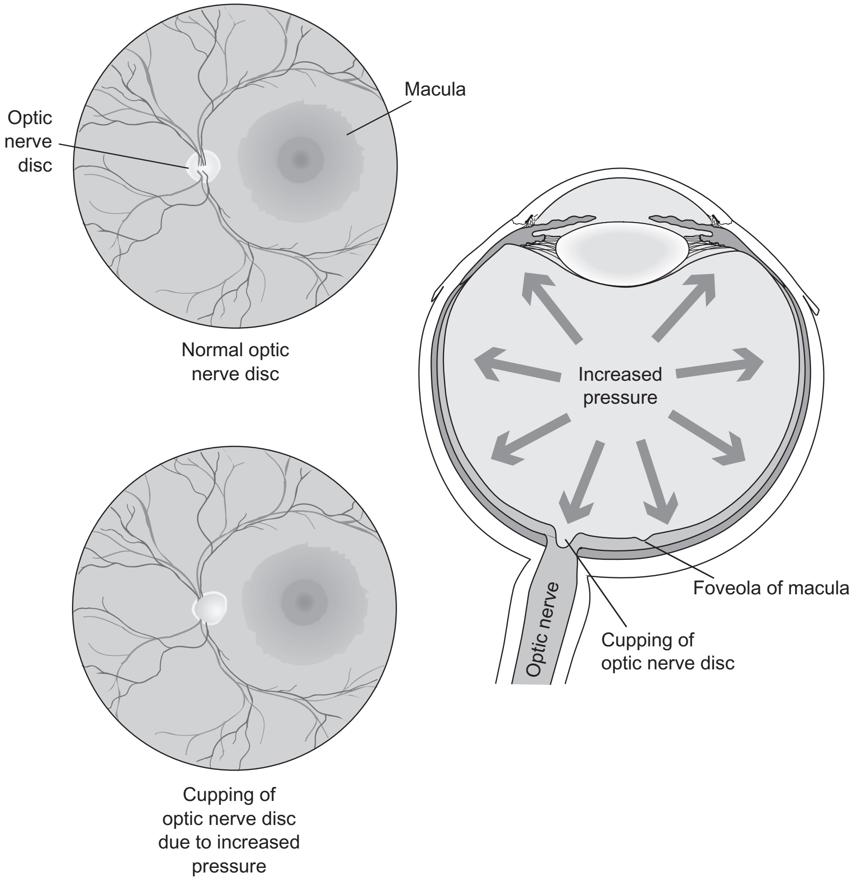

Figure 9.5. Cupping of optic nerve disc caused by elevated ocular pressure

At first this scooping is subtle and mild; in advanced glaucoma, however, the optic disc can become markedly excavated, as if someone had physically drilled out the center of its tissue. When this happens, as you can imagine, many nerve fibers have been lost and the loss of peripheral vision is severe. At this stage, there may be loss of central vision too.

Eye doctors often use the term *cupping* to refer to the relationship between the size of this scooping and the overall size of the optic nerve disc. The cup-to-disc ratio—basically, how much of the disc is damaged—is estimated by the eye doctor when they directly observe the optic nerve head using one of several techniques during an eye examination. Loss of peripheral vision—eye doctors often say "loss of visual field"—is found with increased degrees of cup-to-disc (C:D) ratio. The larger the C:D ratio, the greater the chance of visual field loss. A C:D ratio of .1 implies a relatively healthy optic nerve head with minimal cupping—an optic nerve head usually not associated with glaucoma. A ratio of .9, on the other hand, refers to a major degree of excavation and tissue loss, usually seen in advanced glaucoma. The C:D ratio and its progression over time are important measures for detecting and managing glaucoma.

Note: As always, there are exceptions. Some people have congenital forms of optic disc cupping that can mimic glaucoma. These normal variations, which are present from birth, aren't associated with glaucoma, but they can confuse an untrained observer, leading to misdiagnosis and unnecessary treatment for glaucoma that doesn't exist.

Classically, glaucoma's damage to the optic nerve head leads to loss of peripheral vision (figure 9.6). And unfortunately, as stated before, this can be very difficult to detect in the early stages. Many people try to check this on their own, by placing their fingers far out to the sides of their vision. But this isn't a very precise gauge, and results aren't nearly as accurate as those produced by today's sophisticated tests, performed by specially trained observers.

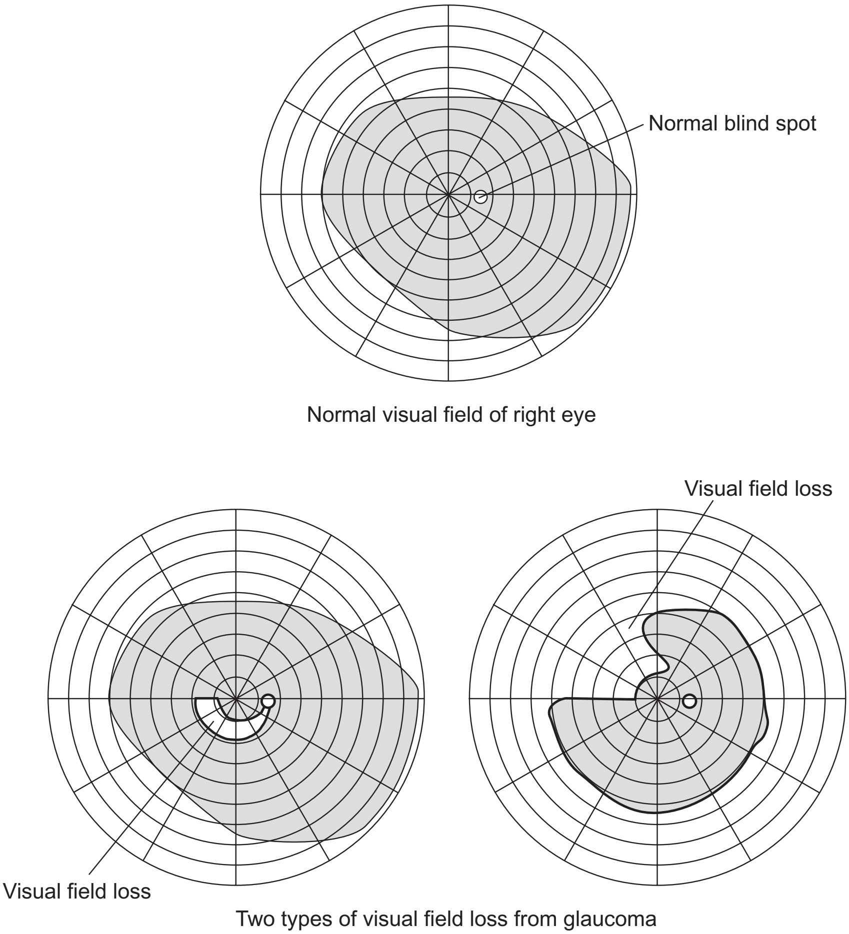

Figure 9.6. Visual field loss from glaucoma

Many years ago, eye doctors relied on manual visual field tests to measure peripheral vision, a process known as *perimetry*. (Testing devices are called *perimeters*.) Early perimetry consisted of holding small test objects to the side of a patient's vision and then mapping what could or could not be seen. In recent years computers have automated perimetry testing, making it much more reliable; these sophisticated "visual field machines" can store vast amounts of information about someone's range of peripheral field, greatly improving our ability to analyze and interpret the test results.

Caution: Because these computerized perimetry machines are so popular, they've also been bought by eye care providers who aren't terribly knowledgeable about how to use them or how to interpret their results—which means, unfortunately, that improper or inappropriate testing is not uncommon. Certain things can skew the test results, including testing patients while they are wearing their eyeglasses or checking someone's peripheral vision without placing the person's proper eyeglass prescription in the perimeter of the testing field. Using pilocarpine, a kind of eye drop, can also cause misleading results.

In addition, some eye doctors may perform tests much more often than necessary. How often visual field tests need to be done is a question with no simple answer. In fact, there aren't many simple answers to questions about glaucoma, including the question of deciding whether someone really has it. Although automated visual field testing is reliable for assessing someone's peripheral vision, the value of this testing as a screening technique for glaucoma is debatable. Furthermore, visual field test results *alone* should never be used to diagnose or manage glaucoma.

Imaging the Optic Nerve within the Eye

Since glaucoma is a disease of the optic nerve, eye doctors are always studying new ways to analyze the optic nerve and the associated nerve fibers that course through it from the retina to the visual centers in the brain. The optic nerve is well visualized in the back of the eye at the optic disc, and as mentioned above, glaucoma damage to the optic nerve can often be observed at this spot in the eye. Until recently, your eye doctor was only able to study the optic disc with high-power lenses and document changes with photographs, all leading to very subjective assessments of this important structure. Luckily, we have seen marked improvement in our ability to image the optic nerve, particularly in an imaging technique of the optic nerve first introduced in the 1990s called optical coherence tomography. OCT has greatly improved our ability to assess the optic nerve for glaucoma, even at its earliest stages, *before* we see loss of peripheral vision on visual field testing. This imaging technique is very similar to the scan used by obstetricians to study babies in utero, but instead of sound, OCT uses light waves to produce reproducible and high-resolution images of the optic disc and retinal layers. By studying these structures and comparing your measurements to those measurements from populations without glaucoma, we now can get a better idea of your probability of having glaucoma. We can also repeat your OCT measurements over time to assess the degree and rate of disease progression.

ARE YOU AT HIGHER RISK FOR GLAUCOMA?

Important risk factors include:

- Elevated eye pressure
- Being over age 60
- Having a family history of glaucoma
- Being very nearsighted
- Thin central corneal thickness
- Being African American

Similarly, glaucoma screening tests—like those conducted at senior citizens' centers, shopping malls, or health fairs—are of rather limited benefit in detecting glaucoma. (Unfortunately, the old adage "You get what you pay for" is largely true here.) The big problem with such events is that they're often conducted by untrained observers, whose unenviable job is to screen a large number of people in a fixed amount of time, and who often rely on measurements of eye pressures and visual fields that are less accurate than those available in a doctor’s office. Therefore, these glaucoma screenings do not replace a comprehensive eye examination for glaucoma performed by a trained eye doctor. This is especially true for people considered to be at higher risk for glaucoma than the general population (see box).

Treating Glaucoma

Because glaucoma is a diverse collection of disorders with a common endpoint—a damaged optic nerve resulting in loss of peripheral visual field—and because everybody is different, there is no one preferred form of treatment. In general, however, the basic goal of managing glaucoma is to lower someone’s IOP—and keep it lowered—sufficiently to prevent further nerve damage and loss of peripheral visual field.

Frequent Monitoring

At first, when you’re beginning a new antiglaucoma medication or changing to a new regimen, you may require weekly or monthly monitoring of your IOPs. Then, once a particular regimen seems to be doing its job—controlling eye pressure and stabilizing your visual field—your eye doctor will probably lengthen the time between visits to every 3–6 months or so. (Visual field testing may be performed less often, depending on such factors as your eye health, degree of visual field loss, OCT findings, IOP readings, and the appearance of the optic disc. If you have severe glaucoma, this testing may be done more frequently.)

What’s the point of such frequent checkups? Eye pressure is not a constant. Your doctor needs to monitor your IOP readings while you are on medication and also will occasionally need to take a reading after asking you *not* to take your medication. Another reason for frequent monitoring is that many patients become resistant, over time, to the effects of a particular antiglaucoma medication; despite faithful use of the eye drops, their IOP gradually sneaks back up to where it was before treatment. For such patients it's clearly important to detect this problem as soon as possible, so that they can be switched to a different type of medication. Also, your eye doctor needs to make sure that your visual field isn't deteriorating by using perimetry and by watching for any significant changes in the clinical or OCT appearance of the optic disc and adjacent retinal layers.

Note: Because eye pressures fluctuate constantly, even from morning to afternoon, it's a good idea to schedule your office visits at different times of the day. *Also, be sure to report any changes in your general health, any other medications you may be taking, or any other visual or medical symptoms that you feel may be important.*

Glaucoma Medications

Welcome to the perpetually evolving world of eye drops.

There are two basic theories in lowering eye pressure. One is to *reduce the production* of aqueous fluid in the eye; the other is to *improve the drainage* of this fluid from the eye. All forms of antiglaucoma therapy are designed to do at least one of these.

Over the years, there have been a variety of clinical research trials studying glaucoma, its progression, and its treatment. One of these studies conducted in the 1990s was the Collaborative Initial Glaucoma Treatment Study (CIGTS). This study compared the use of medical treatment (eye drops) with surgical glaucoma treatment (glaucoma filtering surgery, discussed later), in cases of early glaucoma. The study results did not show a clear benefit to beginning either an eye drop or surgical modality of treatment in newly diagnosed glaucoma patients. Therefore, many eye doctors still initially choose the least invasive course of therapy for newly diagnosed patients with glaucoma and start them on antiglaucoma eye drops to lower their eye pressure. These drops can be used either alone or in combination with other eye drops. No matter what kind of eye drop you're taking, here's an important point to keep in mind: The eye can hold only about 20 percent of one drop. Therefore, it's customary to place *one drop in an eye at a time*, not two drops. If multiple eye drops are to be given around the same time, then they should be *spaced apart by about 3–5 minutes*—so that they can be absorbed properly, and to minimize the chances of washing out one drop with the next. You should also close your eye for 1–3 minutes after instilling your eye drops to help promote corneal penetration and to reduce systemic absorption.

If you're taking a combination of eye drops, it may not matter much in which order you put them in. However, over the years we've found that taking the drops in one order rather than in the reverse order may reduce problems of burning or stinging associated with a particular drop. (This may be because one drop has more of an anesthetic or lubricating quality than the other.)

So, which drops will you take? Here's a brief discussion of some of the more popular *antiglaucomatous* eye drops, their dosages, and potential side effects.

Prostaglandin Analogues

Latanoprost, travoprost, bimatoprost, and tafluprost are relatively new antiglaucoma medications that are chemical compounds similar to prostaglandins. Prostaglandins are hormone-like substances that participate in a wide range of functions in many tissues throughout the body. As prostaglandin analogues, these antiglaucoma drugs are able to penetrate the cornea and become biologically active after being hydrolyzed by a corneal enzyme, corneal esterase. How they exactly work once they enter the eye has still not been fully determined.

These drugs, though, appear to bring about increased uveoscleral outflow and, to a lesser extent, decrease outflow resistance.

Prostaglandin analogues do not appear to have any effect on the production of aqueous fluid. Other antiglaucoma medications, which I will discuss below, primarily lower IOP by decreasing the production of intraocular aqueous fluid or by increasing the outflow of aqueous drainage through the anterior chamber angle.

These prostaglandin analogues are often prescribed for newly diagnosed patients with glaucoma. They can lower eye pressure by 25–30 percent, and if one doesn't work for you, you should try another because switching to a different prostaglandin analogue may prove more effective. These antiglaucoma eye drops are also very popular because they are used only once daily, at bedtime. The ability to use prostaglandin analogues once a day, preferably at night—since IOP is usually at its highest during the early-morning hours—presents an added advantage over other antiglaucoma eye drops, since people may well be more likely to use their glaucoma medication following this schedule. (Patient compliance—getting patients to use their medication—is a very common problem. Doctors and patients need to work together to address whatever it is that's interfering with compliance, whether it's the schedule of drug applications, the cost of medications, side effects of medications, or something else.)

Prostaglandin analogues like latanoprost, travoprost, and bimatoprost do not often cause systemic or ocular side effects. Systemic side effects include flulike symptoms such as headaches, which can be accompanied by joint and muscle pain. On the other hand, these drugs can cause adverse ocular reactions such as eye redness, abnormal eyelash growth, ocular inflammation, and swelling in the retina. Of particular note, some people taking prostaglandin analogues experience darkening of the iris and periocular skin. Changes in iris pigmentation can be permanent, and in at least one study there was a 33 percent risk of this occurring after 5 years of use. The color change is dependent on your initial eye color and seems to occur most often in people with green-brown or hazel (yellow-brown) eyes. If a change in your eye color is a concern for you, please speak with your eye doctor before beginning a prostaglandin analogue. Despite the systemic and ocular side effects, this class of antiglaucoma drugs is excellent and widely used to lower eye pressure.

Timoptic and Other Beta-Blockers

Timolol maleate (Timoptic) is known as a beta-adrenergic blocking agent, or beta-blocker. Timolol maleate and other beta-blockers lower IOP by inhibiting a cyclic nucleotide, 3′,5′-cyclic adenosine monophosphate (cAMP), produced in the ciliary body of the eye. Blocking cAMP reduces aqueous humor secretion and lowers IOP. Decreased aqueous production occurs 1 hour after taking a drop of timolol maleate and can last up to 4 weeks.

Timolol maleate is a very effective antiglaucoma drug and is one of the most popular drugs used in the United States to treat glaucoma—either alone or in combination with other medications. Studies have shown it to have a mean reduction in eye pressure of 20–30 percent. This beta-blocker has been available in solutions of 0.25 percent and 0.50 percent, and in many patients, the 0.25 percent solution is as effective as the 0.50 percent one in lowering eye pressure. Its pressure-lowering effect peaks after about 2–3 hours. Typically, it's given twice a day, although some patients can take it once a day depending on the severity of their glaucoma and other factors.

When using timolol maleate once a day, it is recommended that the drop be put in during the morning to blunt early-morning eye pressure spikes and to reduce the risk of severe hypotension during sleep. As with other glaucoma drops, timolol maleate can lose its effectiveness over time. Also, 10–20 percent of people treated with timolol maleate or other beta-blockers may not achieve a significant lowering of eye pressures. This is particularly true in people who are already taking a systemic beta-blocker. Therefore, it is very important to have regular eye exams so that your eye doctor can change your medication if necessary.

Timolol maleate's side effects in the eye are rare, but they include blurring, irritation, corneal anesthesia, keratitis, allergy, and worsening of myasthenia gravis in people with this condition.

Timolol maleate is related to propranolol (Inderal), metoprolol (Lopressor), and nadolol (Corgard), which are beta-blocker drugs often used to treat cardiovascular disease. It has been found that the blood level of a topical beta-blocker can approach the blood level seen when patients take a systemically administered beta-blocker. Therefore, the systemic side effects of timolol maleate are potentially life-threatening. *Again, it's a must for heart patients to discuss these implications thoroughly with their eye doctor.* Why? Because a drop placed in the eye can flow into the tear sac and then pass into the nose and eventually down to the back of the throat, where it's swallowed and absorbed into the body—possibly inducing or aggravating certain cardiovascular and pulmonary problems. In particular, beta-blockers like timolol maleate can lead to a slowing of the heart rate, congestive heart failure, decreased blood pressure, lightheadedness, decreased exercise tolerance, and an irregular heartbeat. Spasm of the lung's air passages is another important side effect, and all patients should be asked about a history of asthma before beginning beta-blockers. Fatigue, confusion, impotence, and depression have been associated with beta-blockers. Beta-blockers can also cause lethargy, mood changes, altered mentation, syncope, visual disturbances, allergy, and reduced libido.

Timolol maleate is also related to other beta-blocking ocular agents, including betaxolol (Betoptic), timolol hemihydrate (Betimol), carteolol (Ocupress), levobunolol (Betagan), and metipranolol (OptiPranolol). Beta-blockers are very important drugs for the treatment of glaucoma. They are not all the same, and therefore careful consideration must be given when selecting them for patients. Each has advantages and disadvantages. Deciding which beta-blocker to use for a specific patient is not easy, so doctors need to take into consideration side effects, pressure-lowering effect, and price.

Betoptic is a beta-blocker that is more selective in its mode of action, causing fewer breathing problems. It is therefore often used in people with glaucoma who have a history of chronic obstructive pulmonary disease or those who have developed breathing difficulties with Timoptic. Because it is absorbed less by the body than other beta-blockers, Betoptic appears to cause less fatigue, drowsiness, and depression. A drawback to its use, however, is that in new glaucoma patients and in those on chronic glaucoma therapy Betoptic has been found to produce less IOP lowering when compared with other, less selective beta-blockers.

Betimol is a variation of Timoptic. Clinical studies have demonstrated that these two drugs have very similar potency and side effects. *Ocupress* has been found to have special receptor activity and may have less effect on nocturnal pulse and blood pressures, possibly making it a safer choice in people with coronary heart disease.

TIPS ON TAKING EYE DROPS

Patients taking drops for glaucoma, especially beta-blockers, should know about a technique called *punctal occlusion*, a way of administering eye drops that's been proven to minimize potentially serious systemic side effects by reducing the amount of medication that finds its way from the eye into the throat and circulation. Briefly, here's the technique: Place your forefinger at the nasal, or inside, corner of your eye, blocking the tear duct. With your other hand, put a drop of medication in the eye. Close your eye for 2–3 minutes to allow time for absorption. Wipe away any excess drop with a tissue *before* opening your eye and releasing your forefinger's compression of the tear duct.

(*cont.*)

Many patients have trouble getting an eye drop into their eye or feeling whether a drop actually gets into their eye. This can lead to wasting eye drops. (By the way, you only ever need one drop of a medication in an eye at a time because the eye can only hold 20 percent of one drop. All the rest is excess.) If you have trouble putting your drops in your eye, try lying back on your bed, closing your eyes, and then placing a drop in the nasal corner. Once you place one drop in the nasal corner of your closed eye, blink it open and the drop should run right in. You can also keep the drops in the refrigerator so that you will feel the cool drop once it gets in the eye. It may be difficult to do punctal occlusion in conjunction with this technique, but practice makes perfect, as they say.

When taking more than one eye drop at the same time, be sure to space the eye drops at least 5 minutes apart. You don't want to wash out one eye drop with the next. And as with all medications, it is often very helpful to write out a clear schedule for yourself so you can check off your drops each time you place one in your eye.

Betagan is a less selective beta-blocker with a long half-life (longer-lasting effect), in theory making it a better once-a-day product than Timoptic. It requires a larger drop size than Timoptic, and many doctors believe that it is therefore relatively expensive. At one time, *OptiPranolol* in many markets was the least expensive nonselective beta-blocker, with similar efficacy to Timoptic. Although ocular inflammation has been found to be a rare side effect of all topical beta-blockers, it appears to be most common with OptiPranolol.

Epinephrine and Propine

Epinephrine (adrenaline) is a hormone that's found naturally in the body; dipivefrin (Propine) is a synthetic, inactive derivative of epinephrine that seems to be more effective in the eye. Both epinephrine and dipivefrin are considered nonselective adrenergic agonists and lower IOP by decreasing aqueous humor production, increasing uveoscleral outflow, and improving outflow through the trabecular meshwork. When absorbed systemically, epinephrine and dipivefrin have an effect on the cardiovascular system, so these eye drops should be used with caution in patients with a history of rapid heartbeats or arrhythmia. They can induce tachycardia, extra heartbeats, elevated blood pressure, and chest pain due to angina. If you have a history of heart problems, it's essential that you discuss these risks with your eye doctor and your cardiologist.

Antiglaucoma medications related to epinephrine and Propine are isoproterenol, salbutamol, and norepinephrine. These drugs are rarely used any more to treat glaucoma because they have been replaced by other pressure-lowering medications that have proved more effective and safer for patients.

Iopidine and Alphagan

Apraclonidine (Iopidine) and brimonidine (Alphagan) represent a class of topical antiglaucoma drops called alpha 2 selective adrenergic agonists. They lower IOP primarily by decreasing the production of aqueous humor, but brimonidine has been found to also secondarily increase uveoscleral outflow. Because Iopidine and Alphagan selectively stimulate alpha-adrenergic receptors—receptors that aren't found in large numbers in the heart and lungs—they have little effect on heart rate, blood pressure, and breathing. This means that they can be used—with caution—in people with cardiac and pulmonary problems, unlike beta-blockers such as Timoptic (see above), which can cause severe side effects in these individuals.

Both drugs begin lowering IOP within 1 hour, peak in about 2 hours, and are effective for 8–12 hours. They are usually administered two or three times a day. The frequent occurrence of tachyphylaxis and allergic blepharoconjunctivitis seen with Iopidine has decreased its use for long-term therapy. Iopidine has instead been used perioperatively, particularly to prevent postoperative pressure elevation after YAG and SLT laser procedures (see below). Alphagan was developed to be effective for a longer period than Iopidine and therefore is the better choice for long-term glaucoma management. It is also more selective for alpha receptor sites than Iopidine, further decreasing the chance for systemic cardiopulmonary side effects.

As mentioned above, although Iopidine and Alphagan have minimal effects on the heart and lungs, they should still be used with caution in people with hypertension, abnormal or slow heart rates, recent myocardial infarctions, history of strokes, or chronic renal failure. They may also cause an adverse reaction in people taking monamine oxidase inhibitors and tricyclic antidepressants. In the eye, the most common side effects of these drugs include ocular allergic reactions and contact blepharodermatitis such as redness, itching, discomfort, and tearing.

Carbonic Anhydrase Inhibitors

Carbonic anhydrase inhibitors (CAIs) block the production of aqueous fluid by inhibiting an enzyme called *carbonic anhydrase*, which acts on the eye's ciliary body. *Acetazolamide* (Diamox) and *methazolamide* (Neptazane) are well-known CAIs. They're prescription medications available in pill form, as well as in intravenous and intramuscular preparations.

The pressure-lowering effect of Diamox depends on its route of administration. Intravenous acetazolamide can begin lowering eye pressure within 15 minutes. Orally, acetazolamide usually begins working in about 1 hour, peaks at 2–4 hours, and lasts up to 8 hours; Diamox also comes as a sustained-release capsule, which can last up to 24 hours and appears to have fewer adverse systemic effects than its standard form. Neptazane is available in doses as low as 25–50 milligrams. It begins working in about 2 hours, lasts about 10–18 hours, and is usually prescribed to be taken two or three times a day.

CAIs are available as eye drops as well and have fewer systemic adverse reactions than CAIs taken orally. *Dorzolamide* (Trusopt) and *brinzolamide* (Azopt) are topical CAIs approved for use three times a day but are often prescribed two times a day. Slightly greater IOP lowering is observed when using these CAIs three times a day. The side effects of topical CAIs in the eye include allergic reactions of the eyelids and conjunctiva and burning upon instillation, particularly with dorzolamide. Also, because topical CAIs can be absorbed by the body, people may note a bitter taste after administering a drop and should consider using punctal closure (see above) when placing this drop in the eye.

With pills, ocular side effects of CAIs are rare; however, increased nearsightedness has been reported. Systemic side effects are much more common and can include numbness and tingling in the extremities, weight loss, fatigue, kidney stones, and lowered blood levels of potassium, which can cause systemic problems and adverse drug effects. A rare form of anemia can also be caused by CAI use. You should review the full list of side effects with your eye doctor before beginning this drug. Also, CAIs are sulfonamides, which means they shouldn't be given to patients with known sulfa allergies. They're also not recommended for people with severe liver disease, those with advanced lung disease, or pregnant women. Finally, because CAIs may have an "additive effect"—which may magnify these side effects—it's not a good idea to combine the drops with pills, and furthermore, there is no pressure-lowering advantage to using both oral and topical CAIs at the same time.

Parasympathomimetic Agents

Parasympathomimetic agents, or miotics, the first eye drop developed for treating glaucoma (developed nearly 120 years ago), come from a South American plant and generally produce few allergic or toxic reactions in people who take them. This class of pressure-lowering eye drops can be divided into direct-acting cholinergic agonists (Pilocarpine) and indirect-acting anticholinesterase agents. The latter are rarely used today owing to their ocular and systemic side effects. The direct-acting agents, like Pilocarpine, reduce IOP by improving aqueous outflow from the eye and can reduce eye pressure by 15–25 percent. After it's administered, pilocarpine lowers IOP in about 1 hour, with its effectiveness peaking after 1–1.5 hours and lasting about 8 hours. It's usually given as one drop four times a day.

Pilocarpine's most common side effect is miosis, or a small pupil. This can cause diminished vision because less light will be able to get into the eye. Other important side effects in the eye include brow ache, induced nearsightedness, increased bleeding during surgery, increased intraocular inflammation, and retinal detachments. (For more on warning signs of retinal detachments, see chapter 16.) Systemic side effects are rare but can include increased salivation, sweating, nausea, vomiting, diarrhea, and trouble breathing. In the past, the adverse reactions seen with Pilocarpine, along with its four-times-a-day dosing, led to poor patient compliance. With the development of a number of other eye drops with less frequent dosing and fewer side effects for glaucoma over the past 20 years, such as prostaglandin analogues, Pilocarpine is infrequently used today. This miotic agent is now specifically recommended for long-term use in patients with potentially occludable outflow drainage angles despite laser iridotomy (plateau iris syndrome) and to reduce iris movement and blunt pressure spikes during physical activity in patients with pigmentary glaucoma.

Combination Medications

Various combinations of pressure-lowering eye drops are available. A combination pressure-lowering eye drop is rarely used in newly diagnosed glaucoma patients, unless the IOPs are dangerously elevated and need dramatic lowering. These combination eye drops are more often prescribed when a second or third eye drop is being added to a patient's antiglaucoma regimen, keeping in mind the added benefits they may provide, such as increased convenience, increased compliance, and potentially reduced cost. Clinicians may choose to use each eye drop individually to assure that they each have a pressure-lowering effect on a patient before changing the patient to the combined formulation. Generally, combination pressure-lowering medications such as dorzolamide and timolol or brimonidine and brinzolamide are equally as effective in a combination drop as they are when instilled individually. The adverse effects of the individual drugs are the same too.

Generic Eye Drops for Glaucoma

What's in a name? Quite a lot if you are a drug company. You see, a drug keeps its brand name as long as it is under patent protection. For example, when Pfizer's Xalatan (Latanoprost) patent protection expired in 2011, other drug manufacturers were able to produce and market it as a generic. This brings us to the main benefit of a generic. Usually generics are less expensive, as much as 85 percent less for some medications. Needless to say, this can be quite a cost savings, especially if you are taking multiple pressure-lowering eye medications.

But are all generics equal to the brand-name version? Good question. In the United States, the Food and Drug Administration requires that a generic drug be the same as the approved brand-name drug, particularly in standards of manufacturing, dosage form, safety, strength, route of administration, quality, and performance characteristics. Therefore, most health care providers and patients feel comfortable using generics instead of brand-name drugs. Despite the FDA's rigorous oversight of generic medications, however, unregulated aspects of medications can still exist, such as different eye drop containers and tips that can alter dosing. Also, beware of generics from outside the United States. Generics produced outside the United States are often attractive because they are very inexpensive, but they are not always effective or safe to use because of their inactive ingredients. When starting any generic eye drop, discuss this with your eye doctor and have your eye pressures checked after you use it for a month or two to make sure it is effective at lowering your eye pressures; don't just assume it works the same as the name brand.

Use of Glaucoma Eye Drops and Pregnancy or Breastfeeding

Unfortunately, there is little definitive information concerning the safety of glaucoma medication use during pregnancy or while breastfeeding. Theoretically, beta adrenergic antagonists, alpha agonists like brimonidine, CAIs, and prostaglandin analogues may present a risk to the fetus, particularly during the first trimester. Topical ocular hypotensive medications can also be systemically absorbed and secreted in breast milk.

Although well-controlled studies are limited and inconclusive, if you are pregnant or breastfeeding and using glaucoma medications, please discuss the current recommendations with both your ophthalmologist and your obstetrician.

Other Medications

Mannitol, *glycerin*, and *isosorbide* are three other medications used to lower eye pressure. These are mainly used as short-term treatments in special, acute situations to lower eye pressures as quickly as possible. Generally, they are administered either orally or intravenously for a rapid onset of action and work by drawing fluid from the eye into the bloodstream.

There are always new medications on the horizon for the treatment of glaucoma. At the time of this writing, Rho kinase (ROCK) inhibitors are a new class of drugs (Netarsudil being the first to be FDA approved for glaucoma) that appear to increase aqueous outflow by reversing structural and functional damage at the trabecular meshwork. Speak with your eye doctor about current medications and their indications—remember, you are your own best advocate when it comes to your health.

Other Forms of Treatment

Lasers

An increasingly important tool for treating glaucoma, lasers have proven effective in both closed-angle and open-angle glaucoma.

Lasers in treating closed-angle glaucoma: Briefly, the trouble in closed-angle glaucoma is that the anterior chamber angle is narrowed or plugged by the root of the iris. As a result, aqueous fluid cannot flow from its site of production, in the posterior chamber, out of the eye through the trabecular meshwork filter in the corner of the anterior chamber angle, and it "backs up," raising pressure within the eye.

Lasers provide a mechanical solution to the problem by making a hole, or peripheral iridotomy (also referred to as a PI), in the iris to improve the flow of aqueous from the posterior to the anterior chamber (figure 9.7). It's like providing the aqueous with a shortcut to the trabecular meshwork. The peripheral iridotomy relieves the pressure behind the iris, deepens the shallow anterior chamber and narrowed angle, and helps aqueous exit the trabecular meshwork and enter Schlemm canal. Peripheral iridotomies are performed either with cutting lasers (called YAG lasers) or with burning lasers (argon lasers). The peripheral location of the opening can be different depending on the surgeon's experience.

Candidates for peripheral iridotomy include people with acute angle-closure glaucoma attacks (the sudden onset of painful glaucoma described above) and those with chronic closed-angle glaucoma. Occasionally peripheral iridotomies are also performed prophylactically (as preventive measures) on people with narrowed anterior chamber angles to preclude the sudden or gradual buildup of pressure.

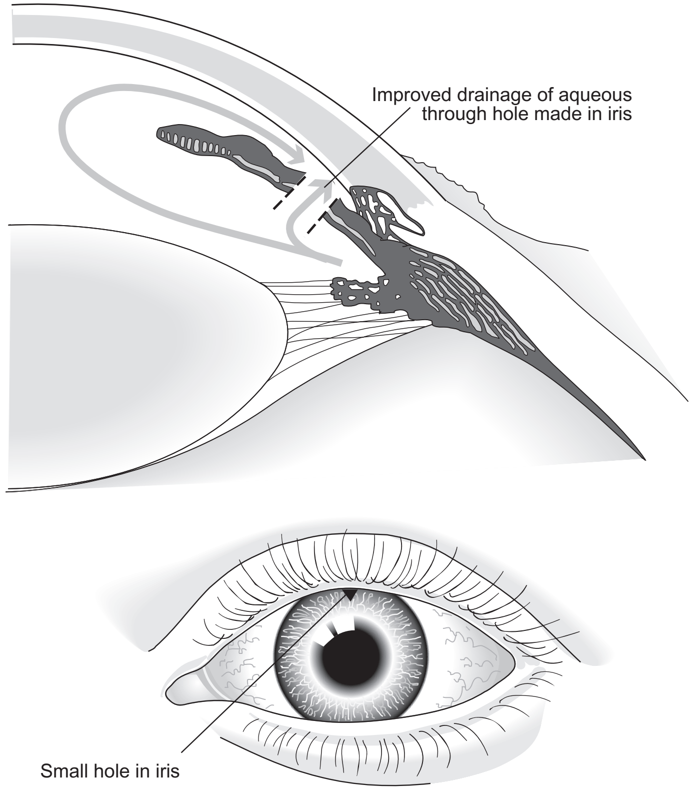

Figure 9.7. Peripheral iridotomy or iridectomy

A peripheral iridotomy is painless, usually takes less than half an hour, and requires no preoperative testing or postoperative restrictions. Complications are minimal and may vary depending on the state of the eye at the time of the procedure. For example, bleeding from blood vessels in the iris is a common and usually limited occurrence after a laser peripheral iridotomy. But in patients with an acute angle-closure attack, this complication can occur more often and may be more difficult to control. Other potential complications of peripheral iridotomies include a temporary elevation in eye pressure, inflammation of the eye (iritis), and temporary blurred vision. (As always, be sure to discuss all risks with your eye doctor before undergoing this or any form of treatment.)

Lasers in treating open-angle glaucoma: Argon lasers are also used in open-angle glaucoma. In several studies these "burning" lasers have been shown to lower IOPs by as much as 10 mm Hg for at least 18 months in a statistically significant number of patients with elevated eye pressure. This effect varies greatly depending on the type of glaucoma being treated.

In this procedure, called *laser trabeculoplasty*, a specially designed mirrored contact lens is placed on an anesthetized cornea. The surgeon can then use a magnified slit lamp to get a good view of the trabecular meshwork. Carefully guiding the laser, the surgeon makes between 50 and 100 "spots," or tiny burns, on the trabecular meshwork. Exactly how these burns lower eye pressure is not known, but current thinking is that they cause the minuscule fibers of connective tissue in the meshwork to contract, opening up sieve-like spaces through which the aqueous fluid can seep into Schlemm canal. The treatment is painless and usually takes about half an hour.

Complications, as with laser peripheral iridotomies, are rare and mainly include a short-term rise in eye pressure and the development of scar tissue in the vicinity of the trabecular meshwork (which can make the drainage problem even worse). One drawback is that the results aren't immediate; it may take 6–10 weeks before eye pressures get lower. Another is that, unfortunately, the effects don't seem to be permanent; studies have found that the results last for only about 5 years in less than 50 percent of patients. In some cases, people undergo repeat laser procedures, but results have not been shown to be consistently successful.

Laser trabeculoplasty can be a first-line choice in the treatment of glaucoma, but it is often used after one or more eye drops have failed to adequately lower eye pressure and prevent advancing visual field loss, or in an effort to delay the need for surgical intervention. Not infrequently patients still need some of their medications despite laser treatment. It is, however, an important treatment option in patients who aren't good candidates for surgery.

Glaucoma Surgery

There are several incisional surgical approaches designed to lower eye pressure. Incisional surgery is the initial accepted treatment for primary congenital glaucoma. Currently, for most other types of glaucoma these techniques are mainly used when medical and laser treatments fail—when, in other words, IOP cannot be lowered sufficiently to halt the loss of peripheral vision.

Trabeculectomy, the most commonly performed surgical procedure for glaucoma, is basically the surgical creation of a new drain in the eye—a custom-built "trap door" in the sclera of the eyeball (figure 9.8). The aqueous fluid collects under the conjunctiva, forming a "blister" of fluid often referred to as a "filtering bleb," and is gradually absorbed into the circulation on the outside of the eyeball. Eventually a permanent fistula, or hole, develops at the trap door, maintaining a constant outflow of aqueous from the eye and lowering IOP with or without medication. Various valves and shunts can also be placed in or near the trap door to improve the postoperative filtration of aqueous out of the eye following a trabeculectomy.

Note: This surgical technique is not without risks and should be performed only by those experienced in this surgery and the management of potential postoperative complications.

Surgically, a trabeculectomy tries to create a fine balance in the eye between *too much* and *too little* outflow of aqueous under a surgical tissue flap (the trap door). Thus, the days and weeks after this type of surgery can often be stormy. For example, *too much filtration* can initially lead to abnormally soft eyes and flat anterior chambers. If not corrected, this situation can lead to eye problems and result in permanent vision loss. The postoperative management of trabeculectomies—as the eye heals and establishes filtration through this new drain—often requires vigilance and patience by doctors as well as patients.

Another risk is that in some people scar tissue may form in this artificial drain, sealing the trap door. Doctors often use medications

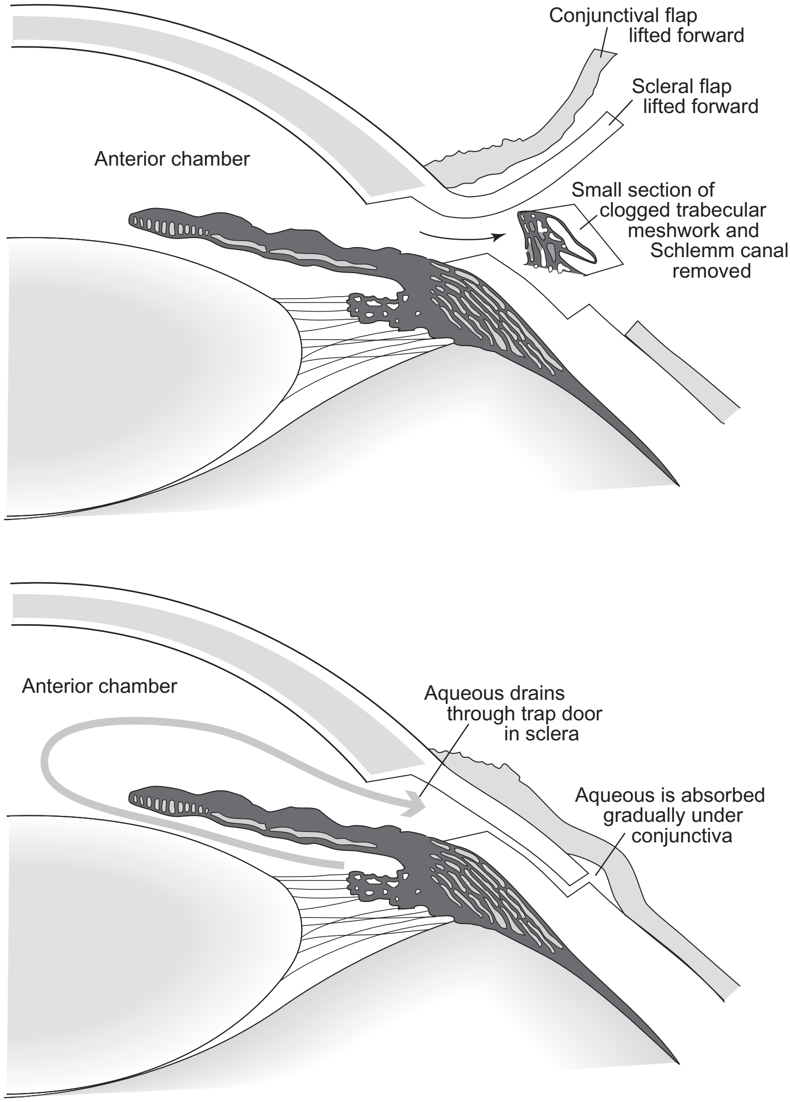

Figure 9.8. Trabeculectomy

such as 5-FU and mitomycin-C (MMC) during or after the procedure to help avert this problem in patients considered to be prone to this outcome.

Other, rare complications include infection, bleeding, and the development of a cataract in the operated eye. The latter complication is often why eye surgeons will combine a cataract surgery with a trabeculectomy at the same operation. Filtering blebs created by trabeculectomy evolve over time and must be carefully followed for infection and leaks. Before consenting to a trabeculectomy, it's important to weigh carefully the benefits of lowered IOP against the potential risks of the procedure.

These risks aside, the long-term results of trabeculectomies for maintaining eye pressure are good. No further progression of glaucoma can be expected in many people after surgery, with a large percent maintaining stable peripheral vision. Following trabeculectomy, some people may never need any medications for pressure control after the surgery, although many still may require some eye drops.

Micro-invasive Glaucoma Surgery

Due to the extent of surgery and the potential risks, trabeculectomy has been reserved for patients with moderate to advanced glaucoma. Other micro-invasive glaucoma surgery (MIGS) options have been developed for patients with mild to moderate glaucoma. Compared with trabeculectomy, MIGS procedures are safer, with fewer complications and more rapid recovery. These less invasive glaucoma procedures have also been shown to be effective at lowering eye pressure and reducing a glaucoma patient's need for medication.

MIGS procedures are not all the same and actually represent a collection of different procedures that all have two things in common—they lower eye pressure, and they are less invasive surgically than a trabeculectomy, often not requiring any sutures. Although MIGS procedures are continually evolving, in general they are primarily designed to increase trabecular outflow, shunt aqueous fluid to the suprachoroidal space, reduce aqueous production, or filter aqueous fluid out of the eye to under the conjunctiva. Currently popular MIGS procedures include Trabeculotome, iStent, XEN Glaucoma Implant, Kahook Dual Blade, Hydrus Microstent, and Gonioscopy Assisted Transluminal Trabeculotomy.

Cyclodestructive Procedures

In unusual circumstances, IOP cannot be adequately controlled despite glaucoma surgery, lasers, and medications. In such situations, it may be necessary to attempt to lower eye pressure by resorting to a cyclodestructive procedure, where part of the ciliary body (that part of the eye that makes the aqueous humor) is destroyed. To do this, a laser probe is either used on the surface of the eye just above the ciliary body or applied directly onto the ciliary body from inside the eye to destroy a portion of this aqueous-secreting structure. You can think of this procedure as basically destroying the eye's aqueous manufacturing facility. Since a cyclodestructive procedure is not reversible, it is generally reserved as one of the last options to treat glaucoma.

What's Best for You?

Traditionally in the United States, glaucoma treatment has begun with a *single eye drop* to lower IOP. If this does not fix the problem—if it fails to lower pressure and halt peripheral visual field loss—then another eye drop is usually added to the regimen. Each drop is evaluated alone or in combination with other eye drops, as doctors work to find the best regimen for each patient. And even when that perfect mix is found, patients must still be carefully monitored because—in a phenomenon frustrating to both doctors and patients—these medications often lose their effectiveness over time, or the glaucoma simply becomes harder to control.

Now, on to plan B: if eye drops don't work to control IOP, or if the nerve fibers in the optic disc continue to deteriorate despite lowered eye pressure, then doctors usually consider lasers and surgery for eyes that don't adequately respond to drops and pills. But studies done in other countries have suggested that this may not be the best way to go. Instead, these studies have suggested that the most effective way to control glaucoma may be to perform a surgical trabeculectomy *before* attempting management with medical and laser treatments. *Trabeculectomy may ultimately produce better IOP control for a longer period of time, with less overall cost to the patient and with fewer side effects.*

From 1993 to 1997, the National Institutes of Health conducted the Collaborative Investigational Glaucoma Treatment Study, or CIGTS, designed to evaluate whether newly diagnosed glaucoma patients truly are best treated by the traditional medical approach (beginning with eye drops) or by surgical trabeculectomy. The study found that initial glaucoma surgery produced better IOP control than initial medical therapy. Over time, though, the surgical group had a higher risk of cataract development, which subsequently led to poor vision and less visual field stabilization. As a result of this study, clinicians have elected to defer incisional glaucoma surgery until other forms of medical and laser treatments have been tried to lower eye pressures and arrest visual field loss. Although it's generally accepted that IOP must be lowered in patients with glaucoma, *by exactly how much* is different for each patient. To make matters more complex, studies have shown that other factors, such as the level of IOP and the degree of optic disc cupping at the time of diagnosis, are also very important. It's probably due to some of these other factors that glaucoma continues to worsen in some patients despite vigorous lowering of IOP. People with normal-tension glaucoma (see above), on the other hand, seem to be more susceptible to developing optic nerve damage at IOPs considered to be normal for the majority of the population. Even more perplexing, some people, despite elevated IOPs, never seem to develop visual field loss or other signs of glaucoma.

The Ocular Hypertension Treatment Study (OHTS), a 2002 national prospective clinical trial, demonstrated that topical ocular hypotensive medications were effective in delaying or preventing the onset of primary open-angle glaucoma. Some of the high-risk factors for developing glaucoma identified by the OHTS were older age, increased optic disc cupping, the central corneal thickness, and baseline IOP.

Some Questions You May Have about Glaucoma

Can glaucoma be caused by reading too much, wearing contact lenses, or even a poor diet?

Although no one really knows why some people develop glaucoma, it definitely does not appear to be related to any of these activities. Age, family history, and race are the most significant risk factors for developing glaucoma, along with the other factors mentioned above.

Will I go blind from glaucoma?

When glaucoma is discovered early, the vast majority of people with glaucoma will not go blind from it because of the excellent array of treatment options available today. Early detection is the key to good glaucoma management, and regular eye exams by qualified professionals are very important. Compliance with prescribed therapies is also essential.

Does glaucoma run in families?

Yes; at least, having a family history of glaucoma raises someone's risk of developing the condition. Other factors that may make someone more prone to developing glaucoma are mentioned previously in this section.

I have hypertension. Does this mean that my eye pressure is high as well?

Although elevated blood pressure can cause elevated eye pressure, for most people these are two separate issues; most of the people who have elevated eye pressure don't have it because they also have hypertension. Elevated eye pressure is also not related to any of the things we commonly think of as raising our blood pressure—increased stress, anxiety, or diet.

Can my eye pressure change from one day to the next?

Absolutely—and not only from one day to the next, but from one hour to the next. Eye pressures are usually highest in the morning. Because of this constant fluctuation, it's important to vary the times of your eye examinations, so that your doctor can get a better overall impression of your eye pressures both right after taking medications and some time later.

If I forget to take my drops, will this really cause me to have more problems from glaucoma?

Missing an occasional eye drop will not greatly affect your glaucoma, since many of the medications have prolonged effects. Mild spikes in eye pressure due to a missed drop also do not appear to cause great damage to nerve fibers. But stopping your eye drops for long periods—like weeks or months—can lead to irreversible visual field loss.

I have a cataract and glaucoma. Can I have surgery for both at the same time?

Yes. Today's modern microsurgical techniques make it possible for surgeons to perform both of these delicate operations at the same time. However, this "combined" surgery is performed only after the eye doctor carefully considers the severity of the person's glaucoma and cataracts. MIGS procedures offer glaucoma surgical options to patients with mild to moderate glaucoma and cataracts, whereas incisional trabeculectomy can be combined with cataract surgery in patients with more severe forms of glaucoma.

Chapter 10

AGE-RELATED MACULAR DEGENERATION

Macular degeneration may be the most baffling and frustrating eye disorder there is.

The official name of this condition is age-related macular degeneration (AMD), but there's no official, universally accepted definition to go along with it. It's mainly found in adults and is the leading cause of blindness in the developed world in people over age 50. Some people get it worse than others, and although normal aging results in a variety of macular changes, specific changes are seen with AMD that are not necessarily part of normal macular aging. At its most devastating, AMD advances unrelentingly, causing severe visual impairment and often overwhelming challenges to the quality of life. Treatment advances in the past 20 years have dramatically improved our ability to control aspects of the most sight-threatening forms of AMD, making a tremendous difference for many people affected by this condition.

How does AMD happen, who's at risk for developing AMD, and what can be done to stop its damage? The answers to these questions begin in the retina.

The Layered Design of Your Retina

Basically, AMD can be thought of as changes in the outermost layers of the retina. Although we often say that the retina is like wallpaper lining the back of the eye, this doesn't tell the whole story. Unlike a single sheet of wallpaper, the retina has many integrated layers of tissue and cells, all intricately connected to each other, all working together, with the brain, to turn random images of light into coherent vision. (Remarkably, all of these layers of the retina are literally paper-thin, between 0.1 and 0.5 millimeters thick.)

The retina's foundation is the sclera, the "white" of the eyes. The retina and its supporting tissues line the entire surface of the inner white sclera inside the eyeball (see figure 1.1A). The next layer is the choroid (which isn't really part of the retina at all), rich in blood vessels. The choroid is like a blood-filled sponge—a network of vascular tissue that serves as a lifeline to the retinal layers that lie upon it, a crucial supplier of nutrients and oxygen. The choroid's constant and rapid blood flow helps maintain a fairly steady temperature and oxygen supply within the retina.

Next comes *Bruch membrane*, a thin wafer that separates the choroid from the retinal layers above it. Right on top of Bruch membrane, like a single layer of bricks on cement, are the *retinal pigment epithelial (RPE) cells*. These cells perform retinal metabolic functions important for vision and help maintain the integrity of the retinal layers. They also serve as trash collectors, removing by-products of the photoreceptors, which lie above and beside them.

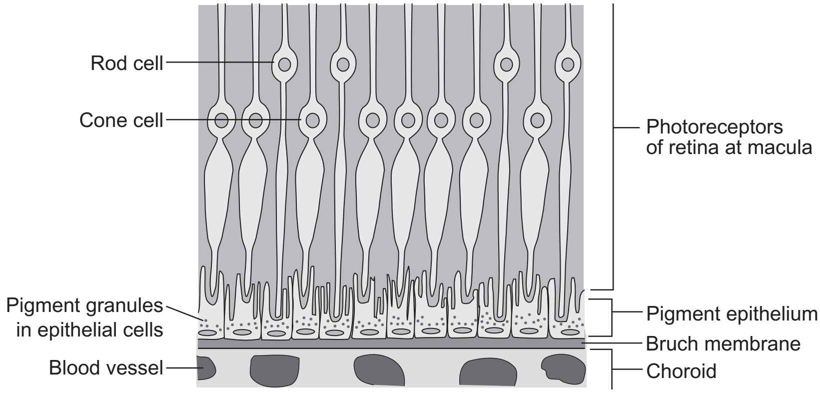

Figure 10.1. Microscopic section of the macular region

The *photoreceptors* are the crucial cells in the retina that convert light energy into nerve impulses that travel to the brain and produce vision (figure 10.1). These specialized cells come in two basic forms: rods and cones. The rods make it possible for us to see in dim light. The cones, which function in bright light, also provide visual acuity—so that we can read, for example—and color vision. These photoreceptors, plus the several (about seven or eight) layers of tissue and nerves that lie above them, plus all of their connections leading to the brain, make up the *sensory retina*. At the sensory retina's innermost core lies the *nerve fiber layer*, the final pathway of all nerve impulses that leave the eye. Here nerve fibers meet to form a "nerve trunk"—like electrical wires intertwined to form a thick cable—called the optic nerve, which connects directly to the brain.

As you can see in figure 1.1, panels A and B, the retina stretches to cover about two-thirds of the inside of the back of the eyeball. Its most significant region by far is the macula, located just next to the optic nerve and between the arcades of the major superior and inferior temporal retinal blood vessels (see figure 1.5). The macula is responsible for central vision, including such functions as reading and fine visual acuity. Made up largely of cones, it's also important for color vision.

Many retinal problems can affect the macula, creating difficulties with central fine vision, reading, and color vision. The macula's *foveal region*, right in the middle, is primarily responsible for our sharpest vision. This region contains an especially dense concentration of cone cells; the cone cell population gradually decreases as we move toward the *peripheral retina*. The rods, important in night vision, have their greatest density farther from the foveal center, and their density also decreases in the peripheral retina. The peripheral retina, as its name suggests, is very involved in peripheral vision. (People with macular disease often have poor central vision but normal peripheral vision because their peripheral retina remains healthy.)

Normal aging observed in the macular region of the retina includes a decrease in the number of photoreceptors, as well as changes in the RPE cells, Bruch membrane, and the choroid.

Types of Age-Related Macular Degeneration

As noted above, there is no universally accepted definition of AMD. But most eye specialists agree that AMD includes certain changes in the outer retinal layers. We can use these changes, in a broad sense, to divide AMD into two basic kinds: *nonneovascular* ("dry") and *neovascular* ("wet").

The Dry Form

The dry, or nonneovascular, form of AMD features slowly progressive, degenerative changes in the outer retinal layers, primarily in Bruch membrane and the RPE (figure 10.2). Remember that we described the RPE cells as a single layer of bricks built upon Bruch membrane? Well, in AMD—think of any time-worn brick house—these "bricks" and the surface they sit upon (Bruch membrane) gradually undergo degenerative changes. The RPE "bricks" weaken, change shape, lose their color, and, occasionally, disintegrate. As these RPE cells slowly change, so do the overlying photoreceptors. Over time they, too, lose their shape and configuration; they also begin to dwindle in number. Since photoreceptors are the main cells responsible for vision, it's not surprising that gradual visual impairment can result from all these changes. To make matters worse, a vicious cycle seems to develop: as the RPE cells and Bruch membrane change and deteriorate, so do photoreceptors, and as photoreceptors degenerate, they release debris, which builds up beneath the retinal pigment epithelium, generally in Bruch membrane, causing further cell malfunction and loss.

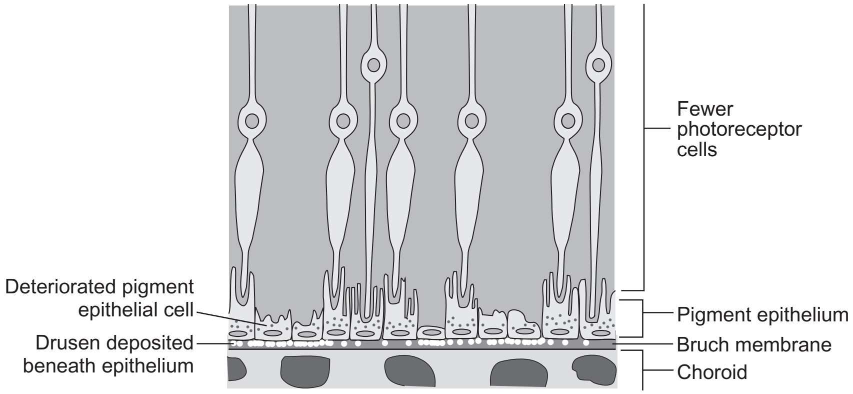

Figure 10.2. Microscopic section of dry age-related macular degeneration

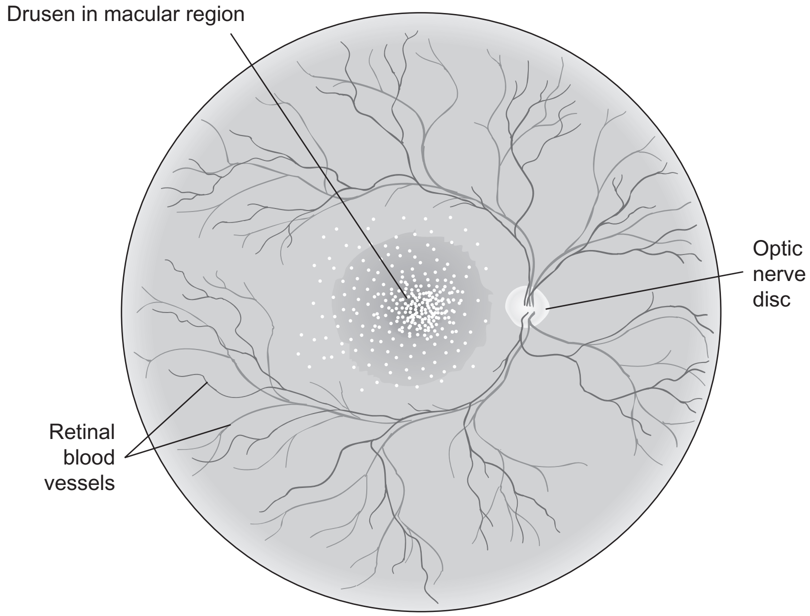

Figure 10.3. Drusen of the retina

Accumulated deposits beneath the RPE and in Bruch membrane form *drusen*, which look like tiny yellowish dots in the retina (see figure 10.3). Drusen exist, studies have shown, in the eyes of most adults. But over time, in people with AMD these deposits can become more pronounced and cluster together, prompting changes in the RPE cells. And this, in turn, begets more retinal degeneration. (Drusen are often considered the hallmark of dry, or nonneovascular, AMD. However, perplexingly, some people have changes in their retinal pigment epithelium without obvious drusen.) Eventually, as photoreceptors also become involved in this slow degenerative process, vision begins to deteriorate. *Note:* Although vision may be significantly impaired, people with this form of AMD usually don't progress to the point of being legally blind.

The Wet Form

The wet, or neovascular, form of AMD is a more aggressive process that can have a much greater impact on vision. It's not nearly as common, but its impact can be much more serious. (Although only about 10–15 percent of North Americans with AMD are estimated to have this form, within this population it is generally accepted as accounting for the majority of the severe vision loss caused by the disorder.) Unfortunately, both the dry and wet forms of AMD can occur in the same person—even in the same eye.

For reasons we don't yet understand, each year a small percentage of people with "dry" changes can suddenly develop fresh threats to the macula: newly formed blood vessel membranes that begin in the choroid (figure 10.4A). Some scientists believe that these membranes may develop in response to inflammation in the choroid or Bruch membrane, as a result of the degeneration described above. Others suggest that RPE cells somehow inhibit the growth of new blood vessels in the choroid—and that as these cells degenerate, this inhibiting effect is lost, allowing unbridled growth.

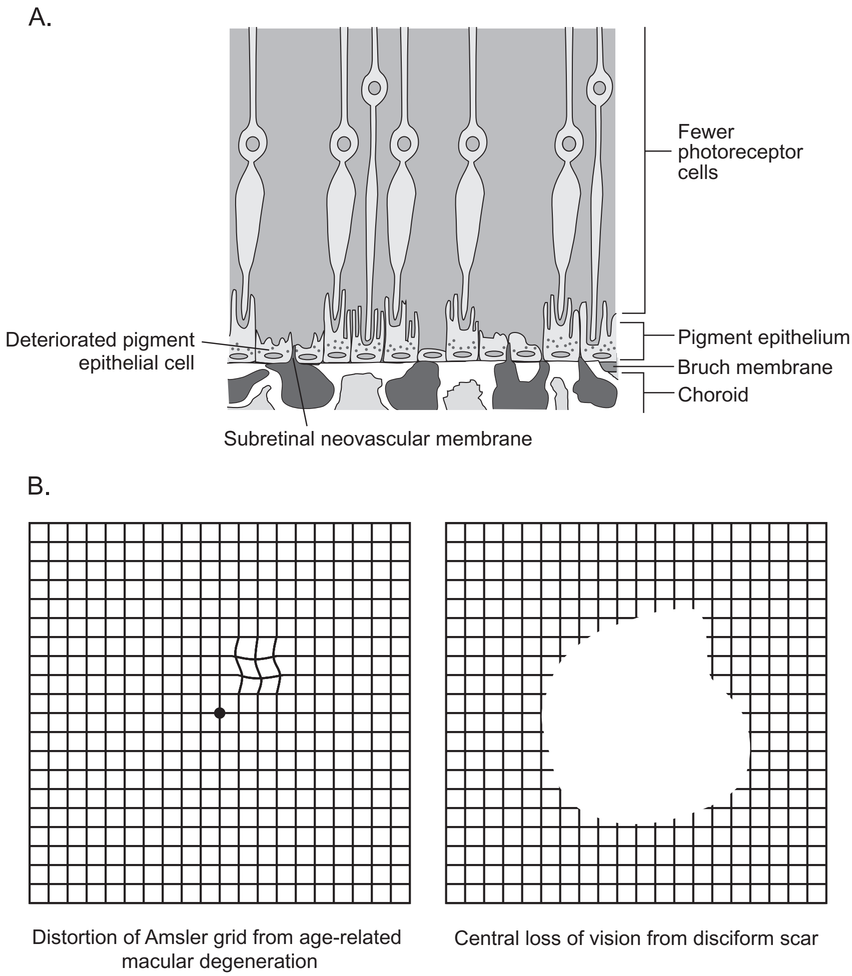

Figure 10.4. (A) Microscopic section of wet age-related macular degeneration, showing new blood vessels growing from choroid into retina; (B) visual effects from age-related macular degeneration and disciform scar

Whatever the reason, these blood vessel membranes, called *choroidal neovascularization* (CNV), begin in the choroid under the retina. As they grow, like unchecked weeds in a garden, they tend to poke through Bruch membrane and to invade the retinal pigment epithelium. Simply put, they can devastate the retina. They can cause fluid to seep through Bruch membrane, forming little raised "blisters," called *RPE detachments*. They can also cause fluid to collect in the sensory retina, disrupting the function of the rods and cones. These membranes, which often bleed and grow fibrous tissue, can cause severe scarring of the macula—and, thus, visual impairment. This central macular disfiguration is often referred to as a *disciform scar*.

Who's at Risk?

As mentioned previously, AMD is recognized as the leading cause of blindness in the developed world in people over 50 years old. Unlike cataracts, which cause a *reversible* form of vision loss, AMD's damage is irreversible. Like glaucoma and diabetic retinopathy, two other well-known causes of serious vision problems in people over age 50, AMD is treatable (see below).

Who's at risk? Well, thanks to many epidemiologic, population-based studies attempting to identify predisposing factors, we now have some enlightenment in this area. The main risk factor remains age. Estimates are that as many as 25 percent of people over age 75 have AMD. We do know a few other generalities. The disease is more common in women than men. Heredity also seems to be a risk factor; if you have a family history of AMD, you should have a careful eye examination done by a specialist familiar with the diagnosis and treatment of this disorder. People with light iris color, especially Caucasians, seem more susceptible.

Other risk factors linked to AMD—but definitely not proven to cause it—include cigarette smoking, cardiovascular disease, elevated cholesterol, and high blood pressure. Genome investigations have identified over fifty genetic variants for AMD, but currently the interpretation and usefulness of genetic testing in AMD are controversial and not recommended until further studies confirm their value for prognostication or response to therapy. Lifetime exposure to sunlight may also be a factor, but this risk factor is also controversial and not supported by all studies. Although in theory sunglasses may modify sunlight's effect on the retina, no definitive, long-term studies have proven this.

The role of vitamins and minerals has also been a subject of scientific investigation and clinical trials (see below). Theoretically these may also protect the retina. More studies are needed in this area, particularly further focusing on identifying which individuals can benefit from vitamin and mineral supplements, specific formulas with a combination of these supplements, and optimal doses to reduce the risk of toxicity and prevent the early development and progression of AMD.

Because the wet form of AMD can result in such devastating vision loss, scientists have tried to identify specific risk factors associated with its development. One thing they've found is that the *type* and *extent* of drusen and RPE changes can help predict the development of CNV. Large, soft drusen—especially when found in both eyes and accompanied by significant epithelial changes—raise someone's odds of developing these membranes. People who already have CNV in one eye are also more likely to develop it in the other eye.

Prevention: Can Nutrition Make a Difference?

Over the past 20 years, much speculation with respect to prevention has given rise to concrete information. Earlier, most studies on the treatment of subretinal neovascular membranes had served mainly to emphasize our limitations and inability to control this devastating process. This led many to search for new treatment pathways and to seek preventive measures.

One of these avenues of study is nutrition—once a long-neglected area of research. Frankly, aside from what our mothers always told us about the benefits of eating carrots, we don't yet know all there is to know about the preventive effects of vitamin supplements on such problems as macular degeneration and cataracts. On the other hand, we do know a fair amount about the effects of vitamin *deficiencies* on vision and eye health. From animal studies we've learned that dietary deficiencies in vitamins A and E can cause the retina to degenerate. Other studies, in rats, have suggested that vitamin C may have a protective effect against sun damage to retinas. How does this information relate to the onset of AMD? The Baltimore Longitudinal Study of Aging, the Eye Disease Case Control Study, the Beaver Dam Eye Study, and other human studies have suggested—but not proven—a link between AMD and such antioxidants as vitamin E, vitamin C, and betacarotene.

Another research study, investigating the effect of oral zinc and other supplements on the progression of AMD, has suggested a beneficial effect. The Age-Related Eye Disease Studies (AREDS and AREDS2), conducted by the National Eye Institute, were large, multicentered clinical trials designed to probe links between diet supplements and such eye diseases as cataracts and AMD in 4,500 older Americans, who received either nutrient supplements or a placebo. (Neither the investigators heading the study nor the patients knew who got what.) The supplements contained concentrations of antioxidants and trace metals. Participants were examined regularly, at least twice a year, for 10 years. The results of this study have given us much better insight into the role of nutrition in eye disease.

The initial AREDS study was a large, multicentered clinical trial sponsored by the National Eye Institute to investigate the benefit of vitamins and zinc supplementation in reducing the risk of vision loss in nonexudative AMD. Participants were entered into the study according to their degree of AMD and randomized into groups taking a supplement or taking a placebo. The study supplement included the antioxidant vitamins C (500 mg) and E (400 IU), beta-carotene (15 mg), and the micronutrient zinc (80 mg zinc oxide and 2 mg cupric oxide to prevent zinc-induced anemia). Patients defined by the study as having intermediate or advanced AMD who took the study supplement were found to have a statistically significant decrease in both progression to more advanced stages of AMD and rates of moderate vision loss (greater than or equal to three lines of visual acuity at 5 years). Study participants without AMD or with only an early stage of AMD did not show any statistically significant benefit of taking the study supplements. The findings of the AREDS study were confirmed by the follow-up AREDS2 study, which further tested the effect of other supplements on the progression of AMD. As a result of the AREDS2 study, patients with intermediate to advanced AMD are advised to take the original AREDS supplement but with lutein and zeaxanthin instead of beta-carotene. This formulation is now available commercially under several names and is additionally labeled as AREDS2. Before taking these high-dose supplements, please consult both your eye care specialist and your general medical doctor or other health care provider to find out if they are appropriate for you and to make sure that they will not conflict with other medications or supplements that you might already be taking.

Signs and Symptoms of AMD

AMD, like many other eye disorders, is at first a dangerously stealthy process. By themselves, drusen and RPE changes usually don't affect vision. Even when drusen become large and pronounced, they rarely cause a noticeable problem; neither do pigment epithelial changes in the retina. However, central reading vision does become affected over time as these changes become more severe and involve the foveal region. For many people the first signs of trouble may be that when they're reading or looking at straight edges, such as tabletops or patterns on clothing, the lines look crooked or wavy; this is usually more pronounced in one eye than the other. Later, reading becomes particularly difficult as letters and words become distorted. Other people notice that their eyes have trouble adjusting from bright sunshine to a dimly lit room; people with advanced AMD often need a few minutes to adapt to this change in lighting.

The Importance of Early Detection and Regular Monitoring

If you've been diagnosed with AMD, it's essential that your vision be monitored regularly. Your eye examinations should include a careful dilated retinal evaluation by an eye doctor who is very familiar with this disorder and its clinical stages. If you're considered to be at high risk for developing subretinal neovascular membranes, you may need eye examinations as often as every 3–4 months. If your retinal changes are less advanced, you may need to be examined only every 4–6 months.

Many eye doctors advocate home tests of visual acuity and function as a do-it-yourself means of monitoring macular degeneration's progression. The most popular means of doing this is called the Amsler grid. As described in chapter 4, this is a black-and-white grid (available through your eye doctor, online, and as a mobile app), to be observed at a distance of about 14 inches with your normal reading glasses or bifocals (see figure 4.4). You should test each eye separately and as often as every day if you're a person at high risk for wet AMD. Be sure to report anything unusual to your eye doctor immediately; this includes a loss of clarity, distortion, or waviness of the lines (see figure 10.4B). Any changes—particularly the development of CNV—may indicate a progression in macular degeneration, and these, if detected early enough, may be amenable to treatment. Speak with your eye doctor to see if you should be monitoring your AMD with an Amsler grid or with another home monitoring test.

Why is early detection important, if macular degeneration isn't usually treatable? This is a good question. Although there is no treatment for the dry form of AMD, vitamin supplements can slow down progression. Early detection can also improve outcome when intravitreal injections (see below) are needed to treat the new membranes that develop in the wet form. *And if this is the case for you, early detection and treatment may mean the difference between useful sight and legal blindness.*

For people with wet AMD, a basic eye exam is often inadequate to establish whether these membranes are present underneath the retina. In patients in whom these membranes are suspected—from the patient's history, for instance, or because of retinal changes—imaging techniques such as spectral domain OCT (SD-OCT), fundus photography, and a fluorescein angiogram can help detect their often-elusive presence. SD-OCT is an enhanced noninvasive OCT imaging technique with high scanning speeds and increased resolution that is safe and easily performed for evaluating the retina, especially when CNV is suspected. This retinal imaging technique has become very important in the diagnosis, classification, and treatment monitoring of CNV, and future enhancements such as OCT angiography may add further to our ability to image the retina in patients with AMD. The fluorescein angiogram (see chapter 4), an essential tool in evaluation and treatment, can also help us distinguish between normal and abnormal blood vessels in the retina. Since these new blood vessels develop *below* the retinal pigment epithelium—which means that we cannot see them with the naked eye—the OCT and fluorescein dye study help reveal their location and extent, especially for intravitreal injection treatment. They are also used after the injection, to make sure that the membrane is regressing, and to monitor patients closely after treatment, to spot the earliest sign that the problem is recurring (see below). Over the years, other techniques have proven helpful for detecting and monitoring of CNV. These techniques include preferential hyperacuity perimetry for detecting the recent onset of CNV in intermediate AMD patients and computer-enhanced indocyanine green angiography, which uses video imaging to study blood flow in the choroid and retina.

Treating AMD

In the first edition of *The Eye Book*, this was a short section because the vast majority of eyes with macular degeneration, dry or wet, couldn't be helped at that time by any form of treatment. In fact, there are still *no* treatments available for the nonneovascular or dry form, the one that affects most people with macular degeneration (although stem cells and recombinant DNA hold promise); however, great advances have been made over the past 20 years in our ability to treat the neovascular or wet form.

Lasers

Although laser treatment has been shown to be successful for patients with the wet form of macular degeneration (the subretinal neovascular membranes), few people—an estimated one out of every ten—are diagnosed soon enough or considered good candidates for the procedure.

Much of our information on the natural history and laser treatment of subretinal neovascular membranes comes from the Macular Photocoagulation Study, a large clinical trial conducted by the National Eye Institute. In this study, argon lasers, in a procedure called *argon laser photocoagulation treatment*, were used on membranes of various sizes and locations in the macula. Laser treatments were shown to be effective for some, but not all, patients with CNV. Also, laser treatments don't always prevent vision from deteriorating further and may merely *reduce* someone's odds of severe vision loss.

Another fact of laser treatment is that, even in the best cases, it destroys retinal tissue. For a surgeon to do a good job attacking the CNV with a laser, it's inevitable that some of the healthy retina will be lost as well. Often this results in a permanent visual blind spot. And the membranes often grow back. For some people, laser treatment can be even more devastating than the disease, and for this and all the other reasons mentioned above, laser treatment is now used only in very rare instances in AMD patients with CNV.

Surgery

Surgical approaches to AMD are purely investigational—and controversial. Retinal specialists attempting to treat subretinal neovascular membranes surgically haven't met with much success. Retinal transplants have also been tried by retinal specialists, but so far we've been stymied by two basic problems. One of them is rejection: the eye—which does very well with corneal transplants because they don't involve many blood vessels—tends not to accept someone else's retina without a fight. The other problem is with retinal cell regeneration and differentiation: the cells don't work as they should after they are replaced in the eye. And finally, the ultimate functional practicality of retinal transplants remains questionable, since transplanted cells must also be able to reestablish and maintain the many complex nerve connections to the brain. Computer microchips implanted on the retinal surface are also being investigated as a way of restoring vision in people with severe forms of macular degeneration.

Many scientists remain optimistic about the potential of retinal transplants, stem cell introduction, or recombinant DNA techniques—one day—to *restore* vision in people with severe macular degeneration.

Antiangiogenic Therapies

The growth of new blood vessels from existing blood vessels is referred to as *angiogenesis*. The new blood vessel growth seen in AMD and leading to CNV arises from the choroid below Bruch membrane and can course upward into the RPE and sensory retina, where it can cause havoc among the normal tissues and disrupt vision. Although the inciting event for the development of CNV is poorly understood, this event begins a well-studied complex cascade of changes in existing blood vessels, which ultimately leads to new capillary development and formation of sinister, fragile vascular networks prone to retinal devastation. Growth-promoting and growth-inhibiting factors secreted by regional cells and tissues associated with angiogenesis have been identified and can sound like something out of your high school chemistry book—VEGF (vascular endothelial growth factor), FGF (fibroblast growth factor), TGF-alpha (transforming growth factor), TGF-beta, thrombospondin, angiostatin, and PEDF (pigment epithelial-derived factor), just to name some of the factors important in this angiogenic cascade.

Although research is constantly ongoing and new antiangiogenic therapies seem to be continually developed and tested, as of this writing antiangiogenic research has mainly focused on the inhibition of VEGF. VEGF is found in high concentrations in excised CNV and vitreous samples and is identified as having an important role in several stages of the angiogenic cascade. A discussion of the science and studies behind this innovative treatment conducted by a myriad of researchers is too exhaustive for this text but can be found online. Suffice it to say, anti-VEGF agents injected into the vitreous of an AMD patient with CNV have become the mainstay of treatment for this condition. And although their names can be daunting to pronounce (try saying these ten times fast: pegaptanib, ranibizumab, aflibercept, bevacizumab), these drugs have miraculously spared many patients from the severe vision loss often associated with neovascular AMD. These treatments are not perfect, however, as they often require monthly intravitreal injections, which, although well tolerated, can on rare occasions lead to serious ocular complications such as elevated eye pressure, retinal detachment, vitreous hemorrhage, and endophthalmitis (a serious infection inside the eye). Stay tuned—the treatment of CNV in the eye should only continue to improve with time thanks to the dedication of basic science researchers and clinicians who have been determined to conquer this condition and prevent vision loss in these patients.

Low Vision Rehabilitation

There's no good way to measure AMD's true impact—its threat to patients' independence and the burdens it often creates for family, friends, and society. But even though there's no cure, yet, for AMD, there are many things patients can do to retain independence and quality of life. For one thing, the benefit of low vision rehabilitation by a licensed low vision consultant, typically an occupational therapist with special low vision training, should not be underestimated. Patients will be introduced to a wide variety of visual aids—eyeglasses, magnifiers, low vision devices, and large-print materials (see chapter 20)—and instructed on vision strategies such as the use of magnification, optimal lighting, contrast enhancement techniques, and eccentric fixation. There are agencies and services whose whole purpose is to help people with "low vision." You owe it to yourself and your family to see what they have to offer.

And finally, there's counseling, which really can help. The tremendous value of counselors and support groups is often underestimated because too often the enormous psychological impact of vision loss is overlooked by doctors as well as patients. For many patients and their families, simply knowing that they're not alone can mean a world of difference.

Part IV

OTHER EYE PROBLEMS

Diagnosis and Treatment

Chapter 11

THE EYELIDS

Their job seems simple enough: open, shut. Blink—and in the process protect the eye from foreign particles and keep it from becoming too dry. What could possibly go wrong here? Well, there are several problems that can occur in the eyelids, ranging from benign dermatitis to malignant tumors. Here are some of the most common.

Allergic Dermatitis (Red, Scaly, Itchy Eyelids)

We all know what "allergy eyes" feel like: inflamed, itchy, and watery (see chapter 13). But an allergic reaction can also cause scaly, red, itchy skin outside the eye and on the eyelids.

Allergic dermatitis is what happens when the skin of the eyelids becomes inflamed by an allergic reaction. It usually involves a miserable cycle of itching, rubbing, and dryness—followed by still more itching, rubbing, irritation, and even peeling and cracking of the skin. (*Note:* Another condition with a similar name, infectious dermatitis, is a different problem altogether. As its name suggests, the trouble here is an infection in the skin, and you can usually tell the difference between these two forms of dermatitis pretty easily: allergic dermatitis itches; infectious dermatitis hurts. The treatment differs as well: infectious dermatitis is treated by antibiotics and warm compresses.)

Treatment: To break the unpleasant cycle of itchiness and peeling, you'll probably be told to apply cold compresses (to decrease swelling of tissues) four times a day (or more often, if possible) and to use topical drops or ointments, as well as oral drugs such as antihistamines. Your doctor might also prescribe a steroid-containing ointment for use in and around the eye. *Note:* Because ointments and creams used *near* the eye almost always work their way *into* the eye, make sure that whatever you're putting on your eyelids is *specifically for eye problems.* If your allergic dermatitis is just on your face but not near your eyes, you can use mild over-the-counter steroid skin creams. But beware of long-term use of any steroid preparation—even one prescribed for short-term use by your eye doctor. Using a steroid cream regularly for months or years—even when it's just applied to your eyelid and not technically *in* your eye—can lead to elevated eye pressure and glaucoma.

Hives: Eat the wrong food, and you may experience yet another allergic reaction on the eyelids: hives. Like hives elsewhere on the skin, these crazy dots or bumps seem to appear out of nowhere. They're red, extremely itchy mounds that can be as small as a kernel of corn or as large as a quarter (or even larger). Their only redeeming feature is that they usually don't last long and tend to go away on their own, or with the help of cold compresses and antihistamines.

Blepharitis (Inflammation of the Eyelids)

Have you ever looked into the mirror and noticed that your eyelashes had crust or flakes in them—especially near the bottom, where they grow out of the eyelid? Or perhaps you've noticed a perennial dusting of flaky particles inside your eyeglasses. Maybe you're prone to recurrent styes, or the edges of your eyelids seem chronically red or pink. Do your eyes sometimes feel gritty and your eyelids heavy, especially when you read? All of these problems can be associated with *blepharitis*, or inflammation of the eyelids—a distinctly unglamorous condition that can be summed up as "eyelash dandruff."

Several conditions can make this happen. By far the most common is seborrhea, a disorder of the oil-making sebaceous glands—

in this case, the ones at the base of the eyelids—that causes them to secrete more oil than usual. People who have seborrhea elsewhere—on the scalp, brow, or face—and/or oily skin may also be prone to this form of blepharitis, which is not infectious. Meibomian gland dysfunction (MGD) can be present too.

People with seborrheic blepharitis often have a secondary bacterial infection on their eyelids, however. Because more than one problem is at work here, this is called a *mixed blepharitis*. This infection, in turn, can cause trouble of its own—namely, chronic conjunctivitis (see chapter 13), with recurrent corneal infections. Its symptoms may include extra sensitivity to bright light, pain, tearing, redness, blurred vision, and mucous discharge from the eye. Worse, the bacteria can infect the glands of the eyelid margins and lead to recurrent styes and chalazia (see below). Misdirected, broken, and missing eyelashes are also common with this infection.

Treatment: Blepharitis is often a chronic condition, so our two goals are to get it under control and then to keep it that way. Lid hygiene and warm compresses (see box) are the mainstay of treatment for blepharitis, especially the seborrheic form. Cleaning the eyelash bases and applying warm compresses regularly will cut the buildup of secretions by the overactive sebaceous glands. Over-the-counter dandruff shampoos, which control seborrhea of the scalp, eyebrow, and face, also may help—although again, because these may inadvertently get into the eye, they should never be used directly on the eyelid. Treatment of associated MGD should also be considered and discussed with your eyecare specialist.

If you're dealing with a bacterial infection on the eyelid margin (as in a mixed blepharitis, described above), you may also need antibiotic and/or steroid drops or ointments. Many people with blepharitis must use some combination of treatment for months or even years to keep this condition under control—especially those with chronically recurring chalazia. Even so, eye makeup and contacts can still be worn. Keep in mind, though, that blepharitis is generally not curable, so the goal is control of the inflammation, as well as restoring comfort to you. As such, even when under good control, flare-ups of your blepharitis, hordeola, and chalazia can occur. On the other hand, if you find yourself faced with a severe case of blepharitis that does not seem to respond to your treatments, ask your eye doctor to evaluate you for *Demodex folliculorum* and *Demodex brevis*. These tiny mites can live in the hair follicles of your eyelashes and deeper glands of your eyelids. They can lead to symptoms similar to those seen with blepharitis. While mites are

LID HYGIENE AND WARM COMPRESSES

How to give your eyelids a gentle bath:

- Place a drop of baby shampoo—it's gentle on the eyes—on a clean cloth, add water, and make a mild lather. (Eyelid scrubs, available at drugstores, can also be used.)
- Close your eyes (this is important).
- Gently rub your lashes, going "with the grain": use a *downward* motion on your upper lashes and an *upward* motion on your lower lashes, along with gentle side-to-side rubbing.
- Rinse thoroughly with warm water.
- Repeat at least twice a day, or as directed by your eye doctor.

How to apply a warm compress:

- Make a barber's towel: place a clean cloth in warm—but not too hot—water, and wring it out slightly.
- Place the cloth over your *closed eye*.
- When the cloth becomes cool, repeat the previous steps.
- Keep this up for at least 10–20 minutes at a time (or longer in some cases).
- Do this at least twice a day.

difficult to eradicate, tea oil treatment of the eyelashes has been successful when applied to the bases of the eyelashes repeatedly over the course of several weeks. This tea oil treatment can be viewed in videos online thanks to many ex-sufferers of Demodex who are happy to share this cure.

Angular Erosion (Chapping of the Eyelids)

Eyelids can get chapped too—just like lips. This painful breakdown of the skin occurs at the outer angle of the eye, where the upper and lower lids meet. A form of blepharitis, often associated with a bacterial infection, *angular erosion* tends to persist if it's not treated.

Treatment: Fortunately, angular erosion can be cured with proper lid hygiene and regular application of warm compresses (see above), as well as an antibiotic and/or a steroid ophthalmic ointment. Again, though, steroids should not be overused on the eyelids. *Note: Redness and pain are symptoms your doctor should assess; make an appointment, and go see them.*

Bell Palsy (Weakness in the Facial Muscles)

A sudden weakness in all or part of the facial muscles is called *Bell palsy*. Although its onset—which often has no apparent cause—is sudden and terrifying, Bell palsy often begins to go away by itself within a few weeks, with complete resolution in 2–3 months. But sometimes during its stay Bell palsy affects the orbicularis muscle, the muscle that closes the eyelids—hampering the eye's ability to close all the way. Then, because the eyes are constantly exposed to the air, they become dry and irritated.

Treatment: Oral corticosteroids and lubricating eye ointments can help, although they do tend to cause blurred vision; some people must also tape their eyelids shut at night to relieve the dryness.

If Bell palsy lasts longer than a few weeks and you are dealing with a dry eye, your eye doctor can perform a procedure called a *tarsorrhaphy*, which involves partially closing the lids with sutures. This can be a temporary or a permanent step toward alleviating the symptoms and potential complications associated with a dry eye. (For more on dry eyes, see chapter 14.)

Blepharospasm (Tight Squeezing of the Eyelids)

The key word here is *spasm*. Like a spasm of any other muscle—in the hand, for instance, or the heart—*blepharospasm* is an involuntary tight squeezing of the eyelids. This may be a symptom of Parkinsonism, or a result of eye irritation such as from a dry eye or intraocular inflammation. Or there may be no apparent cause (this is called *essential blepharospasm*). In minor cases, it's mainly a nuisance, but in its more serious form, blepharospasm can be disabling.

Treatment: Of the many different treatments that have had some success, the treatment of choice is an injection of botulinum toxin (known by most people as "Botox") directly into the muscle around the eye (the orbicularis oculi), which usually gives good relief for several months and can be repeated after it wears off.

For more information on benign essential blepharospasm, contact the Benign Essential Blepharospasm Research Foundation, Inc., PO Box 12468, Beaumont, TX 77726-2468, 409-832-0788.

Dermatochalasis (Drooping Eyelid Skin)

Over the years, eyelid tissue loses its elasticity. *Dermatochalasis* is an age-related drooping or sagging of the skin in the eyelid. (In the upper eyelid, this is commonly called *hooding*. In the lower eyelid, many people use the accurate but unflattering term *bags*.)

Dermatochalasis in the upper eyelid ranges from a mild loss of the normal eyelid fold—mainly a cosmetic issue—to extensive sagging, in which eyelid tissue completely covers the eyelashes and eyes and may even interfere with vision. (The severity of dermatochalasis often becomes an important concern with insurance companies, which tend not to pay for consultations and surgery related to cosmetic problems. Many insurance companies require a thorough eye examination with a summary letter from the eye doctor, photographs, and visual field testing to demonstrate the degree to which the droopy eyelids are impairing vision before they'll agree to pay for surgery to correct the problem.)

Treatment: Surgery to correct dermatochalasis (called *blepharoplasty*) of either the upper or lower eyelids is usually performed by an ophthalmologist or a plastic surgeon. It is generally a safe procedure with few complications. (*Note:* Before having *any* form of surgery, discuss all your concerns with your doctor, and make sure you understand the risks and potential side effects involved.) Both eyes are usually done at the same time, so that the result will look "even."

During surgery of the upper eyelid, the excessive skin is removed. A portion of skin between the brow and lash edge is removed along with some underlying fat, and then the edges of the skin are sewn together. (The operation to remove bags under the eyes is more involved but equally successful.) The stitches are removed within 7–10 days. Discomfort is minimal, although you'll probably have some black and blue marks around the eyes for a week or so; these fade, as bruises often do, to interesting shades of green and yellow before disappearing. Ice packs can help decrease the swelling. Within a couple of weeks all signs of the surgery will disappear, and vision and appearance will improve.

Blepharoptosis (Drooping Eyelid)

Much less common and more complicated than dermatochalasis is drooping of the entire eyelid, not just the skin. This condition, called *blepharoptosis of the eyelid* (or *ptosis* for short), usually occurs when the nerve that works the levator muscle (which raises the eyelid) is damaged. Ptosis can be broadly classified as congenital or acquired. In acquired ptosis, the muscle may have been weakened by a stroke or a condition such as myasthenia, or even by normal aging. A thorough ocular, medical, and surgical history and examination must precede any form of treatment.

Treatment: Surgical repair may be recommended when ptosis interferes with vision, or when it dramatically affects someone's appearance. *Note:* Find a surgeon who specializes in this type of surgery. This operation, which may involve shortening the levator muscle and removing some of the overlying skin or some of the conjunctiva, is far more complicated than dermatochalasis surgery. Good surgical repair of ptosis alleviates the problem. Botched or overdone surgery may mean that your eyelids won't close all the way—so your eyes will get dry and irritated from being exposed to the air. Although lubricating eye drops or ointments can help, this situation can be worse than the original ptosis.

Entropion and Ectropion (the Edge of the Eyelid Turning In or Out)

Sometimes the lower eyelashes turn inward and brush against the eye; this is called *entropion*. Sometimes they turn outward, so that the eyelid doesn't close properly; this is called *ectropion*. Either way, the problem is irritating. Entropion causes the lashes to rub against the conjunctiva and the cornea, irritating the eye. Ectropion exposes the conjunctiva and cornea to the air, causing dryness.

Entropion sometimes begins when the eye is already irritated by something else. You blink hard, trying to get rid of whatever's irritating your eye, and it just gets worse. Fortunately, this is usually a temporary condition that goes away when the initial problem—say, itchy eyes from hay fever—resolves itself. Chronic entropion, on the other hand, often develops as tissue deep in the eyelid ages and loses its strength, causing the edge of the lid to flip inward.

Ectropion, too, is a result of aging tissues. Many people who have it are bothered as much by the way it affects their appearance as by the way it makes their eyes feel; when the lid turns out so much that the lid's reddish inner lining shows, it can be very noticeable.

Treatment: Treatment for entropion may be as simple and low-tech as a piece of adhesive tape (paper tape is hypoallergenic and best tolerated): placed securely on the skin of the lower eyelid, the tape sometimes pulls the edge of the lid down and keeps it from turning in. Happily, this treatment sometimes reverses the condition, which settles down almost as if the lid had been "retrained" not to turn in. But this doesn't always work; in addition, the skin on the eyelid can be irritated by the tape. When the tape treatment doesn't work, surgical repair usually solves the problem. With ectropion, surgical repair as an outpatient is almost always necessary to relieve the chronic irritation caused by this condition, although in some mild cases lid hygiene and warm compresses, along with a lubricating ointment to decrease drying of the conjunctiva and cornea, can help a person avoid the need for surgery.

Myokymia (Twitching Eyelid)

Have you ever felt your eyelid jump, or seen it twitch in the mirror? This rapid twitching, called *myokymia*, though usually temporary, can become a nuisance if it persists. (You can stop it by pressing your finger over the twitching area, but it will probably start up again when you take your finger away.) Myokymia is most often caused by stress or fatigue and is not a sign of disease.

Treatment: The main treatment for myokymia is simply to wait it out and try not to let it drive you crazy. Eventually, when you get more sleep and feel more relaxed, it will probably go away; it usually resolves within 3–4 weeks. *Note:* If it doesn't go away after 3 or 4 weeks, or if it seems particularly severe, then consult your eye care specialist for a thorough eye examination. Persistent myokymia may be the result of other conditions. Regardless of what's causing it, if the myokymia is persistent and bothersome, administration of botulinum toxin to the muscles around the eyes might be considered as a treatment.

Shingles (Nerve Pain and Blistering, Crusty Eyelids)

Remember when you had the chicken pox? Well, that virus is still around, somewhere, in your body. And it may have other cards to play: it's the same virus that causes herpes zoster, or *shingles*, in adults. Anyone who has ever had chicken pox may develop shingles years afterward, particularly if the body's immune system becomes weakened or challenged.

Remember how bad those chicken pox were? Shingles is worse. It can cause pain, often severe pain, plus blistering and crusting of the skin. These blisters follow the route of a sensory nerve, so you develop pain and then blisters down a path on the skin. If the sensory nerve on your upper face is affected, the pain and blistering can blanket your forehead and even the eyelids. Mercifully, although the pain is miserable, the eyes themselves are usually spared. However, if the nerves to the nose or forehead are involved, this often affects the eye—usually after the skin lesions begin to get better. *If you have shingles on your face, you need to see your eye doctor. Without treatment, if your eyes are affected, you're at risk for developing corneal* *involvement, uveitis, glaucoma, and other conditions that could cause permanent harm.*

Treatment: Oral antiviral medication, particularly when started within 72 hours of the onset of symptoms, has been found to decrease the incidence and severity of the ocular complications typically seen with shingles and may also reduce the duration and severity of the lingering neuralgia (postherpetic neuralgia) that often follows. Vigorous lubrication of the eye with nonpreserved artificial tears, gels, and ointments is recommended both during an outbreak of shingles near or involving the eye and following corneal involvement that can lead to decreased corneal sensation (neurotrophic keratopathy).

Hordeola and Chalazia (Styes or Lumps on the Eyelid)

A stye, also called a *hordeolum*, is an infection on your eyelid: a red, swollen area that hurts when you touch it. Styes can crop up on the outside of the eyelid at the base of a hair follicle (an external hordeolum, due to an infected sebaceous gland) or on the eyelid's inner surface (an internal hordeolum, due to an infected Meibomian gland).

Styes can go away by themselves or with treatment. However, sometimes an internal stye evolves into a *chalazion*, a usually painless lump that results from the body's inflammatory reaction to oily secretions in the clogged Meibomian gland (figure 11.1). Chalazia typically don't affect vision, won't turn into cancer, and are essentially benign—more of a cosmetic nuisance than anything else. (However, if one of these lumps is located higher, in the middle of the upper eyelid, it can flatten the central cornea and distort vision.)

Treatment: The best treatment for styes is heat: hold a warm, wet cloth (or something else known to hold heat, like a potato or rice in a sock) over the sore spot for at least 20–30 minutes at a time, three to four times a day. Antibiotics are seldom needed. Steroid injections may be beneficial. Most chalazia go away by themselves, but a little encouragement in the form of lid hygiene and warm compresses (see above) is advisable; we tell our patients that even if

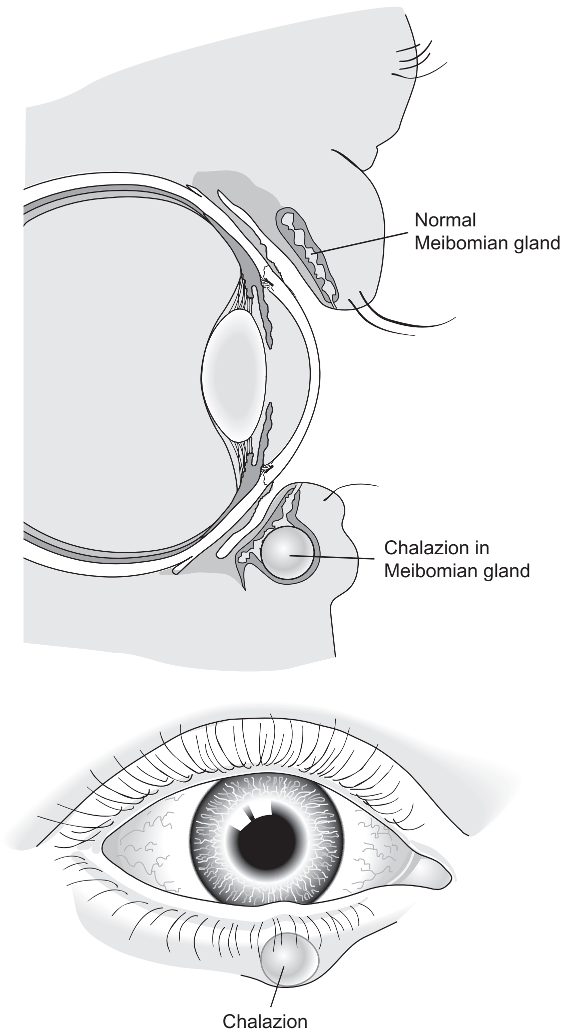

Figure 11.1. Chalazion

it's small and not too bothersome, it's best to apply heat right away before the chalazion has the chance of getting worse. However, if a chalazion gets big enough to be annoying, or if it affects your vision, you may need to have it removed surgically. The procedure is minor, involving local anesthesia, and simpler than having a cavity filled at the dentist's office. Within 24 hours your eyelid will be back to normal, except for some minor swelling and perhaps a black eye. Systemic antibiotics are rarely needed if a hordeolum or chalazion evolves into a diffuse swelling of the upper eyelid, possibly due to a secondary eyelid cellutis. Oral antibiotics like doxycycline may also be given for chronic blepharitis, which can lead to recurrent chalazia (see above). *Note:* Although chalazia are usually minor, one-time occurrences, "repeat offenders" or recurrent chalazia may indicate a more serious problem. Recurrent chalazia may actually be cancerous growths masquerading as benign eyelid lumps and may require a biopsy (a test in which a small sample of tissue is removed and analyzed).

Eyelid Tumors: Dangerous Masqueraders

Most of the eyelid's problems are annoying but benign. A few, however, are more serious. And unfortunately, some of these—particularly, malignant tumors of the eyelid—are sneaky, disguising themselves as blepharitis, chalazia, or styes. *Therefore, if you have any chronic eyelid problem that has not responded promptly to treatment, you should consult your eye doctor.*

Basal cell carcinoma, the most common eyelid malignancy, usually develops on the lower lid in fair-skinned, blue-eyed, red-haired or blond, middle-aged or older individuals, although it can be found in younger people too as part of genetic multisystem disorders. It has many different patterns of growth: it can look like a bump, an ulcer, or a cyst, or it can even appear flat. As it grows, it may cause other eyelid problems, including entropion or ectropion, chalazia, or chronic blepharitis.

Squamous cell carcinoma is another common skin cancer of the eyelid. Squamous cell carcinoma can also mimic several benign eyelid problems.

Also, like basal cell carcinoma, squamous cell carcinoma is thought to be caused by too much sunlight exposure; it often appears on sun-damaged skin, usually on the upper eyelid. *For this reason, it is imperative that people who have had a basal or squamous cell carcinoma wear a wide-brimmed hat, sunglasses, and sunscreen when outdoors.* (Really, this is good advice for everyone, infants through adults.)

Sebaceous cell carcinoma is not as common but is even more serious—in fact, if not detected in time, it can be fatal. It, too, often resembles such common eyelid conditions as chalazia and blepharitis. So again, if you have recurrent or chronic chalazia or other eyelid problems, see your eye doctor, who may decide to order a biopsy.

Chapter 12

THE CORNEA

The cornea is truly the eye's window. As described in chapter 1, it's the transparent, domed "watch glass" that sits over the sclera (the "white" of the eye). Through this clear porthole the iris and pupil are easily visible; looking further still beyond them, we can see all the way to the back of the eye—the vitreous, retina, and optic nerve (see figure 1.1, panels A and B).

Before we discuss some things that can go wrong with the cornea, let's take a moment to review its anatomy. The wafer-thin cornea—amazingly, only about half a millimeter thick—is like a cake with five layers, each with its own special function. On top are *epithelial (outer lining) cells* (the "icing" on this cake, or the skin); this vital layer (also called the *epithelium*) protects the rest of the cornea and provides a smooth surface for tears. Next comes the cellophane-thin *Bowman membrane*; then the tough, transparent *stroma*, the bulk of the cornea (the cake itself); and then another layer of cellophane, called *Descemet membrane*. These middle three layers act as scaffolding, providing structural support to the cornea as it arches over the front of the eye. Last is the single layer of *endothelial (inner lining) cells* (also called the *endothelium*). Because this important layer touches the aqueous of the eye's anterior chamber, it serves as a sort of "bilge pump," keeping the cornea free of excess moisture. When this pump malfunctions, the cornea can swell, and this can distort and blur vision.

The cornea normally does not contain any blood vessels. However, it is rich in sensory nerve fibers: under the epithelial layer alone are about seventy of them, which helps explain why the cornea is so sensitive to pain. The epithelial cells act as a protective blanket, like enamel on a tooth, insulating the nerve fibers from the world. When that blanket is frayed—or, continuing the tooth analogy, when the enamel is cracked or has a cavity—those ultrasensitive nerves react. Even a small loss of epithelial cells can be excruciatingly painful, if these nerve endings become exposed.

Now let's look at some common problems affecting the cornea.

Corneal Abrasion

Because of the abundance of nerves throughout its layers, even a slight injury or irritation to the cornea can result in a lot of discomfort or pain. An *abrasion*—a scrape of the epithelium, or outer surface—is the most common injury to the cornea. It can happen so easily—when the eye gets too close to a baby's fingernail, for instance, or the corner of an envelope, or a tree branch. All of a sudden it feels as if there's a hot poker in your eye. Other symptoms include redness, a feeling like there's a piece of grit in your eye, and extra sensitivity to bright lights. Because it's often difficult to see the actual injury with the naked eye, eye doctors rely on special fluorescent dyes, which target and highlight areas of damage, to help them determine the extent of the wound.

Fortunately, despite the severe discomfort and blurred vision that often accompany corneal abrasions, these injuries usually heal fairly quickly—sometimes in a matter of hours, sometimes within a few days—and don't leave any lasting damage.

Treatment: Basically, the cornea must heal itself, and all we can do is provide the best conditions possible. (Think of skin injured by a scrape or burn; it hurts until your skin lays down new layers of cells, which insulate the nerves beneath.) Thus, the main treatment for a small corneal abrasion is to regularly lubricate the eye and let it heal by itself, and treatment for a larger corneal abrasion is simply to patch the eye. It's not quite as easy as it sounds—in other words, you shouldn't try to do it yourself with an eye patch from the drugstore—because to be effective, the eye patch must immobilize the eyelid and prevent it from rubbing over the injured area. The epithelial cells need time to multiply and coat the injury, which means that the patch needs to be tight enough to keep the eyelid still. In addition, because the abrasion could be infected, you should always see a doctor first.

Although patching an eye with a corneal abrasion can relieve pain by immobilizing the movement of the upper eyelid over the exposed nerves in the abraded area, a patch can be uncomfortable for some people, especially if not applied firmly over the lid. It takes several eye patches—generally three—to create enough bulk to secure the lid. (Eye doctors either stack three patches over the eyelid or use two, with the one directly on the eyelid folded in half.) The eye pads are fixed over the eyelid with at least four pieces of surgical tape, extending from the forehead to the cheek.

Sometimes, when eye patches can't be tolerated or when the abrasion doesn't appear to be healing, eye doctors apply a special "bandage" contact lens over the abrasion. (*Note:* Because there is a risk of infection with these lenses, this should be done only by an eye care specialist very familiar with this technique.) A bandage contact lens allows the patient to avoid having to cope with the nuisance of wearing a large and bulky eye patch and enables the abraded eye to see while it heals.

Recurrent Corneal Erosion

As we said before, most corneal abrasions heal fairly quickly, without causing permanent injury to the cornea. However, an ornery few don't *stay* healed, apparently because the new blanket of epithelial cells doesn't stick to the injured area. This problem is called *recurrent corneal erosion*.

When an abrasion is particularly deep or damaging and healing is inadequate, the epithelial cells simply slide off—even months or years after the initial injury. And unfortunately, losing the protective insulation of the epithelial cells, again exposing the nerves underneath them, hurts about as much the second time as it did the first.

But we do have some clues as to who might be prone to recurrent corneal erosion—and therefore we can try to prevent it from happening. People who have had corneal abrasions due to fingernails, paper, or plant matter seem to be predisposed to developing recurrent erosion. We also know that the epithelial cells, if they're going to erode at all—and remember, in most people they don't—tend to come loose early in the morning, usually when people wake up. Why? Because your eyes dry out as you sleep. When the epithelial cells aren't secured to the cornea, they can be rubbed off by the simple act of opening your eyes in the morning. So if you have a history of eye discomfort when you get up—if you have pain and redness, first thing in the morning—alert your eye doctor.

Treatment: Because dryness seems to exacerbate the problem, recurrent corneal erosion is usually treated successfully with additional lubrication—either artificial tear ointment or a specially prepared hypertonic ointment—in the eye at bedtime. (Some people need to use eye drop forms of these ointments regularly during the daytime as well, to keep the cornea moist and foster healing.)

Interestingly, hypertonic drops and ointments work because of their high concentrations of salt. The salt draws excess water from the healing epithelial cells and enhances their ability to stick to the cornea. (Since too much dryness also makes cells fall off, this might be confusing, but bear in mind that there are different types of dryness. Dry eyes are the result of surface dryness, whereas cellular "dryness" or dehydration is the result of drawing excess water out of the corneal cells.)

Sometimes further treatments are necessary. One such treatment is the use of special "bandage" contact lenses similar to those used for abrasions (see above). And in particularly stubborn cases—if the recurrences are frequent, terribly painful, and debilitating—special surgical and laser procedures may be needed to help repair the damaged cornea.

Corneal Ulcer

An *ulcer* is a focused, inflamed, painful response to infection. In the cornea, having an ulcer can feel a lot like having an abrasion—except that the redness, the sensation of having a piece of grit in your eye, and the difficulty tolerating bright light are usually worse.

Although countless bacteria exist in and around the healthy eye, normally they're effectively prevented from invading the cornea by the epithelium, which acts as a shield, and by the powerful bacteria-fighting agents in normal tears. But these natural barriers aren't impenetrable. They can be eroded by such things as eye trauma, dry eyes (particularly the severe form found in Sjögren syndrome; see chapter 14), refractive surgery, improper eyelid function (a problem with Bell palsy; see chapter 11), contact lenses, and even viruses such as herpes zoster (found in chicken pox and "shingles") and herpes simplex (the same virus found in "fever blisters" on the lips). (Just as fever blisters often come about in response to physical or emotional stress, herpes keratitis can also reappear after months or even years.) *Note:* Viral infections of the cornea are very serious and can ultimately lead to scarring and permanent vision loss. In fact, herpes keratitis is the most common cause of corneal blindness in developed countries.

The slightest chink in the armor of the epithelial cells opens the door to the host of infectious agents crowding just outside—an unsavory cast of characters that also may include fungi and such bacteria as staphylococcus, streptococcus, and pseudomonas (often linked to corneal ulcers in contact lens wearers). Some bacterial strains are so nasty and virulent that, once present in the eye, they can even grow *directly through an intact corneal epithelium*. Contact lenses greatly increase the risk of corneal ulcers when there is an infection present or there has been an insult to the eye, and in such cases they should be removed immediately. Contact lens wearers should see an eye doctor at the first sign of a red eye or persistent eye discomfort.

Treatment: Because corneal ulcers are so serious, and potentially sight threatening, your job is to get treatment as promptly as possible. Your eye doctor's task is to figure out what's causing the infection and how best to treat it—with antibiotic, antiviral, or antifungal agents. Be sure to take the entire dose of antibiotic, if that's the treatment, because if you take less than the full dose, resistant microorganisms might grow and the infection could become much more difficult to get rid of.

Corneal Dystrophy

A *dystrophy* is an abnormal, possibly progressive condition that is often hereditary and usually present at birth. Many forms of dystrophy can affect the cornea, but the two most common are corneal epithelial basement membrane dystrophy and corneal endothelial cell dystrophy.

Corneal Epithelial Basement Membrane Dystrophy

Think of the basement membrane of the corneal epithelium as a slab of cement. On this cement, in nice, neat rows, are stacks of bricks—in this case, epithelial cells. The smoother the cement, the neater the stacks of bricks, and the better they serve as a wall against infection and as a smooth surface that, like a clean windshield, allows clear vision.

Basically, epithelial basement membrane dystrophy is a problem with the cement and bricks. It usually occurs in adults between the ages of 40 and 70, is slightly more common in women than men, and is without a well-documented inheritance pattern. The problem here is that there is abnormal epithelial turnover and the basement membrane underneath becomes abnormally thick and irregular, forming a telltale pattern (as seen under the high magnification of the slit lamp) of ridges, cysts, and whirls—thus the descriptive name for this condition, "map-dot-fingerprint dystrophy." This causes the overlying epithelial cells to buckle, break down, become "unstuck," and slough off.

Symptoms range from mild irritation to severe pain and redness in the eye. Because the underlying problem doesn't go away, and because symptoms are identical to those of recurrent corneal erosion, epithelial corneal dystrophy can even be thought of as a cause of recurrent corneal erosion.

Here, too, as in recurrent corneal erosion, symptoms are usually worst in the early morning. Remember, while we sleep, when our eyelids aren't constantly blinking and applying new coats of lubricating tears, our eyes naturally become a little dry. But without that extra lubrication—if epithelial cells are poorly stuck to the cornea *already*—opening the eye is somewhat akin to scraping sandpaper across a layer of varnish; the eyelid rubs these cells right off, which can be very painful.

Treatment: Because this problem is so similar to recurrent erosion—and, in difficult cases, often just as frustrating—the treatment is much the same: keeping the eye properly hydrated so that the epithelial cells stay put.

The first line of attack is usually ointments—artificial tears and hypertonic saline preparations—at bedtime and drops during the day. An eye patch or "bandage" contact lens (described above, under "Corneal Abrasion") may also be necessary.

Because your eye, like your skin, responds to your immediate environment, it may also help to make your home and office more humid—with cool misters or vaporizers, or even a fish tank.

If the extra humidity and lubrication fail to stop these cells from falling off, the next step may be surgery—lasers or other techniques. For example, some people have been helped by surgery that gently clears away some persistently "unsticky" cells to make room for new, more adherent cells.

Corneal Endothelial Cell Dystrophy

Corneal endothelial cell dystrophy (Fuchs dystrophy) is a bilateral condition (one that affects both eyes); it usually manifests itself in people in their forties and fifties, it is slightly more common in women than men, and some cases exhibit autosomal dominant inheritance.

Remember how the cornea's endothelium acts as a pump? Well, in this disorder the pump slowly fails. And as it does, the excess moisture that used to be siphoned away starts to build up. The cornea swells and becomes less transparent, and ultimately vision can deteriorate.

The first symptom of this corneal swelling is usually blurry vision, particularly noticeable when you first wake up. Here as well, too much moisture is a bad thing. During the day, when your eyelids are mostly open, water evaporates from the cornea; it's also removed by the pumping action of the endothelial cells, which siphon off excess water. All of this moisture removal helps keep the cornea clear. But when you're asleep, only one of these water-removing processes continues. There's no evaporation because the eyelids are closed, so the endothelial cells have to work extra hard to keep the cornea dehydrated. In endothelial cell dystrophy, however, because the pump isn't operating at top form, excess water accumulates. Many people with this problem wake up with markedly swollen corneas and blurred vision—both of which improve gradually during the day, as the evaporation process commences again.

Note: Eye surgery, particularly cataract surgery, can hasten the deterioration of the endothelial cells in people who have this dystrophy. (Eye surgery can be stressful on the eye anyway, but particularly when these cells are already vulnerable.) Surgery can cause severe corneal edema, which may even result in the need for a corneal transplant to restore someone's vision. So if you have a problem with blurred vision in the morning, make sure your doctor knows this before you have any kind of eye surgery.

Treatment: The best way to treat endothelial cell dystrophy is to identify, as soon as possible, the people at risk for developing it. If you have a family history of this disorder, tell your eye doctor. Regular examinations will be very important as a means of detecting early changes in your corneal endothelium. As soon as these changes progress and cause your cornea to swell and retain fluid, you can begin helping your eye's "pumps" by using hypertonic saline drops and ointments to draw out excess water. Eye pain can occur when this excess water forms cysts that rupture at the corneal epithelial surface. A bandage contact lens can be used to treat these ruptured cysts and alleviate pain and discomfort. Unfortunately, for many people dystrophy ultimately progresses to the point where ointments no longer work and vision is impaired. The next step, then, is a corneal transplant. Like a replacement window for your home, this is a fresh start, and it can improve your vision dramatically. (The transplant tissue, or "graft," comes from an organ donor, after death.) Corneal grafting was the first widely successful human transplant operation. The key to its success—particularly when compared with other tissue transplant operations—is the fact that corneas have very few blood vessels; thus, because there's little interaction with the rest of the body, the graft is less likely to be rejected as "foreign." Today the odds of success have been boosted even higher by improved surgical instruments and techniques and the wider network of eye banks (foundations devoted to harvesting donor eye tissue and providing them to recipients in need). Full-thickness corneal transplants for corneal endothelial dystrophy have been largely replaced by endothelial keratoplasty alone. This more focused and limited form of corneal transplant specifically targets replacement of the diseased endothelial cells and has proved very successful. In the future, other treatments for corneal endothelial dystrophy may involve the stimulation of healthy corneal endothelial cells to replace diseased endothelial cells and the use of a patient's own cultured endothelial cells injected into the anterior chamber to regrow on the posterior corneal surface.

Keratoconus

Keratoconus is a progressive thinning that reshapes the cornea, causing it to protrude or bulge outward like a cone. This corneal disorder is common (incidence of about 1 per 2,000), and although without a definite inheritance pattern, a positive family history has been reported in 6–8 percent of cases, particularly among first-degree relatives.

The corneal changes seen in keratoconus occur during puberty and progress rapidly in young adults, slowing and leveling off in their thirties and forties. Most cases are bilateral, but often asymmetric. As the change in corneal shape progresses, the eye develops an irregular type of astigmatism that distorts vision. New evidence has demonstrated an association between eye rubbing and the development of keratoconus. As such, please try not to constantly rub your eyes. If you have allergies and itchy eyes, see your eye doctor for drops that can help alleviate the symptoms so that you don't rub your eyes. This is the first step in prevention.

Treatment: Glasses can be very beneficial in mild cases of keratoconus. Contact lenses, particularly hard or gas-permeable contacts, can dramatically improve the vision of patients with keratoconus. Special contact lenses combining soft and hard lens designs (hybrid contact lenses) and scleral contact lenses can be beneficial in advanced forms of this disorder. For progressive disease, corneal cross-linking can be employed to increase corneal rigidity and stabilize the corneal curvature. This technique, developed in 1997, uses UVA light to activate a chemical process in the cornea that causes corneal collagen fibrils to form strong chemical bonds, thus strengthening the cornea and preventing further bulging.

Corneal UV Light Burns

Your eye can get sunburned too. And like sunburn on the skin, injury to the cornea from UV light is acutely uncomfortable—but mercifully short-lived.

As their name suggests, these injuries to the cornea are caused by overexposure to UV light—from a sun lamp, from sunlight reflected off snow or water, or even from brief exposure to the intense flash of electric arc welding. (*Note:* Sunglasses are adequate protection against a UV corneal burn from snow or water, but not against one from strong sunlamps or "welder's flashes." A safe encounter with one of these powerful sources of UV light means wearing extremely dense, UV-blocking lenses.)

As with sunburn, it takes a while for the rays of UV light to start hurting your eye—usually about 6–12 hours—so you might wake up in the middle of the night with your eyes feeling like they're on fire and watering like crazy. The good news, again, is that—although intensely painful—most UV light burns of the cornea heal quickly. Immobilizing the eyelid with a patch (described above, under "Corneal Abrasion") can provide comfort and hasten healing.

Chapter 13

THE CONJUNCTIVA

The conjunctiva is the thin, slippery membrane that covers the outside of the "white" of the eye and the inside of the eyelids. What can go wrong here? Two things, mainly. The most common problem is *conjunctivitis*, an inflammation of the conjunctiva caused by a virus, bacteria, allergies, or exposure to chemicals. Another common problem is *subconjunctival hemorrhage*, a dramatic red blotch on the "white." Reassuringly, these problems often look worse—sometimes a whole lot worse—than they really are.

Note: Many people mistakenly feel that "conjunctivitis" is a specific term for an eye infection, such as "I have conjunctivitis!" or "Stay away, I may have conjunctivitis." In fact, the term *conjunctivitis* is just a general term meaning an inflammation of the outer part of the eyeball, the conjunctiva. As you can see above, many things can lead to this inflammation, so in the future you don't need to run the other way every time someone declares that they have conjunctivitis.

Conjunctivitis

Viral Conjunctivitis: The Dreaded Pink Eye

Pink eye. Yuck! The name itself conjures up distasteful images of pinkish, swollen, watery eyes. Worse, it's highly contagious (ask anyone with small children), often sweeping through a school several times, for instance, before finally moving on to torment some other group of people.

Unpleasant as it is, however, you might say that pink eye has received a "bad rap." This is not to say that pink eye isn't awful, but it's not the cause of every single case of eyes with inflamed, red, or pink conjunctiva. Actually, pink eye itself is a very specific problem, a viral conjunctivitis. (In fact, many people who believe they've endured pink eye probably had something else—symptoms caused by bacteria or by an allergic or chemical reaction.)

Pink eye, in the true ophthalmic sense, is caused by an adenovirus, one of the viruses responsible for the common cold. As noted above, it's extremely contagious, with a leisurely incubation period: symptoms usually manifest themselves 7–10 days after you come in contact with someone who's infected with it. In its most aggressive form, it can be a miserable condition. Besides being predominantly pink—as opposed to the bright red, mucus-oozing eye seen in bacterial conjunctivitis, for instance—the affected eye is also itchy and watery. These symptoms may spread to the other eye within a day or two; sufferers may also experience swollen lymph nodes in front of the ear or below the rim of the jaw.

Treatment: Like the common cold, pink eye usually has a long course: it can last weeks. Blurred vision, sensitivity to light, and watery, runny, itchy, swollen eyes are very common with pink eye. Antibiotics aren't much help, just as they're often ineffective at speeding recovery from a sore throat, runny nose, and other symptoms of the common cold. Thus, the treatment for pink eye conjunctivitis sounds a lot like that recommended for the common cold: lots of rest, plenty of fluids, aspirin or Tylenol for the discomfort, and antihistamines. Eye doctors often prescribe antihistamine eye drops and recommend cold compresses to ease eye puffiness and swelling. (Some doctors also prescribe steroid eye drops, but there's some debate as to when this is appropriate.) Because true pink eye is *very contagious*, you also need to take extra precautions in preventing its spread: don't share face towels, pillowcases, or washcloths, and don't leave tissues or other potentially infected items in places where they're likely to be touched by others.

Bacterial Conjunctivitis

If viral conjunctivitis is "pink eye," bacterial conjunctivitis might be considered "technicolor eye"—markedly inflamed, bright red eyes with a thick yellow mucous discharge. Its onset is quicker—within days of coming in contact with someone who has it—than that of pink eye. (Another difference is that swollen lymph nodes are rare with this form of conjunctivitis.)

How'd you get this? The possibilities are limitless. It is ridiculously easy to introduce infectious bacteria into your eye because they're everywhere. Rub your eye after coming into contact with one of these organisms, and boom—whatever you just touched may have been transferred right into your conjunctiva: potentially infectious bacteria from, perhaps, your mouth, nose, or scalp, from your grandchild's sticky fingers, from the stranger's hand you just shook, or even from the dog's head you just scratched. *Note:* The conjunctiva of the eye, like the mouth, *normally* contains bacteria. The bacteria that cause bacterial conjunctivitis are not the bacteria that are usually present in the eye, however; they are introduced from somewhere else.

Now, the eye has some pretty good defenses—namely, its protective eyelids, plus bacteria-fighting ingredients in tears and epithelial cells—that help keep normal bacterial flora in check. (Otherwise, conjunctivitis would be the norm, not the exception.) Trouble happens when the eye somehow becomes compromised: if the eyelids don't close the way they should, for instance, or if you have dry eyes, or a scratch, or chemical exposure, or some other injury—all of these things (and even viral conjunctivitis) can weaken the eye's resistance to infection.

Treatment: Antibiotics do a great job of treating bacterial conjunctivitis; the trick is figuring out *which* antibiotic you need. (It's not uncommon for an eye doctor to start a patient on one form of antibiotic eye drops and then change medications midstream if the infection doesn't respond within a few days.) Sometimes the eye doctor will take a culture of a severe or persistent infection, to identify the bacterium and determine its sensitivity to various antibiotics. (In rare cases, patients need to take antibiotics orally or even by intravenous injection.)

Note: As with any form of infection, good hygiene is crucial here. This means you'll need to scrub away any accumulated crust and debris along the eyelids and apply warm compresses regularly (see chapter 11).

Allergic Conjunctivitis

Your body's being invaded. At least it thinks it is, and it's reacting to the enemy—cat hair, pollen, mold, dust, even food—by making antibodies, sending specialist "warrior" cells into battle. Soon the skirmish gets ugly. Chemical weapons released by these warrior cells are called into play, causing the battleground—in this case, your eyes—to become even more inflamed. This inflammation, your basic allergic reaction, can range from mild to severe.

In the eye, allergic reactions are usually characterized by mild redness, itchiness, and swelling of the conjunctiva, as well as excess tearing. (This often happens in both eyes at once.) Most people who get this form of conjunctivitis are no strangers to allergies; they've probably had some allergy-related conditions—asthma, hay fever, or hives—all their lives.

For some people, allergic conjunctivitis is a predictable, seasonal event, rearing its ugly head without fail whenever the air is rich in oak pollen, for example. Other people never figure out what's driving their eyes crazy. And for some people, allergic conjunctivitis hits with the subtlety of a freight train, producing dramatic, instantaneous swelling of the conjunctiva that makes the eye seem to bulge from its socket. (This effect, called *chemosis*, is the eye's version of a sudden hive on the skin; with treatment it tends to go away as quickly as it came.)

Some eye care products can also cause allergic conjunctivitis. Eyeglass-cleaning soaps or detergents, for example, can irritate the eye if you don't rinse away every last trace of residue. Preservatives in eye drops and solutions—for treating dry eyes or glaucoma or for cleaning/storing contact lenses, for example—produce allergic reactions in many people. Also, some contact lens wearers develop a form of allergic conjunctivitis called *giant papillary conjunctivitis* (see chapter 6).

Treatment: Treatment is just what you might expect for an allergic reaction: antihistamines, decongestants, cold compresses, and occasionally such medications as aspirin, Tylenol, and Advil for discomfort. *Note:* Steroid eye drops should be used with caution. Regular, prolonged use of these drops can cause glaucoma. Also, take care not to *overuse* Visine or similar over-the-counter drops that "get the red out." Although these medications alleviate redness and itching at first, if used too frequently (four times a day for 3 or 4 days, for instance) they can produce "rebound redness" (similar to the rebound effect caused by overuse of nasal decongestants) when they wear off. This leads to *more* red in the eye instead of less.

Over-the-counter eye drops designed specifically for allergic conjunctivitis are available; you might want to ask your eye doctor whether one of these is right for you. Some of these drops can even be used prophylactically, as preventive measures for allergy sufferers during hay fever season and other high-risk times.

Conjunctivitis Caused by Chemicals and Irritants

Really, very few things in this world were meant to be placed in or near the eye. Thus, *any* exposure to chemicals or irritants—either directly spilled into the eye or carried in by smoke, fumes, or dust—can cause conjunctivitis. Reaction may be severe (such as that caused by exposure to strong household cleaners; see chapter 18), or it may be fairly mild (getting suntan lotion in your eye stings, for instance, but the discomfort usually doesn't last long).

Treatment: Even if you don't know what got into your eye, *wash it out*. It's best to use a chemically balanced irrigating solution if you have one on hand—drugstores sell several different brands, and you may want to buy one for emergencies—but the old standby, tap water, is also fine. If you can, remove any solid material from the eye by gently dabbing it with a cotton-tipped applicator. There's no such thing as using too much water. *Irrigation should be copious*, and if your injury was caused by an acid or alkali, such as lye and certain cleaning ingredients, you should bathe your eye *continuously for half an hour to an hour*. (For more on eye injuries, see chapter 18.) Afterward, try holding a cold cloth or ice bag to your eye for the pain; aspirin, Tylenol, Advil, or similar medications may also ease the discomfort. Then, call your eye doctor—*especially if the pain and irritation persist*. You may need additional treatment, including prescription eye drops (which help relieve pain but can also prevent a secondary bacterial infection; see "Bacterial Conjunctivitis," above).

Lumps and Bumps of the Conjunctiva: Pingueculae and Pterygia

What the heck is this? Thousands of people visit their eye doctor each year because they've spotted something that wasn't there before: a raised cream-colored, white, or chalky growth on their conjunctiva.

These tissue growths commonly appear on the surface of the conjunctiva nearest the nose (this is called the *nasal*, or medial, side), but they can also occur on the opposite side (called the *temporal*, or lateral, side) of the eye. They're particularly noticeable when the eye becomes inflamed (such as in bacterial or allergic conjunctivitis, described above). These areas are called *pingueculae*, as depicted in figure 13.1. When their growth extends onto the cornea, we call them *pterygia*.

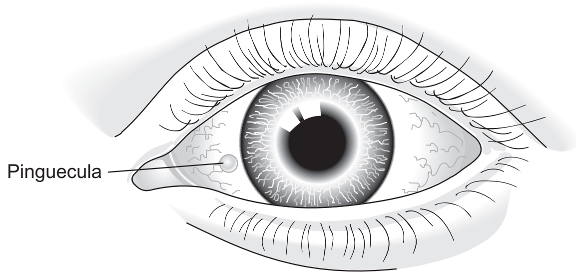

Figure 13.1. Pinguecula

But don't worry. As scary looking as either of these conditions may be, and as alarming as their names sound, they are benign. Think of them as harmless "age spots" in the eye: they're an age-related degeneration of the conjunctival tissue, the result of decades of sunlight and general environmental exposure. *However, unlike sun-caused changes to the skin, these aren't dangerous*. Pingueculae are especially common in people living near the equator, whose lifetime exposure to sunlight is much greater than the exposure of, say, people in Scandinavian countries. (Interestingly, some scientists believe that the reason these growths are most often seen on the nasal side of the eye is that anatomically the nose may actually play a role in creating a different concentration of UV rays on this area as opposed to the temporal side of the eye.) Wearing eyeglasses and sunglasses, which help protect the eyes from UV exposure, probably lowers your risk of developing pingueculae. Regular lubrication with artificial teardrops to alleviate any eye irritation is also highly recommended.

Pingueculae seldom grow, and they almost never cause discomfort. They're just a cosmetic nuisance. Again, unlike skin changes from the sun, pingueculae and pterygia *have only a very slight tendency to become malignant*.

On the rare occasion when a pinguecula does grow and slowly creeps onto the cornea (becoming a pterygium), it hardly ever affects vision. If it does, or if it irritates the eye, you may need to have it removed surgically; this can be done under local anesthesia. The problem here is that, despite meticulous surgical technique, these annoying things often grow back. The rate of recurrence after excision is high in inexperienced hands. (In fact, when pterygia recur, they tend to come back faster and bigger.) In an attempt to lessen this high rate of recurrence, eye doctors use techniques such as autologous conjunctival grafts (replacing the "bad" conjunctiva with tissue from another area of your own eye) and additional treatment with medications that inhibit cell growth.

But for now the bottom line with these nuisances is to leave pingueculae and pterygia alone, unless there's a clear need to remove them.

Birthmarks of the Conjunctiva and Beyond

Besides pingueculae and pterygia mentioned above, there are other growths on the conjunctiva that also bring people to the eye doctor each year. These changes can come in all shapes and sizes, ranging from diffuse, flat, pigmented areas to elevated reddish lesions to fleshy, salmon-colored growths extending up from the conjunctival surface or even from inside the eyelid. Please get these checked by an experienced eye care professional, especially if you suddenly notice a growth on your conjunctiva when looking in a mirror or in a photo, or after an observant friend says, “Hey, what’s that in your eye?” You can never be too cautious.

Flat or elevated, discrete, light-tan to brown pigmented areas of the conjunctiva are very often common and benign. They may also contain cysts. These “birthmarks” are usually conjunctival nevi and have an extremely low malignant potential (<1 percent). That said, eye doctors are always on the lookout for conjunctival melanoma, a very rare form of malignancy found mainly in people of European ancestry and located on the conjunctival surface of the eyeball, near the limbus (often making it very hard to distinguish from a pinguecula or pterygium). But these can also hide under the upper eyelid, so a careful examination is always prudent. As found in benign, conjunctival nevi, the degree of pigmentation in conjunctival melanoma is also highly variable. With both conjunctival nevi and melanoma, there is also a nonpigmented form—frequently making diagnosis difficult and the biopsy of suspicious conjunctival growths essential.

Reddish lesions that appear in the exposed areas of the eye can end up being a range of tumors, including squamous cell carcinomas. These lesions, if left untreated, can result in invasion of the eye and even spread to other areas. Again, if you notice something suspicious like this, see your doctor.

Do you have “bleary” or dirty-looking eyes? This appearance can be from a rare congenital pigmentation of the white portion of the eye that occurs in approximately 1 in every 2,500 individuals, particularly among Black, Hispanic, and Asian populations. These more diffuse slate-gray pigmented patches are at the level of the episclera, just below the conjunctiva, and are referred to as ocular melanocytosis. Many people with ocular melanocytosis complain that their eyes are just not white and look “bleary” all the time. These people try all types of eye drops to whiten their eyes, unfortunately with no success. Although there is little eye doctors can offer people with ocular melanocytosis in the way of cosmetic appearance, these people should be made aware of their increased risk of developing glaucoma. They should also be regularly checked for other ocular pigmented neoplasms since their lifetime risk of developing these is also higher than in the general population.

One more thing: take a selfie, or get someone to take a close-up picture of your conjunctival concern. Of course, this is not so you can post it on social media (although nothing would surprise me these days) but so you can follow this suspicious pigmented area or growth over time and see whether it changes in color or size. Any newly acquired conjunctival pigmentary change or even a change in any conjunctival lesion should be immediately checked out by your eye doctor because when caught and treated early, neoplasms of the eye, particularly conjunctival melanoma, have a much better prognosis than when discovered on the skin. On rare occasions growths on the conjunctiva that suddenly appear or change can also be a warning sign of systemic problems.

Subconjunctival Hemorrhage

Speaking of scary-looking changes to the eye, hardly anything is more terrifying than looking in the mirror and seeing a huge red blotch in your eye. And yet amazingly, the most dramatic thing about a subconjunctival hemorrhage (one under the conjunctiva) is its appearance.

Here's the story: All over our body, all the time, tiny blood vessels break and are repaired. A blood vessel in the conjunctiva may break spontaneously for no apparent reason, or when someone coughs especially hard or vomits forcefully. An injury to the eye may also cause a subconjunctival hemorrhage (and in this case it's important to make sure that the injury didn't do any damage to the rest of your eye). Sometimes this causes a little discomfort, but most people feel nothing unusual at all. With time and patience, subconjunctival hemorrhages will typically resolve on their own within 1–2 weeks, and there are no drops or pills that will help speed their disappearance. Artificial teardrops can be used for comfort.

Note: Many people think that a broken blood vessel in the eye is a warning sign of dangerously high blood pressure, meaning that you're about to have a stroke. Not true. A subconjunctival hemorrhage looks terrible, but it doesn't mean that you have high blood pressure. (On the other hand, if you have two or three of these in a month, you probably need to see your general medical doctor or other health care provider; recurring subconjunctival hemorrhage can signal a health problem, such as high blood pressure or a blood-clotting disorder.)

Chapter 14

THE COMPLICATED WORLD OF TEARS

Tears aren't simple. They're complex creations of water, mucins, oils, and electrolytes; they also possess some protective bacteria-fighting substances that help reduce our risk of getting eye infections. Their functions are many and essential. For the cornea, they provide a smoother optical surface, so that our vision remains clear; they also help keep the cornea properly moisturized and rich in oxygen. For the eye in general, tears also act as "wiper fluid," allowing the eyelids to wash the eye free of debris with every blink.

Tears, believe it or not, are layered (figure 14.1). The innermost layer contains *mucins*, which allow tears to adhere to your eye and coat it evenly. These mucins are produced by many tiny "factories" named *goblet cells* in the conjunctiva (the clear covering over the "white" of your eye) and inside your eyelids. (They are called goblet cells because they are shaped like goblets; goblet cells are present in all mucous membranes in the body.) The middle layer, which makes up about 90 percent of the tear, is mainly water, with just a pinch of salt. Most of this watery layer is produced by the lacrimal glands, located just above and outside each eye (figure 14.2). As a backup system, our eyes are also equipped with accessory glands, which provide extra water. The outermost layer contains fatty oils, called *lipids*, which slow the evaporation of the watery layer and thus keep tears in our eyes longer, just as a coating of lotion helps skin retain moisture. These oils are produced by the *Meibomian glands* on the edges of the eyelid, just behind the lashes. (Here, too, there's an additional backup system of accessory oil glands.) A reduction in any of these layers can lead to dryness.

When you blink, your upper eyelid sweeps tears across the surface of the cornea, down toward the inner corner of each eye. The tears drain through a small opening in the eyelid called the *puncta*. Each eye has two of these small openings, one on each eyelid. The tears flow through the puncta into the *nasolacrimal duct*, a canal that drains excess tears into the nasal passages (which is why, when you cry, you also need to blow your nose). (This process of draining tears is different from the process of draining aqueous fluid from the anterior chamber of the eye, described in chapters 1 and 9.)

There are two different types of tearing: the first, *basic tearing*, is normal tearing, which helps maintain the eye. The second, *reflex tearing*, is a reaction to a stimulus, such as a foreign body in the eye or a strong emotion (happy, sad, or surprised).

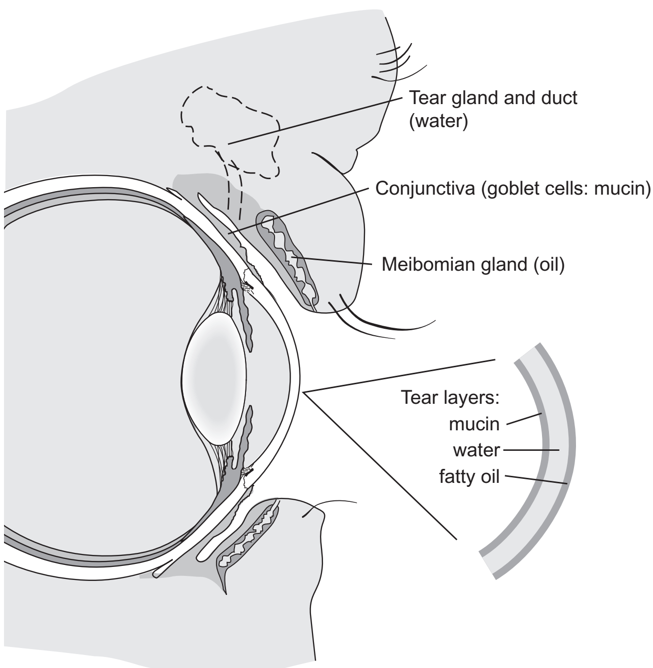

Figure 14.1. Side view of tear layers, showing goblet cells and Meibomian gland

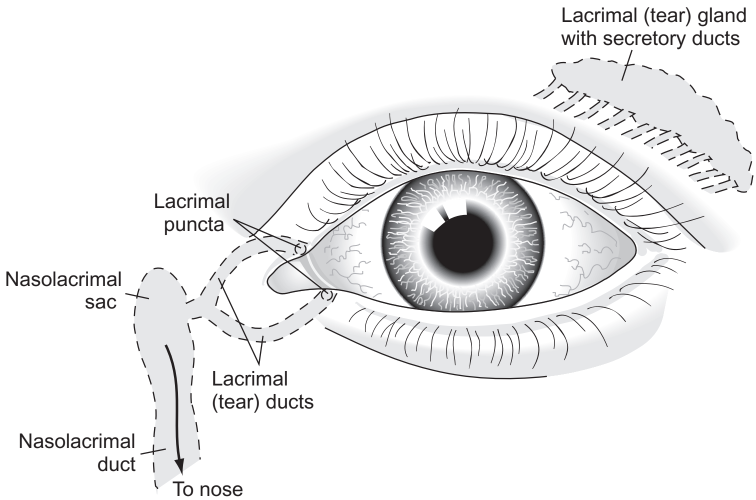

Figure 14.2. Front view of tear gland and tear ducts

When your eye is irritated, the reflex tearing mechanism causes the lacrimal glands to produce water—the goal being simply to wash away the irritation. Reflex tears, designed to solve a specific, temporary problem, contain much more water than basic tears; they're low in mucins and oils, so they don't do much to lubricate the eye.

If your eye becomes significantly irritated—from dryness, say, or allergies—then reflex tearing will start. Your eyes will get very watery, but because the quality of these tears is so poor, the excess water won't really help with the dryness. But simply adding a drop of an artificial tear substitute to your eyes when they are watering excessively can change everything. The extra lubrication from the drops helps alleviate the dryness, and this in turn relieves the excess watering.

As people age, they sometimes have tear problems that cause discomfort: some people have dry eyes, and some have excessively wet eyes, from tearing.

Dry Eyes

The diagnosis: you have dry eyes. And it's no fun having eyes that often burn or feel tired, gritty, irritated, itchy, or sticky.

For people who suffer from it, having dry eyes can be a constant source of discomfort that makes it difficult to get through the day. Having dry eyes means you're infinitely more sensitive to everything around you. Symptoms get worse, for instance, whenever it's windy, when the air quality is poor, or when the humidity is low. Indoors, heating and air conditioning can wreak havoc on both your comfort and your vision.

Having dry eyes is a chronic problem, and currently there's no cure. But there are good treatments—drops, ointments, punctal plugs, and even "bandage" contact lenses—that can make you feel almost as good as new by helping control the dryness and the miserable symptoms it can produce. Before we cover how these work, let's take a moment to consider the problem.

Why Are My Eyes Dry?

There are two basic problems: either you're not making *enough* tears, or the tears you're making aren't as *good* as they used to be. Occasionally dry eyes may be caused by a third problem: the eye itself can't get the tears where they need to go.

Not Making Enough Tears

Perhaps your eyes don't make enough tears. This condition, called *keratoconjunctivitis sicca* (KCS), usually occurs in both eyes but can be worse in one eye than the other.

One of the most common causes of tearing deficiency is simply age. Like skin and hair, our tears tend to "dry up" slightly as we get older; we just make fewer tears. For most of us this decrease isn't terribly noticeable, but for some people tear production can drop off significantly—enough to produce the classic dry-eye symptoms of irritation, redness, grittiness, burning, and eye fatigue. (KCS is also more common in older women than in other groups, probably because of the hormonal changes that occur with age.)

Other health problems or issues can hamper tear production. One of these is *injury to the lacrimal glands*, from infection or trauma; the effect of the injury may be temporary or permanent. Another is Bell palsy, a condition that affects the facial nerves; its effects may also be either temporary or permanent. People with this ailment are often unable to close one eye or blink on one side of the face, and that eye also produces fewer tears. As you may imagine, the combination of not being able to blink and making fewer tears causes major problems by exposing the corneal surface to excessive drying, resulting in *exposure keratitis.* A decrease in corneal sensitivity that stimulates the lacrimal gland to produce tears can also lead to a dry eye and can be seen with refractive surgery (i.e., LASIK), cataract surgery, contact lens wear, and abuse of topical anesthetic eye drops.

Autoimmune disorders can impede tear production. *Sjögren syndrome* is the miserable trio of symptoms—dry eyes, dry mouth, and joint pain—that may be associated with other autoimmune disorders, such as rheumatoid arthritis, systemic lupus erythematosus, and scleroderma. (The term *secondary Sjögren syndrome* is used to describe dry eyes associated with any other disease.) Other systemic ("whole body") diseases, such as sarcoidosis, leukemia, lymphoma, and chronic thyroid problems, often diminish tear production as well.

Occasionally *medications* decrease the tear-making ability in some people. For instance, as you may already know too well, antihistamines and decongestants for allergies and colds dry out everything—eyes in addition to sinuses. Diuretics, taken to lower blood pressure and ease water retention, may decrease tear production. Hormone replacement therapy and even birth control pills also can lead to dry eyes. Other potentially eye-drying medications include certain eye dilators (atropine and scopolamine), motion sickness inhibitors (scopolamine), tricyclic antidepressants (amitriptyline, desipramine, imipramine, nortriptyline), oral acne medications (Accutane, tetracycline), and opiate-based pain medications (morphine). *Note:* Of course, even though these and other drugs may produce dry eyes, this isn't reason enough to stop taking them. If the eye-drying side effect really bothers you, talk to your doctor. It may be possible for you to switch to an alternative medication.

The Old Tears Ain't What They Used to Be

Even if your tear *production* is just fine, your eyes can still be dry if the *quality* of tears is poor. Remember the ingredients in each tear; they're all important, and when the balance of them is off, your tears (and your eyes) may suffer as a result.

Diseases in the eye or body can cause a drop in either the mucin or the lipid portion of tears. Vitamin A deficiency, trachoma (an infection that's very common in the Middle East), Stevens-Johnson syndrome (an inflammation of skin and mucous membranes causing scarring and dysfunction of those membranes), and chemical burns of the eye all cause a breakdown and scarring of the conjunctiva and sclera. This in turn destroys goblet cells and causes the production of mucins to dwindle. Without mucins, tears don't hold up as well; they break apart much more quickly on the surface of the cornea. (Imagine the difference in texture between watercolor and oil-based paint.) As a result, the cornea tends to dry more quickly.

One of the most common eye diseases to obstruct lipid production by the Meibomian glands is blepharitis, an inflammation of the eyelid (see chapter 11). When the eyelid becomes inflamed, bacteria (and the immune reaction they trigger) can cause the Meibomian glands to clog and shut down. Again, the result is a more watery (and less oily) product: tears that evaporate much more quickly from the eye. Even worse, as these lipid-lacking tears evaporate, they leave behind a greater-than-normal concentration of salt, and salt burns the eyes. Recalcitrant blepharitis and dry eyes are often seen when rosacea (yes, the same rosacea that caused zits on your face when you were a teen) involves the eyelid margins. This condition affects people ages 30–60, more often affects women than men, and is often associated with Meibomian gland dysfunction of the eyelid. Besides contributing to tear dysfunction and a dry eye, rosacea can cause other ocular conditions such as recurrent chalazion, chronic conjunctivitis, severe stromal keratitis, marginal corneal ulcers, and uveitis. Just like when you were a teen, the antibiotic tetracycline (or its derivatives minocycline and doxycycline) can be helpful for treating rosacea affecting the eyelids, both orally and topically. Topical steroids may be necessary for some of the ocular complications caused by rosacea.

Another common cause of dry eye from lack of lipids is sleeping with your eyes open (*nocturnal lagophthalmos*). Sleep is the body's great restorer, a chance for everything, including eye moisture, to be replenished. If you don't close your eyes fully when you sleep, exposed parts of your eye tend to dry out. Symptoms are usually at their worst when you wake up, and they get better during the day as normal blinking returns moisture to the eye. This is a fairly easy-to-treat problem; often, simply adding humidity to the room where you sleep with a humidifier and applying an artificial tear ointment before bedtime are enough to keep the eye moist overnight. (Nocturnal lagophthalmos is also a common problem for people with Bell palsy; the lid of the disabled eye doesn't close at night, and this makes the already-dry eye feel even worse. But taping the eye closed at night, along with the use of artificial tear ointments, can help replenish eye moisture.)

Distribution Problems

With tears, as with any complicated manufacturing system, the breakdown may come not in quality control or production but in shipping or distribution. Sometimes the tears themselves are just fine, and they're made in adequate amounts, but the eye itself can't get them where they need to go.

Irregularities on the surface of eyelids or corneas, for instance, can cause dryness even if tear production is adequate. If the eyelids are scarred significantly—a problem in chronic blepharitis—the lid can't distribute tears evenly across the surface of the cornea; think of faulty wiper blades trying to sweep a car's windshield. Similarly, if the cornea is scarred, the lid can't do a good job of spreading tears. In either case, the tear-deprived surface of the cornea becomes parched.

Growing older can also cause *changes in the musculature and shape of our eyelids*, occasionally causing them to sag or turn outward (ectropion) or inward (entropion; see chapter 11). These problems also disrupt how tears are spread across the eye and how they flow out of the eye. Often, when this happens, people experience symptoms of dryness. A person may also have tears that stream down their face. (This may sound like a flat-out contradiction of a diagnosis of dry eyes: after all, how can your eyes be dry when they're literally overflowing with tears? But think of water pouring down from a damaged gutter in a heavy rain. Water just isn't getting where it is supposed to go.)

Finally, some people just don't do a good job of blinking (a common symptom of Parkinson disease); consequently, tears don't get spread across the eye as they should. With each complete blink, the upper lid should meet the lower lid. *Partial blinking* leaves the lower portion of the cornea constantly exposed and increases dryness over the course of the day.

Diagnosing Dry Eyes

The first step in diagnosing dry eyes is for your doctor to take a careful history to determine whether you have any ocular or systemic conditions that may be contributing to your dry eye symptoms, such as past refractive surgery, contact lens wear, an autoimmune disorder, Parkinson disease, or thyroid dysfunction, and to find out what medications you are using that might contribute to a dry eye, such as antihistamines, antihypertensives, antidepressants, and psychotropic drugs. Your eye doctor should also perform a careful examination of your eyes with a *slit lamp biomicroscope*, a microscope that gives a 3D magnified view of the front surface of your eye. The doctor will look for any irregularity on the surface of your cornea, any abnormality in the position and function of your eyelids, and any dysfunction of your Meibomian glands. Are your eyelids closing properly? Is there an inflammation in or around your eyes affecting the quantity and/or quality of your tear production? Do you have an eye condition producing symptoms that might be confused with a dry eye?

The next step is to measure both the quantity and the quality of your tears. Again using the slit lamp biomicroscope, the doctor may use special stains—fluorescein, lissamine green, or rose bengal (described in chapter 4)—to highlight damaged cells and dry spots on the surface of the cornea. (The principle here is similar to that behind those awful red dyes dentists sometimes use to illustrate where you're not adequately brushing your teeth. In this case, areas of damage and dryness absorb the stains and pinpoint the trouble spots on your cornea.) Are your tears relatively clean, or do they contain "ocular debris" (skin cells, airborne particles, and mucin strands)? Are you blinking well? Your doctor will also check to make sure that your eyelids are adequately spreading tears across the corneal surface of the eye.

Tear *volume* can be measured with something called a Schirmer test. "Schirmer strips" (sterile pieces of filter paper) are folded and hung over your lower eyelids. They'll soak up your tears; then, your doctor will measure the saturated area of each strip to determine whether you're making enough tears. A Schirmer test can be done with or without topical anesthesia, and depending on how it is performed, it can measure reflex or basic tear secretion. Some doctors are convinced that the Schirmer test is very useful, while others question its value. I think that it actually does tell something useful about tear production.

Fluorescein dye may also be used to determine your "tear breakup time" (how well your tears maintain their integrity)—in other words, to find out whether your problem is an issue of tear quality. After putting a few drops of fluorescein in your eyes, your doctor will ask you to blink several times, to get an even distribution of your tears across the cornea. Next, you'll be asked *not* to blink, while your doctor observes and measures how long it takes before the tears evaporate and dry areas are observed on the cornea. The lissamine green and rose bengal (as mentioned above) are other staining techniques in which a dye placed in the eye can help doctors diagnose damaged corneal epithelial cells and aid in the diagnosis of a dry eye.

For more specific tests, your doctor may need to send samples of tears or tissue (this is painless) from your eye to a laboratory. Tears can be tested for quantities of salt, electrolytes, and proteins to help pinpoint the cause of dryness, and conjunctival tissue can be biopsied to look for changes within the cell structure that may indicate the source of the problem. Nowadays, there are machines in some offices that can test for the concentration of salts in the tear film on the spot to help evaluate your tears as part of an examination for dry eyes. Like many tests available for dry eyes, some doctors believe that this machine helps, while others do not.

Treating Dry Eyes

After making sure to address underlying conditions, the basic goal in treating dry eyes is to keep the eye moist—in other words, often we treat the symptoms, and not the cause. There are several ways to do this.

Tear Substitutes

Tear substitutes are used to rewet the ocular surface. Fortunately, there are many good over-the-counter teardrops to choose from. Depending on why your eyes are dry, you'll probably find that some tear supplements work better than others. Some people need a drop that "mimics" tears to add more quantity; others need drops containing extra lubricants and oils to enhance the mucin or lipid layers and improve tear quality.

If burning from the drops is a problem, you can find drops that are hypotonic (containing less salt than natural tears). If your problem is more severe and you need drops particularly often (more than four times per day), you may prefer preservative-free tear supplements, which are often easier on the eye. Tear gels and ointments are especially useful for people who wake up at night or in the morning with dry, gritty, irritated eyes. They are inserted in the eyes at bedtime. Tear sprays are also available for humidifying relief, which can soothe the eye quickly and without the need to steadily aim and squirt an eye drop into your eye.

Note: Be careful using drops designed to "get the red out" and improve the cosmetic appearance of your eyes. *These treat a different problem.* Often these drops contain ocular decongestants and vasoconstrictors that shrink the dilated blood vessels that show up when your eyes are dry. These additional ingredients can affect mucin production, so although your eyes may look better, they'll still feel dry. Also, as many of us have learned the hard way with similarly acting nasal sprays, constant use of vasoconstrictors can lead to a temporary "rebound" reaction, in which these blood vessels actually dilate *more* and your eye looks even redder than it did before you used the eye drop. If your eyes are red because they're dry, appropriately rewetting them with an artificial tear supplement usually takes care of the redness as well.

Procedures to Fix Your Tear Drainage System

If tear supplements don't ease all your symptoms, your doctor may suggest methods of making more use of the tears you have, by keeping them in your eye longer.

One approach is to close the puncta (the eye's "tear drain") to slow or lessen drainage of tears into the nose. Remember, you've got two of these in each eye, one on the lower eyelid, and one on the upper eyelid (see figure 14.2). Your doctor may want to close only the one on the lower lid to reduce the outflow of most of your tears, leaving the upper lid's puncta open. One bonus here is that this procedure doesn't have to be permanent; your puncta can be closed temporarily, as a test to see whether such treatment will help or not. Your doctor can close the puncta with collagen plugs, which will slowly dissolve over the next few days. (If the plugs work and the dryness improves, then you can talk about more permanent treatment.) If the collagen plugs don't last long enough for you to measure the effectiveness of this approach to treatment, your doctor can use silicone plugs (which will close the puncta until they're removed). Then, if you and your doctor decide it will indeed help, the silicone plugs can be left in or the puncta can be permanently closed with thermal cautery. In thermal cautery the doctor applies a very hot wire to the puncta after first numbing the area with anesthetic. This shrinks the tissues in the area and causes scarring and permanent closure of the puncta.

Beyond Tear Substitutes and Drain Closure

A potpourri of other therapies exist for dry eye sufferers. As mentioned above, preservative-free eye drops are often a better choice for dry eye patients to help them avoid the toxic effects of preservatives in tear substitutes. To improve Meibomian gland dysfunction impacting tear quality, eyelid hygiene with warm compresses (see chapter 11), with or without oral and/or topical antibiotics, is important. Topical eye drops have also been developed to specifically address ocular inflammation, which can lead to Meibomian gland dysfunction and a poor tear quality. Topical cyclosporine A 0.05 percent used twice a day in the eye has been effective at reducing ocular inflammation, although it may take months to observe an effect. Lifitegrast 5 percent eye drops are another topical treatment for dry eyes that inhibits T cells and cell binding and also lessens ocular inflammation. Modalities such as mechanical Meibomian gland probing, thermal eyelid pulsation systems, thermoelectric heat pumps for the eyelid, and even intense pulsed-light therapy have all been tried to improve Meibomian gland function and tear quality in dry eye patients. In severe dry eye cases, hydroxypropyl cellulose inserts and moisture-retaining eyewear are available. Various pharmacologic drugs have been tried to stimulate tear production but have met with limited success, especially considering their potential systemic complications with long-term use. Dietary supplementation with omega-3 fatty acids has been observed to increase average tear production and tear volume, and various commercial preparations are available.

"Bandage" Contacts

For some people, contact lenses can be helpful as a "bandage" that holds more water on the eye and smoothes the surface of the cornea (see chapter 12). However, the risks may outweigh the benefits of this type of therapy: the bandage contact lens is more likely to allow bacteria (as well as moisture) to accumulate in your eye, and this can cause even worse problems than dryness—problems like infections and corneal ulcers. If your doctor decides that this form of therapy is appropriate, you'll need to have your eyes checked frequently, so that any potential problems can be treated as soon as possible.

Tearing

Tearing—by the way, the word we're using rhymes with *hearing*, not *herring*—isn't just crying, although that's certainly one reason for tearing. When eye doctors use the term, we simply mean "making too many tears"—in other words, having watery eyes.

Ideally the eye maintains a delicate balance between tear production and drainage. To review briefly: Most tears are secreted by glands in the upper eyelid onto the cornea, where they act as the eye's "window-washer" fluid, constantly bathing the cornea (see figure 14.2). They either evaporate or collect in the "gutter" created by the lower eyelid, called the *inferior cul-de-sac*. Blinking pumps the tears in this gutter ever downward toward the nose; first, they drain through the puncta in each eyelid, into a common aqueduct to the nasolacrimal sac. From here tears flow into the nose and then to the back of the mouth, where they mix with saliva and are swallowed.

Many things can cause excess tearing. Most common are foreign particles (specks of dust, for instance) that get blown into the eye; the eye jump-starts its tear production in an attempt to wash out these invaders and cleanse itself. Eye infection, emotional stimuli (such as, literally, the "tear-jerker" movie), wind, smoke, and fumes—all of these can cause more tears to be made. Ironically, as mentioned above, even dryness in the eye can cause increased tearing.

But tearing can also result from *poor drainage* of tears from the eye—think of rain that pools in a blocked gutter. Sometimes irregularities in the shape of the eyelid can hamper tear drainage or hinder blinking (a critical means of keeping tears moving through the drainage system). A deformed punctal opening or blocked tear duct—this sometimes happens with aging—may also cause a buildup of tears. In this case, as a simple outpatient procedure, your doctor can dilate, probe, and irrigate or flush the nasolacrimal drainage system and reopen this passage. If this does not work, then thin silicone tubing can be used to dilate and reestablish the flow of tears through this system.

One important but often overlooked cause of tear-draining problems is an infection in the nasolacrimal sac called *dacryocystitis*. Remember, tears drain into this sac before they pass downward into the nose and throat. Sometimes bacteria find their way here as well, and the resulting infection can be difficult to treat because the sac is located so deep within the tissues around the eye. The nasolacrimal sac is hard to reach with topical drops, and oral antibiotics are often needed to knock out the infection.

The biggest problem here, however, is that because of the often-elusive nature of such infections, they can go undiagnosed for months—leading to scarring of the nasolacrimal sac and chronic tearing problems. When this occurs, it may be necessary to open the scarred sac surgically. (This procedure is known as a *dacryocystorhinostomy*.) Patients with tearing difficulty due to dacryocystitis must weigh their degree of discomfort against the anxiety, inconvenience, and cost of undergoing surgery. You may decide that having too many tears isn't so bad after all. As one patient points out, "It's better than having a dry eye."

Some Questions You May Have about Dry Eyes

Sometimes my vision gets blurry, but I can clear it with a few blinks. What's the problem?

If your eye is dry, the surface of your cornea can lose some of its smoothness. Dry patches form on the cornea, and this tends to blur vision in between blinks. But by blinking several times in a row—think of applying a roller of paint to a rough wall—you fill in those dry patches with tears and clear your vision. This problem can also be improved by artificial tear supplements, which help wet the dry patches and maintain more consistent vision.

Why do my eyes burn when I work at my computer?

You know that daze you feel sometimes when you stare at the computer for hours on end? You're not imagining it; many of us really do go into a kind of trance after prolonged computer use. We blink less, for one thing. Then, with a lower tear supply, the moisture in our eyes starts evaporating. When this happens, the normal amount of salt in our tears builds up, becomes more concentrated, and starts burning. Using an artificial tear supplement that is hypotonic (containing less salt than natural tears) helps ease this symptom. (It may also help if you make an effort to blink more often while you're working on the computer.)

Why don't my eyes feel dry all the time?

Look around you. For the comfort of your eyes, environment is everything. Temperature and humidity, for instance, both influence tears; sudden changes in either of these can cause dryness.

Indoor heating during the winter, especially the forced-air kind, can significantly dry your eyes, just as it dries your skin. A humidifier, even placing a fish tank in a dry room, can help immensely. (It really is true what they say: "It's not the heat, it's the humidity.") In the summer, air conditioning—which makes the rest of your body so much more comfortable—is designed not only to cool the air but to take excess water out of it as well. And either of these—the loss in humidity or the cool air—can dry your eyes.

Also, the big difference in temperature and humidity that hits us when we go from a heated or air-conditioned house into the seasonal weather takes its toll on the eyes. Until they catch up and adapt to the climate change, our eyes often feel dry as a result.

Spring and fall—the time for relief? No, the time for pollen. If you're one of the millions of Americans who suffer from pollen allergies, you're probably way too familiar already with the dry, itching, burning eyes that go along with the sneezing and scratchy throat. A big drawback to oral allergy medications is that they usually make this dryness worse. You may need allergy medications especially intended for eyes; these reduce the swelling and itching from allergies but also contain an artificial tear supplement to ease the dryness.

Sometimes I wake up at night with a pain in my eye. What could be causing this?

Two of the most likely suspects are dry eyes and recurrent corneal erosions (see chapter 12). However, another possibility is that you have a recurrent sinus infection. The sinuses surround the eyeball, which means that if they're inflamed, there can be real discomfort around the eye. Besides seeing your eye doctor, you should also consider seeing your general medical doctor or other health care provider to check for this.

Chapter 15

THE UVEA: IRIS, CILIARY BODY, AND CHOROID

Uvea is the Latin word for "grape," so it's a good name for this purple, blood-rich layer of tissue located just inside the eye. In fact, the uvea is sometimes called the eye's "grape" layer. Lying below the sclera (the "white" of the eye), the uvea is made up of three regions—the iris, ciliary body, and choroid—whose main function is to nourish and maintain the integrity of the eye and its tissues. (For more on the parts of the eye, see chapter 1.) The choroid supplies important nutrients to the retina, while the ciliary body produces aqueous fluid, which is essential to the health of the anterior segment and shape of the eyeball. The iris and ciliary body are also vital in helping the eye see properly.

The two most common problems in the uvea are uveitis and iris nevi.

Uveitis (Arthritis of the Eye)

Arthritis is an inflammation of the tissues in the joints, right? So how can it be a problem in the eye? Well, in some ways eyes have a lot in common with knees or elbows: both are relatively self-contained, with definite boundaries or walls that create fluid-filled cavities, or spaces, of connective tissue. (In our joints the job of the fluid is to help unyielding surfaces, such as bones and ligaments, move smoothly over each other.)

The eye's version of arthritis is called *uveitis*. This is the general term for inflammation of the uveal tissue structures in the eye—the iris, ciliary body, and choroid. Arthritis in the iris specifically is called *iritis*; in the ciliary body, *cyclitis*; and in the choroid, *choroiditis*. Uveitis may strike one eye or both. When it does, it can cause redness, throbbing pain, and difficulty with bright light; it may even affect the vision. It can also be "silent" (if it affects only a small area in the back of the eye).

Just as in many cases of arthritis, determining exactly what causes uveitis can be baffling and frustrating. Some cases of uveitis, frankly, stump us; they seem to arise out of thin air. In other people uveitis may be linked to a host of medical problems including headaches, infections, allergies, deafness, numbness or weakness, vitiligo, skin rashes, oral or genital ulcers, bowel problems, joint aches or pains (yes, sometimes from certain types of arthritis), or difficulty breathing. There's some speculation that smoking cigarettes and having a poor diet may contribute to the condition.

With uveitis, the first step for the medical professional is to take a very careful medical history. Be sure to tell your eye doctor about any other eye problems or general health problems you're having now or have had in the past (including surgery or trauma). Your doctor may recommend further testing, which may include a chest X-ray and tuberculosis test (if a lung problem is suspected), blood tests, stool evaluation, skin tests, or even a spinal tap. You may also need a biopsy (a test in which a small sample of skin or tissue is removed and analyzed).

Even after all these tests, uveitis can be a real challenge to treat; recurrences are common and are frustrating for both the doctor and the patient. Also, just as chronic arthritis can lead to joint-crippling deformities, uveitis can lead to other problems, including glaucoma, cataracts, and swelling in the retina, called *macular edema*, similar to the macular edema of diabetic retinopathy (see chapter 19).

Fortunately, steroid and nonsteroidal anti-inflammatory eye drops—often the first line of treatment—are very effective at treating most forms of uveitis. If the inflammation persists or comes back, your doctor may also inject steroids around your eye or prescribe additional medications including oral steroids, antibiotics, antifungals, antivirals, or even a drug that arrests cell growth (called an *antimetabolite*).

Nevi (Birthmarks of the Eye)

Iris Freckles and Nevi

Think of them as birthmarks in your eye. Like birthmarks on your skin, pigmented freckles and nevi on the iris come in all shapes and sizes; even the degree of pigmentation can vary greatly among these areas in the same eye. And, like freckles and nevi on the skin, they're almost always benign. Conjunctival nevi are usually benign too (see chapter 13).

Freckles on the iris look like "pigment dust" on the iris surface and are typically superficial, often ill-defined, and benign. Iris nevi extend deeper into the iris tissue, are often dark and well-defined, and may extend above the iris stromal surface or into the anterior chamber angle. Nevi that are small and unchanging should be routinely checked whenever you get your regular eye examination—every year or two. But if nevi are atypical, vascular, and large, or if there's a suspicion that they're growing, then they should be checked at least every few months because these suspicious iris lesions that are on the move—ones that are either growing or changing in shape and color—may be malignant and need attention.

However, if you have iris nevi, don't worry. It's highly unlikely that they'll ever cause you any trouble. In fact, clinical studies suggest that only 5 percent of even the most suspicious-looking ones ever change—become malignant—within 5 years. Of course, you don't want to take any chances with malignancy, so take a picture of your eye with your phone and use this photo to check the nevi from time to time in your bathroom mirror. Look for any changes in size and color and any changes in the shape of the pupil. You probably won't find any. But if you do, contact your eye doctor and have it checked out.

Also, your eye doctor may want to make a record of photographs of suspicious iris nevi, to monitor any changes over time.

Choroidal Nevi and Melanomas (Pigmented Growths under the Retina)

Nevi can also be seen *below* the retina, in an area of tissue called the *vascular choroid*. These choroidal nevi are fairly common and can be seen during a routine eye examination. They almost never cause any problems with vision, and they rarely become malignant. It's estimated that fewer than 15 percent of them ever grow at all over 5 years. (Here, too, as with iris nevi, a photographic record is often an invaluable means of detecting changes and growth.)

Melanomas, malignant pigmented cancers, can also occur in the choroid or ciliary body. They usually develop spontaneously and almost never arise from preexisting choroidal nevi. Like all pigmented lesions in the eye, they are slightly more common in people with skin melanoma. However, they are still very rare.

Choroidal and ciliary body melanomas don't usually produce any early warning symptoms; it's only as they enlarge that people may experience visual changes or even develop eye inflammation. Because these cancer cells begin to grow under the retina, at first they can be hard to distinguish from benign choroidal nevi or other common retinal changes and growths. When a diagnosis of a choroidal or ciliary body melanoma is made, there are various treatment options to consider. Depending on the size, location, and extent of the tumor, the appropriate treatment may be observation, radiation, or enucleation (removal of the eye).

As with any medical problem, it's essential to seek the advice of expert health care professionals with experience in diagnosing and treating your problem.

Chapter 16

THE RETINA AND VITREOUS

In chapter 9 I described how the aqueous and vitreous cavities help maintain the eye's shape. Vitreous, you may remember, is the jelly-like substance—a gooey mass of connective tissue—that fills the eye's posterior cavity (see figure 1.1A). The walls of this cavity are lined by the retina, the crucial layer of the eye that converts light energy into nerve transmissions and sends them to the brain, where they're converted into images that make sense. When things go wrong with the vitreous cavity or with the retina (or with the part of the retina responsible for central vision called the macula; see figure 1.1B), your attention is required; although the consequences are not always serious, they can be, and you need to know what's what.

Floaters and Flashes

The retina and the vitreous cavity, always immediate neighbors, are particularly closely linked at several key sites, including certain blood vessels, the optic nerve, the far edges of the retina, and the macula. But sometimes—as a result of eye or head trauma, or simply aging—the vitreous jelly can shift and separate from the retina, a condition known as a *posterior vitreous detachment* (PVD). (Think of an old house that develops cracks as it settles.)

The repercussions of such shifts vary. Among the most common consequences are what eye doctors think of as "condensations" or "opacifications" in the vitreous, and what patients often describe as "hairs," "gnats," or "spider webs" in their vision: *floaters*. Light entering the eye passes around these opacifications in the vitreous and casts a shadow on the retinal photoreceptors; therefore, we see a spot floating. A particularly large and annoying floater may occur when the vitreous separates from the optic nerve head margin. Due to the round shape of the optic nerve head, this separation can result in a ring-shaped floater, like a smoke ring, donut, or spider web in the vision, called a Weiss ring. The PVDs producing a Weiss ring can be very annoying because of its size and position along the visual axis of the eye. In general, though, almost everybody experiences floaters at some point in life. If the shift in the vitreous jelly is associated with traction or rubbing on the retina, patients can also experience quick sparkles of light or lightning, known as *flashes*.

Both of these, by themselves, are harmless. A shift in the vitreous alone is no cause for concern. Floaters can go away fairly quickly, or they can last for months to years. Usually, with time, they become less annoying and more tolerable. Flashes due to the rubbing or pulling of the vitreous on the retina are also usually short-lived.

So why worry about the sudden onset of floaters or flashes? If the traction against the retina is significant, the shift of the vitreous can cause the retina to rip slightly. *Such a tear can lead to a retinal detachment*. And retinal detachments can lead to permanent loss of vision. Therefore, suddenly experiencing flashes or floaters means you need to be evaluated by an eye care specialist, so that any holes or tears in the retina can be repaired before they cause permanent damage. Flashes and floaters accompanied by bleeding into the vitreous (often described as the sudden onset of reddish tinted streaks, swirls, or specks in the vision) are particularly worrisome because of their high association with a retinal tear. *Note:* Flashes and floaters associated with retinal detachment usually happen only in *one eye* at a time, not both. (For more on this serious problem, read on.) Bilateral flashes (in both eyes, especially if they last minutes to hours, are patterned, and have color) are an unusual phenomenon and are usually associated with visual forms of migraine, with or without an accompanying headache (see chapter 19).

A Detached Retina

The retina is often described as the wallpaper lining the back of the eye, even though, as I've discussed earlier in this book, it's infinitely more complicated than a single wafer of paper. For one thing, the retina isn't one sheet; it's an elegant, intricate network of layers. Its job is to take the light rays that enter the eye, convert them into nerve impulses, and then telegraph them, via the optic nerve, to the brain, where they're decoded into images that make sense.

Simply put, we see because of the retina. An eye without a working retina is blind. Therefore, when the retina becomes detached, or unhinged from the back of the eye, it must be treated immediately because the repercussions are so great.

Fortunately, there are some warning signs of a detached retina. At first, you may experience the sudden onset of flashes—bursts of light, like fireworks or sparklers, that last only seconds at a time. Remember, the flashes we're talking about happen *only in one eye, not both eyes at the same time*. Another cause for concern is the sudden development of annoying spots or specks in the eyes—floaters—which may resemble gnats, flies, spider webs, or even a recognizable shape like a ring or heart. (Typically, these are seen best against a solid background, such as the sky or a white wall.)

Floaters and flashes are most often due to a shift in the vitreous, the gooey jelly that fills the eye. Sometimes this vitreous shift leads to a break in the retina, in the form of a tear or hole. Then, gradually, the retina begins to detach, or peel off, from the back of the eye as the vitreous starts to seep through this opening. When this happens, patients can notice a slow loss of sight in that eye, as if a curtain were being drawn up or down across their vision. (This generally begins on one edge and may move centrally; moreover, if the detachment moves to affect the macular region at the back of the eye, central vision may also become affected.)

WARNING SYMPTOMS OF A RETINAL TEAR OR DETACHMENT

The following may be signs of a retinal detachment:

- A gradual or sudden increase in floaters in one eye. Like pieces of lint on a movie screen, these intrude on vision and may resemble spider webs or even circles.
- A gradual or sudden increase in flashes in one eye. Fleeting bursts of light, like fireworks or lightning, these may be especially noticeable in the dark.
- The gradual or sudden appearance of a dark cloud or "curtain" over your field of vision, from any direction.

If you experience any of these symptoms, call your eye doctor immediately.

Ways the Retina May Become Detached

There are three basic things that can go wrong here.

Rhegmatogenous (or mechanical) retinal detachment: In this most common type of detachment, a hole or tear develops in the sensory retina, allowing liquid vitreous (most of the vitreous is a gel; however, as we get older, some of it becomes more liquid) to seep through the sensory retina and sever it from the retinal pigment epithelium. Those at risk for this type of detachment include people with specific forms of peripheral retinal thinning such as lattice degeneration, people with severe nearsightedness, or those having undergone past cataract surgery (even if the surgery went perfectly). People with a history of blunt trauma—from boxing, for instance—or penetrating eye injury are also at risk.

Tractional retinal detachment: In this less common condition, fibrous scar tissue on the sensory retina's inner surface contracts—just as scar tissue does elsewhere in the body—pulling the sensory retina away from the retinal pigment epithelium. This problem is seen in people with diabetic retinopathy after a vitreous hemorrhage that produces scar tissue. It also may occur after eye trauma, or even as a complication following surgical repair of a rhegmatogenous retinal detachment.

Exudative retinal detachment: In this form, there's neither a hole for vitreous to pass through nor shrinking scar tissue to tug on the retina. Instead, fluid oozes up from the choroid below, through Bruch membrane, and accumulates under an *intact* retina, like a blister. This may happen as a response to inflammation or in such conditions as uveitis (see chapter 15) or age-related macular degeneration (see chapter 10).

Fixing a Detached Retina

How hard is the task of repairing a detached retina? Imagine trying to unfold a crumpled piece of Kleenex in a glass of water without tearing it. This delicate, precise surgery requires steady hands, high-powered magnification, and special instruments.

The good news is that remarkable advances have been made over the past several decades in our ability to treat each form of retinal detachment. I would like to illustrate this with a brief discussion of the surgical treatment of rhegmatogenous detachment.

Rhegmatogenous detachment: The goal here, clearly, is to reattach the sensory retina to the retinal pigment epithelium, and retinal surgeons do this by compressing the sclera—either with a buckle or with tiny sponges—to force these two layers back together. (A buckle is often required to indent the scleral wall from the outside of the eye enough to put these two retinal layers on the inside of the eye back in touch with each other, so that they can reattach.) Surgeons also may inject gas bubbles into the vitreous cavity to help push the sensory retina up against the retinal pigment epithelium. (*Note:* Because the eye may have to be specially positioned to make these bubbles "float" into the best position, some people need to spend hours in one position—on their side or even face down—as the retina heals after surgery.) It's almost always necessary to close the hole or tear in the sensory retina, and surgeons use lasers or cryotherapy (localized freezing techniques) to "spot-weld" around any retinal breaks. Sometimes this same treatment is used prophylactically on eyes prone to retinal detachment, to avoid a detachment before it occurs. Some people also may need to have excess retinal fluid drained from beneath the detachment so that the sensory and retinal pigment epithelial layers can reattach to each other. Modern microsurgical techniques using sophisticated small instruments for work inside the eye may also be used in reattaching the retina and for manipulating the vitreous. Which procedure is done to repair the tear or detachment depends on the particular situation, as well as the preference of the surgeon.

When the Eye's Blood Supply Is Blocked

It's simple: every single ounce of tissue, every tiny cell we have, needs oxygen to live.

Oxygen comes through the blood, and blood is piped throughout the body via our arteries and veins. Arteries deliver oxygen-rich blood throughout the body; like rivers, they branch into ever-smaller streams to reach every part of us. Veins make the return trip back to the heart and lungs, where more oxygen is pumped into the bloodstream; then, the arteries deliver it all over again (figure 16.1).

Blood reaches the eye through the big aorta and carotid arteries, which basically transport blood up through the neck; then, a smaller vessel, called the *ophthalmic artery*, carries it up into the eye. This important artery branches into smaller arteries as it nears the eye. Some supply blood to the choroid layer underneath

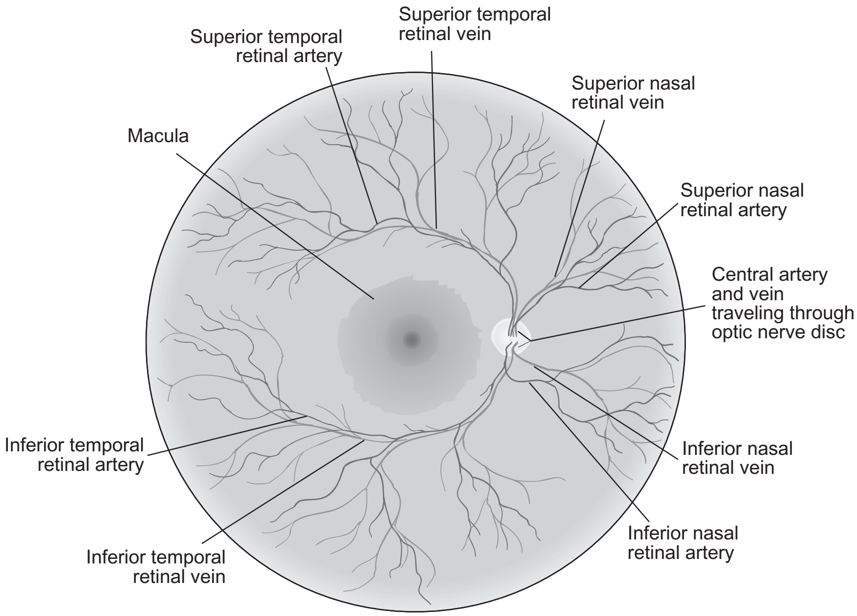

Figure 16.1. Arteries and veins in the retina

the retina's pigment epithelium; others penetrate the optic nerve outside the eyeball and travel inside it to reach the eye's innermost workings. Most crucial of these branches are the *central retinal artery*, which supplies oxygen-rich blood to the retina's inner layers (these are known as the sensory retina), and the *central retinal vein*, which takes the oxygen-depleted blood out of the eye back toward the heart.

Blockage of the Retinal Blood Supply

These major retinal blood vessels, then, are pipelines—or, more precisely, lifelines—entering and leaving the eye. As you may imagine, a clog in one of these pipes can be devastating. Say the blockage is of an incoming, oxygen-bearing artery: deprived of oxygen, the retina immediately begins to react—to degenerate and swell. If the clog is in an outgoing retinal vein, the reaction is equally abrupt, like a sudden traffic jam on a major interstate—an almost-instantaneous backup of blood and fluid into the retina.

Retinal vessel blockage—either arterial (with incoming blood) or venous (involving outgoing blood)—is a significant cause of visual problems in all ages, but especially in people over 65. Just how common are these blockages? Nobody knows for sure; one difficulty in making estimates is the fact that many people don't notice a problem if it occurs in the nondominant eye or on the far edge of vision. Although their specifics differ, depending on whether an artery or a vein is involved, these blockages share one important common denominator for the retina: they mean big trouble.

Retinal Artery Blockages

Before I discuss retinal artery blockages, picture a river with four branches, or a road with four forks. The main line, or river, is the central "trunk" of the retinal artery; each of the four arteries, which branch at the head of the optic nerve, supplies one-quarter of the retina. These are the *superior temporal*, *inferior temporal*, *superior nasal*, and *inferior nasal* arteries (see figure 16.1). There are many variations, but this is the basic pattern.

As you may imagine, the degree of injury—and its effect on vision—depends on the location of the blockage, or "occlusion." A clog at the central retinal artery, the main line, can cause an eye to lose all vision instantly. If the problem is in a branch artery, vision loss is confined to the particular quadrant of the visual field served by that branch. (*Note:* Remember from chapter 1 that the retina's image is *inverted and reversed* by the brain. This means that a blockage of, say, the superior temporal retinal artery will cause a corresponding loss of vision in the inferior nasal visual field.)

In either case—whether it's a central or a branch artery involved—the resulting loss of vision is usually sudden, painless, and complete. There's an *infarction*, just as in a heart attack or stroke. Blood supply is cut off, and oxygen-starved tissue begins to swell, deteriorate, and then die. Almost always, this tissue loss is permanent.

As if this weren't devastating enough, there are other implications here. Is this clogged artery a symptom of a really big problem in the rest of your body? In other words, is there an even worse infarction—a heart attack or stroke—waiting to happen? Also, could the same thing happen in the other eye, causing total blindness?

The most common cause of central and branch retinal artery blockages in older people are cholesterol plaques lining the carotid arteries, a result of atherosclerosis ("hardening of the arteries"). Atherosclerosis is also an important factor in heart attacks and strokes. In the most likely scenario, a piece of the cholesterol plaque breaks off, floats downstream through the ophthalmic artery, and makes its way into the eye through the central retinal artery. At each fork in the road, the passage becomes tighter. Because they're so narrow, the central retinal artery and its branches in the retina are particularly prone to obstruction by these runaway cholesterol plaques.

Other causes of central and branch clogs in the retinal arteries include calcium deposits from damaged heart valves, leftover bits of a blood clot after a heart attack, and even foreign particles injected during intravenous drug abuse. Also, blood disorders such as sickle cell disease, other health problems such as migraines, collagen vascular diseases such as systemic lupus erythematosus, giant cell arteritis (see chapter 18), and even too-low blood pressure, by allowing these vessels temporarily to collapse, may cause these blockages. (In giant cell arteritis, the other eye is at especially high risk for a similar blockage.)

Fortunately, the chances of recovering vision are much better in branch blockages than with central retinal artery blockages. However, even though they may recover much of their lost vision, many people with branch blockages do have some permanent vision damage.

Artery blockages in the retina are almost impossible to treat because medical care must be practically immediate. *Within the first hour after the artery becomes clogged*, either the blockage must be removed or blood flow to the retina must be improved through the use of medications to dilate the arteries. After that, the lack of oxygen to the retina causes permanent and irreversible damage—and treatment days or even hours after the fact won't help. *Note:* Some patients do recover a little of their lost vision weeks afterward; when this happens, most doctors believe, it's because of relief from the swollen retinal tissue, not from a return of blood flow to already dead tissue.

Because, as mentioned above, this blockage might indicate other serious health problems that need prompt medical attention, patients with retinal artery blockages need a careful physical exam—perhaps including an evaluation of the carotid arteries and heart—beginning with a thorough and complete medical history. So, although this problem may begin in the eye, your general medical health care provider or cardiologist definitely needs to see you as soon as possible.

Retinal Vein Blockages

As you can see from figure 16.1, the retinal veins form almost a mirror image of the retinal arteries. However, instead of bearing oxygen-*rich* blood into the eye, the veins take oxygen-*poor* blood out of it. So instead of depriving retinal tissue of blood, a blockage in the veins causes blood to back up and pool there, like a clogged drain in a sink with the water still running. This can happen either *acutely* (a total block, causing sudden symptoms of vision loss) or *gradually* (a partial block, progressively slowing the outflow over months to years).

Again, there are two types of blockages: central and branch.

Central Retinal Vein Blockages

The main vessel, or "trunk," of the retinal vein lies at the optic nerve head. As with the central artery line, an obstruction here can cause major trouble: a huge backup of blood into the retina, usually resulting in a sudden loss of vision (see figure 16.2). When the blockage is more gradual, symptoms are less severe but may still end in vision loss.

The two big complications associated with central retinal vein blockages are *damage to the macular region* in the retina, causing swelling and permanent vision loss, and *neovascular glaucoma*, a rare but devastating form of glaucoma that can happen days to months after the fact (especially within the first 90 days). Fortunately, most people with a central retinal vein occlusion do not develop neovascular glaucoma. This extremely serious condition can be excruciating. Even worse, it can cause patients to develop uncontrollable elevated eye pressure and chronic discomfort. Neovascular glaucoma may require injections of anti-VEGF medications (see chapter 10), laser

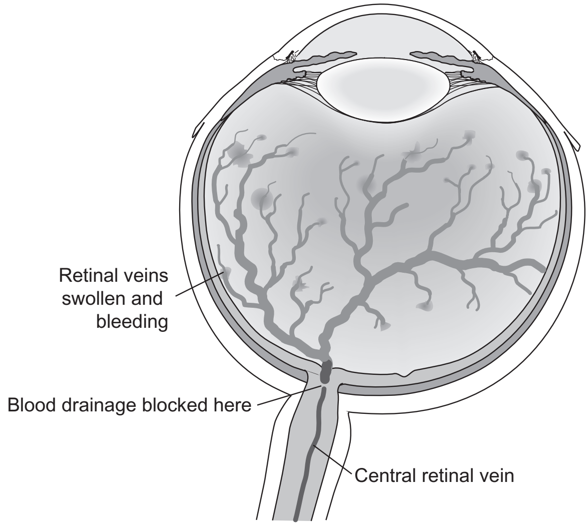

Figure 16.2. Central retinal vein blockage

treatment, cryotherapy, or surgery to alleviate pain and preserve the eye, even when there is no hope of recovering vision. Eye injections of anti-VEGF medications can also be effective for treating swelling in the macula (cystoid macular edema), but the visual benefit of this treatment is much better for patients with branch retinal vein occlusions than those with central retinal vein occlusions. Although there's practically no treatment of a central retinal vein blockage that can restore vision, patients still need careful monitoring afterward, in case neovascular glaucoma develops.

Again, as with artery blockages in the retina, problems in the veins may indicate larger health problems, particularly hypertension, cardiovascular disease, and diabetes. Thus, patients also need a general medical workup to avert any further trouble, either in the other eye or elsewhere in the body.

Branch Retinal Vein Blockages

The central retinal vein splits into two main branches, which serve the superior and inferior halves of the retina. Blockage in either of these veins causes trouble in the corresponding half of the retina. These major branches are fed by the temporal and nasal retinal venules (smaller veins) and by their own tributaries. A blockage in any of these branches causes swelling and a backup of blood and fluid—but smaller, more focused areas of damage.

As in central retinal vein blockages, macular swelling, or edema, is a common complication that may lead to vision loss. (The threat of neovascular glaucoma is much less common in these smaller blockages.) *Note:* Branch blockages here usually don't mean both eyes are at risk; in fact, if you've had one in one eye, your risk of having a similar blockage in the other eye is only about 10 percent. Branch retinal vein blockages tend to occur mostly in people with hypertension or cardiovascular disease.

Within the first months after the branch retinal vein blockage, there is often so much pooled blood and swelling that it's difficult to determine the extent of injury to the retina. As this hemorrhage and fluid gradually clear, your eye doctor will probably want to use optical coherence tomography and fluorescein angiography to assess the damage and to see whether macular edema is present.

As the excess blood and swelling recede, some people spontaneously regain their vision; others may need pharmacologic management with anti-VEGF injections or laser treatment for residual macular edema. Although some people do get better on their own, it is recommended that pharmacologic management should start immediately once the branch retinal vein occlusion is diagnosed.

Macular Edema

It is a beautiful sunny day and you are outside watering your lawn, when suddenly a leak forms somewhere in your hose. Water slowly oozes out of your leaky hose, and the grass becomes excessively wet and boggy in the area beneath the leak. This is what happens in macular edema (obviously without the hose or grass). Remember from chapter 1 that your retina is composed of many layers. Lying within these layers of retina are retinal blood vessels supplying nutrients and oxygen to the very delicate cellular layers of the retina. You will also recall that the macula is the area of the retina most important for your central vision. In macular edema, like with a leaky hose, the blood vessels spring leaks, and fluid from the blood oozes out into the retinal tissues. Just as the lawn gets soaked by this leaky fluid, so does the retina, particularly in the macula, where the retina cannot absorb the excess fluid buildup fast enough and becomes overwhelmed by this fluid accumulation. This unwelcome soaking causes dysfunction and abnormalities in the nerve cells, leading to problems with your vision—predominately resulting in blurred vision (think of how you see without goggles when you open your eyes underwater).

The leakage of retinal blood vessels leading to macular edema can occur from a wide variety of conditions. Any condition that can cause an increased leakage from these vessels through either inflammation or a change in blood flow can cause macular edema. When there is a cystic appearance to the macular edema, as is often the case with macular edema secondary to inflammation in the eye (i.e., uveitis), it is called cystoid macular edema (CME). In CME, the fluid in the macula pools in extracellular spaces that appear as cystic areas on OCT and fluorescein angiogram testing. Due to the radial arrangement of nerve fibers and supporting tissue at the center of the macula, these cystic spaces can often form a "flower-petal" (petaloid) arrangement, a classic and frequent finding in CME.

Eye conditions commonly associated with macular edema include diabetic retinopathy (see chapter 19), central retinal vein occlusion, branch retinal vein occlusion, all forms of uveitis, and retinitis pigmentosa. Even ocular surgery such as cataract surgery, retinal detachment surgery, vitrectomy, glaucoma procedures, photocoagulations, and cryopexy can lead to macular edema because of their secondary effect on the permeability of retinal blood vessels. Actually, cataract surgery, even when perfectly performed, is currently considered the most common cause of CME.

Your eye doctor will do an eye examination to evaluate you for macular edema if you develop blurriness or a change in vision. This change in vision, which happens despite a current eyeglass prescription, can suggest macular edema. Your eye doctor will examine your retina very closely, particularly your macula, with a special contact lens or high-powered magnifying lens. Macular edema is not always evident on clinical examination, though, and an OCT and intravenous fluorescein angiography are excellent additional tests for detecting the presence and extent of macular edema.

The good news about macular edema and CME is that they often resolve on their own without treatment. Spontaneous resolution can take as long as 6–12 months, but it frequently occurs within weeks when this swelling is secondary to conditions like uncomplicated cataract surgery. Topical corticosteroids and nonsteroidal anti-inflammatory drugs have been shown to be effective against CME, both prophylactically and after diagnosis. Periocular and intraocular steroid injections are also used for severe cases or for patients with CME who have not responded to topical treatment. Anti-VEGF intraocular injections have now replaced focal laser photocoagulation as treatment for diabetic macular edema (DME) and for forms of CME related to other retinal disorders (see chapter 21). Ocular surgery is rarely necessary to treat CME and is reserved for specific cases where vitreous adhesions to a wound (Irvine-Gass syndrome), vitreomacular traction, or epiretinal membranes may be the underlying cause. Unfortunately, while vision can improve with treatment, it does not always return to the way it was.

Macular Wrinkling

There are many names for this phenomenon, including macular pucker, epiretinal membrane formation, surface wrinkling retinopathy, and cellophane maculopathy. The basic problem is the growth, over the surface of the macula, of a membrane that causes it to contract and wrinkle (the macula, remember, is the most important part of the retina, the part that's responsible for our central vision). These membranes are relatively common (at autopsy, they have been found in 2 percent of people over 50 years old and in 20 percent of people over 75 years old) and harmless. But occasionally they can progress, leading to marked distortion of the retina, and sometimes limiting vision.

PVDs (see above), which can occur asymptomatically or in a variety of eye conditions, are thought to play a role in the development of these membranes. Abnormal membranes can be found after vitreous hemorrhages or eye trauma, or after eye surgery (to repair a retinal detachment, or remove a cataract, for instance); they may also be associated with certain retinal diseases, especially those that cause inflammation. They can show up, *for no apparent reason*, in healthy eyes—one or both—as well. Although these abnormal membranes are composed of a variety of different cell types found in the back of the eye, it is speculated that they may arise from vitreous remnants left after a PVD or separation on the internal limiting membrane that covers the retina (see chapter 1).

For most people these membranes remain stable for years, causing no deterioration in vision (85 percent of people retain a visual acuity of 20/70 or better, and 67 percent have 20/30 or better; fewer than 5 percent ever progress to 20/200 or worse). However, if epiretinal membranes do grow to a point where they begin to distort the retina and cause vision problems, symptoms usually begin with mild distortion or blurred vision.

There is a possible treatment: surgical stripping of epiretinal membranes from the retina. However, most retinal surgeons will attempt this procedure only if it's clear that the vision problems are definitely being caused by the membrane and, depending on the membrane's location and growth, that there is a good chance that removing it will actually improve someone's vision. Microsurgical vitrectomy techniques have come a long way in recent years and have also proved very effective in removing advanced epiretinal membranes. However, as with all procedures, there are risks involved—including infection—and you and your doctor will need to discuss them thoroughly before deciding whether this procedure is for you.

Macular Cysts and Holes

It's rare, but sometimes—for reasons that aren't clear, but likely occurring during or after a PVD and related to traction on the macula by vitreous adhesions—people develop a small cyst or hole in the center of the macula. Some people experience absolutely no change in vision; others may suffer a total loss of central vision.

OCT has helped us classify disorders that appear to arise from focal or broad vitreomacular adhesions. These adhesions alone usually do not cause visual symptoms. A person develops vitreomacular traction (VMT) syndrome when these adhesions lead to an abnormal tugging on the macula, causing anatomical distortion and cystic swelling in this crucial area of vision. These tractional forces on the macula—tugging too much or over a long period of time—are also implicated in the development of macular hole formation. The latter can have a profound and permanent effect on vision.

Often people with VMT syndrome or early macula hole formation first notice the problem—manifested as a subtle distortion—when they're reading. The lines of the crossword puzzle, for instance, start to bend. Letters of words in a book may seem distorted or appear to be missing. If you're experiencing any changes like these, see your eye doctor for a complete eye examination, including a dilated retinal evaluation.

Due to the success of modern microsurgical techniques, intervention should be considered in VMT or macular hole formation. Pars plana vitrectomy has been very successful for treating VMT. Intravitreal injection of a drug called ocriplasmin, which can sever the adhesions present in VMT, has also met with success at treating this condition and offers hope for the future. Because approximately 50 percent of early macular holes can spontaneously resolve, surgical intervention is usually reserved for those more advanced stages of macular hole formation with a full-thickness defect on OCT and declining visual acuity. In the best of hands, vitreoretinal surgeons offer no guarantees because even when the hole is closed and the retina looks perfectly normal again, unfortunately vision may not improve.

Chapter 17

THE OPTIC NERVE

Here we are, in the eye's nerve center—a massive cable that links the eye to the brain, allowing us to make sense out of what we see. Like a mighty river fed by countless streams, the optic nerve cable, made up of more than a million tiny fibers, starts small—in the ganglion cells of the sensory retina. These fibers connect to the retina's interior, where they form the nerve fiber layer, and then amass in a giant bundle at the back of the eye to form the optic nerve. The next stop, via the sclera at the eye's "back door," is the brain.

As you can see from figure 1.1A, the optic nerve is the only game in town: every single visual impulse that travels from point A, the eye, to point B, the brain, must take this route. Thus, even the slightest disruption—from inflammation, poor blood flow, infection, trauma, or a tumor—can have devastating consequences for someone's vision. Two important optic nerve problems that warrant special mention here are *optic neuritis* (inflammation of the optic nerve) and *ischemic optic neuropathy* (a tiny stroke in the optic nerve).

Optic Neuritis

Optic neuritis is an inflammation of the optic nerve. It can be caused by infection and immune-related illnesses, or its cause can be *idiopathic* (a medical term that means, essentially, "We don't know why this has happened").

When the optic nerve becomes inflamed, the impact on vision is prompt: a marked decrease in central or fine visual acuity, or loss of visual field. Usually only one eye is affected at a time. Other symptoms almost always include pain or tenderness of the eyeball, with discomfort as the eye muscles pull or rub on the optic nerve sheath surrounding the optic nerve. In optic neuritis, it may be difficult to see straight ahead, colors may appear washed out, and lights may seem dim; trouble with depth perception is also common. Exercise, a hot shower, or any other activity that raises body temperature may make the vision problems worse.

In a typical episode of optic neuritis, the decline in vision tends to level off within a few days; eyesight improves gradually over the next 4–6 weeks. At least 85 percent of people with an episode of optic neuritis regain useful vision, and any loss of central, peripheral, or color vision is often mild, detectable only on testing. Also, the majority of people with optic neuritis never suffer another episode. Only in very rare cases, when involvement has been particularly severe, does it happen that vision fails to recover from the initial decline.

Although, as mentioned above, most cases of optic neuritis are idiopathic, many ailments can also take their toll on the optic nerve, including viral illnesses (such as mumps, rubella, and cytomegalovirus), bacterial infections (such as Lyme disease, cat scratch fever, and tuberculosis), sinus infections, and inflammations elsewhere in the body or eye. Also, because the optic nerve is, in effect, an extension of the brain, it seems to be susceptible to some of the brain's own disorders, particularly multiple sclerosis.

Multiple sclerosis is what's called a *demyelinating* condition: it is an autoimmune condition where the body attacks its own nerve fibers connecting the brain with the body and erodes myelin, the protective sheath of insulation around these nerve fibers, leaving the bare "wire" exposed. No one understands exactly what triggers this immune system attack against myelin, disrupting the conduction of electrical impulses, causing delayed transmission, and leading to such classic symptoms as numbness and tingling in the arms and legs, difficulty walking, and double vision (due to an effect on the nerves that control the eye muscles). *Note:* One episode of optic neuritis certainly doesn't mean that you have, or that you are going to develop, multiple sclerosis. However, up to 95 percent of people who do develop multiple sclerosis will have an episode of optic neuritis at least once in their lives. (It's also worth noting that multiple sclerosis has many degrees of severity. Many people live completely normal lives with very mild forms of the disease. In fact, scientists believe that some cases of multiple sclerosis are never even diagnosed because the symptoms are so minor.)

Treatment: Treatment begins with an exhaustive medical history and a physical examination—and that's the easy part because there is not one widely accepted treatment for optic neuritis. Sometimes you can see the inflamed optic nerve in an eye exam. Rarely does treating an *underlying* disease or condition alter the course of optic neuritis; only time will tell whether vision will return after the inflamed optic nerve gets better on its own.

For years controversy surrounded the use of *steroids* (medications known to decrease swelling in the body) in various dosages and regimens against optic neuritis. In a search for better, more definitive answers, the National Eye Institute sponsored the national Optic Neuritis Treatment Trial, a large, multicentered clinical trial with a 10-year follow-up designed to study the effects of steroids on optic neuritis. The study's striking results have completely changed the way we treat people with optic neuritis. Scientists found, to their surprise, that steroids did not significantly improve vision after the episode, nor did they lower the odds of recurrence. But intravenous and oral steroids were found to speed visual recovery by 1–2 weeks, and in people with optic neuritis and brain scan evidence suggesting multiple sclerosis, they found that steroids *helped slow the course of multiple sclerosis*. This "protective" effect of steroids, though, was lost after 3 years.

Today, as a result of these findings, all patients newly diagnosed with optic neuritis are advised to have an MRI (magnetic resonance imaging) of the brain (a painless, noninvasive test) as soon as possible. If the scan suggests the possibility of multiple sclerosis, then patients are considered for high-dose intravenous steroid therapy—a treatment that should begin within 8 days of the onset of optic neuritis symptoms. Each patient with optic neuritis must be assessed individually and carefully followed. Immunomodulatory therapy is another treatment that has been shown to reduce morbidity associated with the relapsing-remitting form of multiple sclerosis. In some patients with optic neuritis, immunotherapy has also been found to delay their conversion to multiple sclerosis. The treatment of optic neuritis is an evolving field, though, where much research is being done all the time.

Anterior Ischemic Optic Neuropathy (Poor Blood Flow to the Optic Nerve)

When the supply of blood—and the vital oxygen it carries—is shut off, the result is called *ischemia*. This can happen, in mild or severe form, anywhere in the body. In the heart, major ischemia can cause a heart attack; fleeting ischemia can cause the intense chest pain of angina. In the brain, severe ischemia causes a stroke; temporary ischemia can lead to transient ischemic attacks, or "mini-strokes." In the eye, episodes of *temporary* ischemia—usually from atherosclerotic narrowing of the carotid artery, hindering blood flow to the retina—can cause "gray-outs" (also called *amaurosis fugax* or *retinal transient arterial ischemia*; see chapter 19). And *severe* ischemia—a shutoff of blood flow thought to result from artery disease within the optic nerve near the optic nerve head—can lead to the eye's version of a stroke: nerve cell damage and a sudden, dramatic, and usually permanent loss of vision in one eye. This is called *anterior ischemic optic neuropathy* (AION).

There are two distinct varieties of anterior ischemic optic neuropathy. The first is nonarteritic AION. It's a long name, but the word *idiopathic* (meaning "we don't know") ought to be in there somewhere because although we know what happens to the optic nerve, we don't know why, or what causes it. Much less frequent (equally serious but with systemic implications) is arteritic AION.

We do know what causes this: an inflammatory condition of the blood vessels supplying the optic nerve and of other blood vessels throughout the body.

Nonarteritic Anterior Ischemic Optic Neuropathy

People with nonarteritic AION experience a scary, painless sudden loss of vision, sometimes the upper or lower half of their visual field. There are no early warning signs. The problem seems to be age related: it tends to strike people in their sixties. Many of these people also have hypertension, hyperlipidemia, sleep apnea, or diabetes. It is assumed that these diseases play a role in causing nonarteritic AION, although we don't know exactly how. (Some experts speculate that the problem is caused by atherosclerosis, or "hardening" of the eye's blood vessels.) Unfortunately, most of the vision loss is immediate and permanent; recovery of the lost vision is rare. Plus, in about 10–15 percent of people, nonarteritic AION strikes the second eye as well—and sadly, we have no means of preventing this loss.

Arteritic Anterior Ischemic Optic Neuropathy

Arteritic AION happens when the blood vessels that feed the optic nerve become inflamed. The inflammation chokes, or sometimes blocks completely, blood flow to the optic nerve, particularly the anterior portion where the optic nerve meets the back of the eye, which includes the optic nerve head. It is not an isolated problem: this same inflammation also occurs in blood vessels elsewhere in the body, causing symptoms that may include headache, scalp tenderness, jaw discomfort when chewing or talking, fever, malaise, weight loss, and muscle weakness in the arms and legs. This generalized inflammation of the blood vessels—also known as *temporal arteritis* or *giant cell arteritis*—is usually confirmed by a blood test called a *sedimentation rate* and a *C-reactive protein level*.

Temporal, or giant cell, arteritis is characterized by a classic headache along the artery at the temples; when samples of the affected artery are examined under the microscope, we can see telltale enlarged (or giant) cells in the blood vessel walls. A biopsy of the temporal artery is usually needed to confirm this diagnosis. Your doctor may need samples of both temporal arteries (called a *bilateral biopsy*) to be certain. Fortunately, unilateral and bilateral biopsies don't interfere with blood flow to the head or face. Giant cell arteritis is thought in some patients to be related to a larger disorder known as *polymyalgia rheumatica*, characterized by pain and discomfort in the large muscles of the shoulders, neck, and thighs. Both conditions tend to occur in older people, often in their seventies, and most commonly in women.

In arteritic AION the vision loss is usually more severe than in the nonarteritic form. Some people experience transient visual disturbances, or fluctuations in vision, before the acute loss of vision with AION—probably caused by intermittent blockages of blood flow.

Treatment: There is no proven treatment for arteritic AION, although many patients experience a modest improvement in vision over time. The big thing to worry about here, as in nonarteritic AION, is the second eye. In 95 percent of people with arteritic AION, the second eye becomes involved within days to weeks after the first eye. *Therefore, when arteritic AION is suspected, high-dose oral steroid therapy should begin immediately in order to protect the other eye.* This *prophylactic*, or preventive, steroid therapy is often needed for months or years to keep the giant cell arteritis under control. Unfortunately, however, prolonged use of steroids can cause problems of its own. Be sure to discuss these with your general medical doctor or other health care provider, who will almost certainly want to monitor you closely, to check for the development of any steroid-related side effects.

Part V

OTHER THINGS YOU NEED TO KNOW

Chapter 18

EYE TRAUMA AND EMERGENCIES

It stings, it hurts, it's red, it's watery—but is it an emergency? You need to know because if it *is* an emergency, it is essential that you get prompt care, either from your eye doctor, or from an urgent care center, or at the emergency room of a hospital. Doing so or not doing so can make a big difference.

So, let's start this chapter off with a list of *emergency situations*. All of these require immediate attention:

- Any severe eye pain or discomfort
- Chemicals in the eye
- Eye trauma (like getting punched in the eye)
- A feeling like there's a foreign body in the eye
- Sudden loss of vision
- Any postoperative eye discomfort or change in vision
- Sudden onset of double vision

Now, here are the symptoms of an *urgent situation*. If you have any of these symptoms, you need to see a doctor within 24–48 hours:

- Gradual loss of vision over days or weeks
- Recent onset of light flashes and floaters
- Red eye without loss of vision or severe pain
- Recent onset of sensitivity to light

In this chapter I'll take a close look at some of these emergency and urgent situations. Other situations (like flashes and floaters) are covered in other chapters (check them out in the symptom index).

Chemical Burns

It hurts like crazy; it may also cause permanent damage. When chemicals get splashed or sprayed in the eye, you need emergency attention—fast. How bad is the injury? Can the eye recover? This depends not only on which chemical has injured your eye—and how severe the injury is—but also on how quickly you get medical help.

There are two main categories of chemical burns in the eye: those caused by alkalis, such as lime, lye, and ammonia, and those caused by acids, such as battery acid.

Alkali burns generally do the most damage. These chemicals react rapidly with fats in the cell membranes, the protective barrier covering the eye's outer surface. Weakening this natural shield allows the chemical to penetrate even deeper, into the cornea—often causing serious corneal swelling, inflammation, and even cataracts and glaucoma. Sometimes the cornea and its stem cells used for repair become so severely scarred that it can't even be fixed by a corneal transplant; the result is permanent vision loss.

Acid burns, surprisingly enough—even those caused by such harsh chemicals as battery acid—are usually tolerated better than alkali burns by the cornea. Because they tend not to damage the cell membranes, they usually don't penetrate deep into the cornea. Therefore, the risk of major corneal scarring, as described above, is much lower.

Detergents are other chemicals that often find their way into the eyes. More often than you might think, people inadvertently mistake liquid dishwashing soap for a contact lens cleaning solution, causing painful inflammation. Despite the irritation and swelling they may produce, detergents in the eye, as chemicals go, are usually pretty harmless. Even when, as sometimes happens, they injure the cornea's epithelium (its outermost layer of cells), the eye almost always recovers completely.

Treatment: No matter what caused the injury, your immediate response should be copious irrigation. In other words:

Step 1: Wash it out. The long-term health of your eye depends on how quickly you can begin rinsing it. You can use tap water, contact lens wetting solution, or saline. Tap water is usually the fluid most readily available in large quantities; it's best to splash water into the eye with your hand, rather than stare up into the gushing faucet.

Step 2: Don't stop. Keep irrigating vigorously for about 30 minutes.

Step 3: Go to the eye doctor or emergency room. An eye exam at this point will reveal the extent of the damage and the need for further treatment. This may include further irrigation, debridement (removal of foreign particles or injured tissue), medication, or an eye patch.

Thermal Burns

Like in other areas of the body, the eye, particularly the cornea, can be injured from exposure to excess UV radiation or heat, ranging from prolonged sunlight exposure to burns from a hot curling iron, cigarette, fireworks, or splatter from a heated liquid. All thermal corneal burns should be considered an eye emergency. And if you are foolish and don't wear protective eyewear when you are at risk for a thermal corneal burn, you will become a fervent believer in protective eyewear after suffering through just one episode. The pain can be excruciating, and generally the faster a thermal burn is treated, the better the prognosis. In the case of a thermal burn of the cornea after excessive UV light from sunlight outdoors, a sun lamp, a tanning bed, or arc welding, all that may be needed is patching the eye along with antibiotic eye drops and a drop to relax the ciliary muscle in the eye. The cornea heals very quickly, often within 12–24 hours, and oral analgesics are rarely necessary.

Thermal burns from heat can cause a lot of eye inflammation and may lead to corneal melting. These burns are very serious and can lead to permanent corneal scarring, particularly devastating if the scar occurs within the eye's line of sight. All heat burns of the cornea require attention to comfort first, followed by treatment to limit associated ocular inflammation, limit eyelid damage, and minimize subsequent scarring. Topical eye drops to relax the ciliary muscle in the eye and antibiotic drops to prevent a secondary infection are common first-line treatments. Debridement of damaged corneal and eyelid tissue may also be necessary before adding a steroid eye drop to decrease inflammation and then applying various techniques to temporarily, and later permanently, reestablish the corneal surface. Corneal transplants are reserved for when medical therapies are unsuccessful and are only indicated in a limited number of cases because of their variable success after thermal corneal burns.

"Black Eye" and Other Trauma

No matter how you got it—by falling, being punched, or getting elbowed while shooting hoops—the same injury that causes the classic "shiner" can cause severe internal eye damage, which may include bleeding within the eye, iritis (arthritis-like inflammation in the eye), glaucoma, double vision (due to difficulty moving the eye), a detached retina, and even temporary or permanent loss of vision. If the floor of the orbit is fractured, this could cause muscle damage, which may limit eye movement and create the appearance of a sunken eyeball—either of which may require surgery. So don't be your own expert and simply apply the beefsteak. First, let your eye doctor or local emergency room doctors or health care professionals check it out.

Corneal Abrasions and Foreign Bodies

Even though these can be some of the most uncomfortable eye problems, they're also among the most easily treated.

Why does it hurt so much? It's because a host of sensory nerves make their home in the cornea and conjunctiva. Their job is to sound the alarm, alerting the eye's defense mechanisms to dryness, foreign bodies, injury, and even temperature change. The eye then responds—by blinking or producing tears, for example.

When a foreign body, such as a tiny fleck of metal or rock, invades the cornea and becomes embedded in it, these same sensory nerves can make a splinter feel like a log. *Note:* They can also cause misleading sensations, making you think that something actually lodged in the center of the cornea is under the upper eyelid, when in fact it's the movement of the eyelid over the foreign object in the cornea that's so painful.

Treatment: Most foreign bodies stay on the surface of the cornea. They're fairly easily removed, under high magnification at the slit lamp, using a cotton-tipped applicator, needle, or other instrument. Your eye doctor will want to make sure that the foreign body is a lone invader (or, if it's not, to remove any other specks or splinters), that it hasn't perforated the eyeball, and that there's no associated infection, trauma, or injury. (This may require a dilated eye examination.)

To prevent the risk of infection after the fact, your doctor may also give you an antibiotic eye ointment under a pressure patch worn for 12–24 hours. Fortunately, because the corneal epithelium grows so fast, the cornea usually repairs itself, quickly covering any dents or scratches left when a foreign body is removed. Usually the cornea heals in 24 hours, with no permanent visual defect. (If, however, the foreign body manages to penetrate the center of the cornea, it may cause a corneal scar, and this may affect vision permanently.)

Recurrent corneal erosion (see chapter 12): Materials with rough surfaces—paper, wood, even fingernails—can cause a corneal abrasion. Either by becoming lodged within the eye or simply by rubbing or poking the cornea, they can significantly alter the corneal epithelium's basement membrane. Picture a slab of cement, with layers of epithelial cells as bricks stacked upon it: damage to this cement affects the way these cells stick to the basement membrane and eye. They may become loose and "slough off," especially at nighttime. (When this happens, the eye feels like it's being injured all over again, hence the term *recurrent corneal erosion*.)

Recurrent corneal erosions are common and can be very annoying. Fortunately, they usually don't last too long, and plenty of help for the discomfort—including drops, ointments, patches, surgical

PREVENTING EYE INJURIES: CAUTION AND COMMON SENSE

There are some easy, commonsense steps you can take to prevent one of the most common causes of eye problems in this country: eye injuries, which result from an unbelievable variety of activities. Obviously, it's not possible to prevent a car crash or freak accident. But it doesn't take long, when you take care of patients in a busy hospital emergency department, to grasp a few lucid points. One of them is that using a grinding wheel or chain saw without goggles can and does result in eye injuries. Letting your kids run around holding scissors with the points exposed is not a good idea. Nor is putting in contact lenses at a bathroom counter cluttered with household chemicals. Being a little neurotic about protecting your eyes from injury just makes good sense.

debridement or scraping, and even lasers—is available. Your eye doctor may want to see you at least one more time to rule out any infection or other complications.

Vision Disturbances

I've already talked about flashes and floaters (see chapter 16). But other, equally distressing, transient disruptions in the visual field are strange patterns—wavy lines, broken glass, or jagged edges—that often show up first at the edge of vision and then march toward the center and back again. These are often found to be a form of migraine, *with or without the headache* (see chapter 19). Many things can combine to cause this, including stress, caffeine, certain medications, hormonal surges (including those in pregnancy and menopause), and diet. The good news is that when the migraine goes away, so do these weird patterns.

Sudden Loss of Vision or Visual Field

Don't wait for this to get better on its own: *seek help immediately*. In the world of eye problems, it doesn't get much more serious than this. *Note:* By "loss of vision" I mean here *partial or total loss of sight in one or both eyes*—not just something funny going on with your vision, such as floaters, migraine patterns, second images of cataracts, or blurry vision caused by dry eyes or infection (although these also are important and require medical attention).

One Eye, or Both?

If you are suffering vision loss, your eye doctor's first step will be to figure out what's causing the problem. In addition to receiving a thorough eye exam, you'll be asked a lot of detailed questions. The first will probably be, Is this happening in one or both eyes?

This is terribly important because *if you're having simultaneous loss of vision in both eyes, chances are that the trouble isn't originating in your eyes*. One cause of a sudden vision loss in both eyes (called a *bilateral* loss) is a breakdown in the pathways that connect the eyes to the brain. The occipital lobe is the brain's vision center; a stroke or infarct (caused by a blocked blood vessel) here can cause a sudden, and often permanent, bilateral loss of vision. Migraines can also cause temporary bilateral visual loss (see chapter 19).

If the vision loss is in one eye (called *unilateral* loss), the important question is, Is the problem temporary? The most common cause of transient unilateral loss of vision is "fleeting blindness," or *amaurosis fugax*. In this case, the loss often progresses from the edge to the center of vision, like a dark curtain closing. Then, seconds to minutes later, the curtain opens again, with vision returning gradually but completely within about 20 minutes. This odd and often-frightening problem is believed to be caused by platelets or other tiny impediments that briefly interrupt blood flow in the retina. Many people who suffer from fleeting blindness have carotid artery disease—atherosclerosis in the carotid artery, another problem not to be taken lightly. They should undergo a careful physical examination; if significant blockage or buildup is discovered, these patients may need a surgical procedure called an *endarterectomy*, the surgical cleaning out of cholesterol plaque from the carotid artery. Other causes of transient unilateral vision loss include atypical migraines, hypotension, anemia, arteritis (see below), and elevated intracranial pressure from a variety of causes, including tumors and bleeding in the brain.

If the vision loss in one eye is permanent, the next big question is, Where's the loss—in your *central* or your *peripheral* vision? Because the optic nerve or retina can be involved in both cases, a thorough eye examination, including a dilated optic nerve and retinal evaluation, is crucial for pinpointing the problem.

Several things can cause sudden loss of central vision in one eye, including inflammation of the optic nerve, blockage of a main or branch retinal artery (see chapter 16), blockage or inflammation of other nerves in the eye, a detached retina, or a subretinal neovascular membrane (see chapter 10)—a problem often associated with macular degeneration. *Note:* It is rarely caused by cataracts, glaucoma, or diabetic retinopathy, and it's *never* caused by inadequate eyeglasses.

Giant Cell Arteritis

Giant cell arteritis, also called temporal arteritis, is a fairly common condition in people over age 65 that can lead to sudden permanent vision loss in one or both eyes. A disorder of the body's autoimmune system, giant cell arteritis is an inflammation that affects blood vessels—particularly those near the eye. Symptoms of giant cell arteritis, or inflammation of the blood vessels supplying the optic nerve, may begin with transient visual disturbances—brief episodes of losing central or peripheral vision, like temporary blackouts in an overheated city. Eventually these blackouts may become permanent, resulting in the total loss of central vision, or loss of the top or bottom half of the visual field.

What's happening here? The inflammation shuts off blood flow to the nerve, a condition called arteritic ischemic optic neuropathy (see chapter 17). Although there's no blood clot involved, the nerve damage is like that brought on by a stroke or heart attack: without oxygen, the optic nerve quickly begins to deteriorate, causing permanent damage—and, perhaps, irreversible loss of vision. Giant cell arteritis often causes other problems, including headaches, tenderness in the temples or scalp, trouble hearing, jaw pain, and trouble chewing. Clearly, if you're having any of these symptoms—particularly the vision disturbances described above—call your doctor immediately. Another worry is that giant cell arteritis often affects both eyes; therefore, early diagnosis and treatment are crucial.

Diagnosis and treatment: Your eye doctor will begin with a careful medical history. If giant cell arteritis is indeed suspected, you'll need blood tests called a sedimentation rate (also known as a "sed" rate) and a C-reactive protein. These tests aren't definitive, but they can show whether the body's immune system is working overtime, as it does in arteritis. However, a similar immune response happens in other diseases, including arthritis and cancer; therefore, if the sedimentation rate and C-reactive confirm that giant cell arteritis is a possibility, your doctor will perform another, more specific test: a temporal artery biopsy. There are two temporal arteries, one located near each temple; the biopsy—which causes no lasting effects, poses minimal risks, and is performed under local anesthesia—will probably be done on both sides.

The treatment in giant cell arteritis, to protect the other eye from ischemic optic neuropathy, or to preserve vision in the first one, is high-dose steroids; your doctor may even prescribe them before performing the biopsy. Because steroids can cause many problems of their own (see chapter 21), they're never prescribed lightly; because treatment for this disorder is often long-term, lasting months or even years, your eye doctor will want to monitor you carefully for any sign of side effects.

Nonarteritic Ischemic Optic Neuropathy

There is another form of ischemic optic neuropathy that also affects people in their fifties and sixties; because it is not related to arteritis, its name, by default, is *nonarteritic ischemic optic neuropathy* (see chapter 17). It differs from the arteritic form in that it often affects only one eye, it's associated with only mildly elevated sedimentation rates, steroid therapy doesn't help, and—perhaps most importantly—vision loss is usually not as severe or as permanent. Its cause is not known, though it seems to be found more often in people with hypertension. Unfortunately, there is no widely accepted treatment for this condition.

Chapter 19

GENERAL HEALTH PROBLEMS THAT CAN AFFECT THE EYES

Sometimes a health problem doesn't begin in the eye at all. The disease is *systemic*—that is, it affects the whole body. But as far as the eye is concerned, the consequences of some of these general health problems are as serious as any specific eye disease could ever be. Some of these disorders are discussed in this chapter, beginning with the big threat to eyesight posed by diabetes.

Diabetes

Diabetes cuts a wide, devastating swath through the body. No cell or organ, it seems, is immune to its ravages, and the eyes seem particularly vulnerable. In fact, among Americans of working age, diabetes is a leading cause of new cases of blindness.

Diabetes can cause trouble in the lens, eye muscles, iris, and other eye structures. People with diabetes are more prone to developing cataracts and glaucoma. But within the eye, diabetes has its worst effect on the retina. It is estimated that retinal involvement can be seen in a third of the people in the world with diabetes, many to the point of it being vision threatening.

What diabetes does to the retina—and this encompasses a broad spectrum of changes, ranging from microaneurysms (see p. 383) to retinal detachments, which may result in blindness—is known as *diabetic retinopathy*. Fortunately, most people with diabetes do not wind up blind from diabetic retinopathy; the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR), conducted in the 1980s on a white population of northern European descent, found that only about 3 percent of all people with diabetes eventually develop severe vision loss, largely dependent on how long someone has diabetes. This finding may be even lower today with increased awareness, better screening techniques, and newer treatments. But most people with diabetes do, at some point, experience some eye complications.

Before we discuss these complications, let's take a minute to review diabetes itself, which is primarily classified into two forms: *type 1*, formerly known as juvenile diabetes or *insulin-dependent diabetes*, and *type 2*, or formerly known as *non-insulin-dependent diabetes*. Only about 10 percent of all people with diabetes have type 1, which is usually diagnosed in childhood or adolescence and results from destruction of cells in the pancreas that make insulin; insulin is a hormone that helps the body keep blood sugar levels consistent. Because these people have the disease throughout their lives—as opposed to those with type 2, who develop a resistance to insulin over time and tend to develop diabetes later on in life—the disease has plenty of time to cause trouble. Diabetic retinopathy is especially prevalent in type 1 diabetics. In the WESDR study, 25 percent of those with type 1 diabetes had some retinal changes after 3 or 4 years, but after 20 years of having diabetes a staggering 99 percent showed signs of diabetic retinopathy. In comparison, 60 percent of type 2 diabetics showed signs of diabetic retinopathy after having the disease for 20 years. Both results highlight the importance of regular eye examinations in *all* diabetics.

The vast majority of people with diabetes have the type 2 variety. Because the classic symptoms of this disease—increased thirst, frequent urination, weight loss, and lack of energy—are often ignored, not recognized as warning signs, or confused with other ailments, it may be years before the condition is discovered. And because of this delay, in many people retinopathy is found soon after the diabetes is diagnosed. (Fortunately, it often doesn't seem to be as severe as the retinopathy found in type 1 diabetes.)

What Diabetes Can Do to the Retina

Diabetes attacks the small blood vessels of the body—the essential pathways that help supply blood and nutrients to the brain, peripheral nerves, kidneys, and eyes.

Briefly, diabetes targets the small blood vessels' basement membrane—which, as its name suggests, is their foundation, or cement. On top of this basement membrane, lining the inside of the blood vessels, are endothelial cells. Other tiny yet important cells are *pericytes*, whose job seems to be to help the basement membrane support the retinal blood vessels. In the eye, diabetes causes the basement membrane to thicken and the number of pericytes to dwindle, particularly in the retina. This in turn makes the blood vessel cells more porous and less able to carry oxygen and nutrients to the retinal tissues—which over time become malnourished and sickly. This leakage can lead to swelling and abnormal fluid buildup in the retina. Additionally, as retinopathy progresses, these sickly retinal tissues cry out for help and release factors that stimulate new blood vessels to sprout from existing blood vessels. Unfortunately, these new blood vessels are abnormal, are fragile, and easily bleed in the retina, leading to additional problems at these advanced stages. And this, basically, is diabetic retinopathy.

The damages here can be classified into two general types: *nonproliferative diabetic retinopathy* (tiny blood bulges, or microaneurysms, pinpoint hemorrhages, cotton wool spots, changes to the wall of blood vessels, macular edema, and shunts) and *proliferative diabetic retinopathy* (an unwanted surge in the growth of blood vessels, or *retinal neovascularization*).

Nonproliferative Diabetic Retinopathy

The retinal changes of nonproliferative diabetic retinopathy, described below, can be ranked according to their severity (figure 19.1). They may be mild to moderate, moderate to severe, or very severe.

These ratings are particularly important when recommending how frequently a person with diabetes should have an eye examination and for determining when someone should undergo treatment.

Microaneurysms, tiny blood vessel outpouchings or balloon-like bulges that look like small red dots in the retina (particularly in the macula) and that arise from diabetic changes in the retinal blood vessels, can go away all by themselves. But they also tend to leak fluid into the retina, contributing to a far more serious condition called macular edema (see below).

Dot hemorrhages are pinpoint areas of bleeding in the retina. *Blot hemorrhages* are larger, irregular, and roundish. Both of these types of bleeding also may be absorbed by the retina without causing any long-term damage.

Cotton wool spots, or *soft exudates*, are localized areas of retinal infarction (loss of blood flow to an area of tissue). These happen

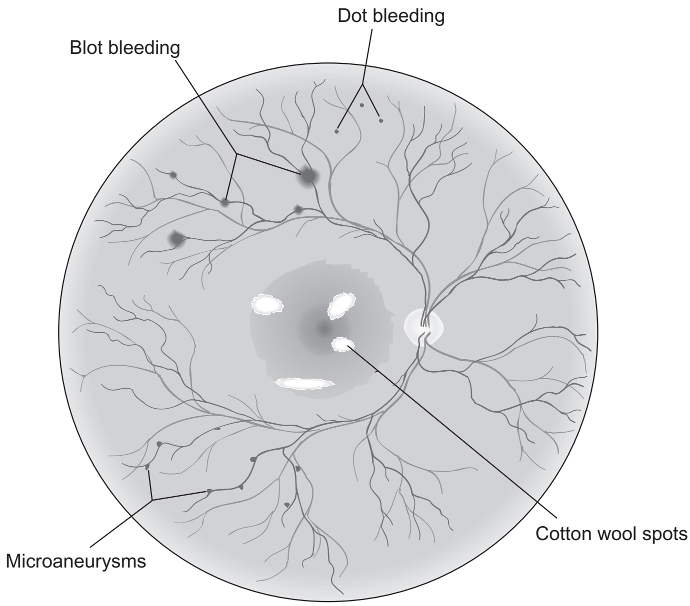

Figure 19.1. View of the retina with nonproliferative diabetic retinopathy

when tiny capillaries clamp themselves shut, halting the blood supply to nerves in the retina. The nerve tissue then swells (on examination, this looks like wisps of cotton on the retina).

Venous beading can cause the normally smooth walls of retinal blood vessels to look bumpy. Other results of retinal blood vessel changes are *abnormal blood flow patterns* and *shunts* (small, tubular areas of mutated capillaries that look like spaghetti). These are called *intraretinal microvascular abnormalities* (IRMA), as depicted in figure 19.2. (Both of these are common in advanced forms of nonproliferative diabetic retinopathy.)

Macular edema is the most common cause of visual impairment in people with diabetic retinopathy (figure 19.3). Nearly all of the retina's surface area is devoted to peripheral, or side, vision. A surprisingly small area—about 10 percent—is responsible for our fine central, or reading, vision. This is the macula (see figure 1.1B).

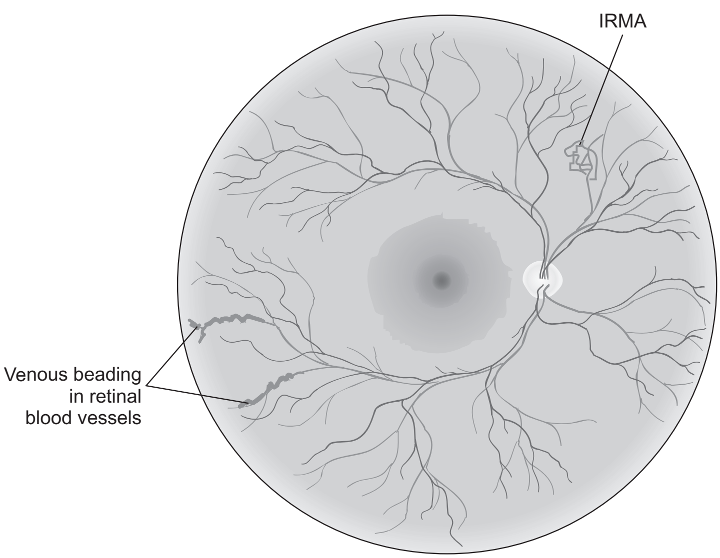

Figure 19.2. View of the retina with intraretinal microvascular abnormalities (IRMA) and venous beading

And the heart of this minute but critical region, the *fovea*, is a tiny area (less than 2 millimeters wide) of nerve cells—yet this is the epicenter of vision, the site of our most important sensory vision cells.

Macular edema doesn't just erupt overnight. As diabetic retinopathy takes its slow toll on the retinal blood vessels, they get progressively weaker and form tiny microaneurysms—particularly in the macula. These microaneurysms—which actually are abnormal areas of the blood vessel walls—leak; they ooze a nasty, fatty fluid into the retina. The swelling this causes is called macular edema. Imagine trying to watch a TV screen behind a fish tank: the water

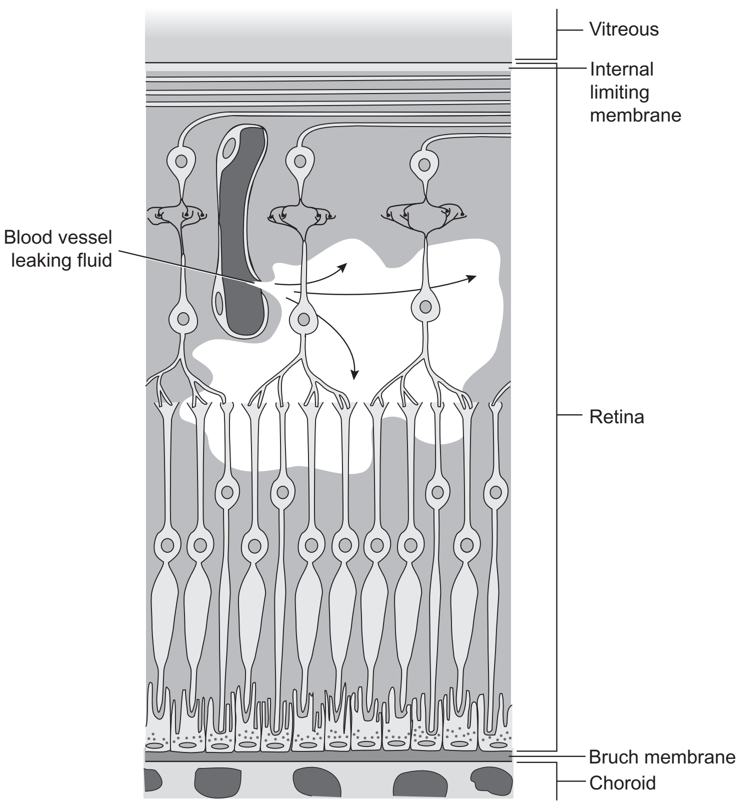

Figure 19.3. Microscopic section showing macular edema

would blur the picture. Well, the same thing happens in macular edema: The fluid obscures central vision. Reading is blurry. Looking straight ahead is blurry. And frustratingly, eyeglasses can't do anything to help. No matter how sharply light rays are focused onto this swollen retina, the retina's machinery simply can't function any better because the leaking fluid is in the way.

Although sometimes this fluid buildup gets reabsorbed on its own, mostly it doesn't. And over time this edema can cause irreversible damage to the retinal sensory cells, resulting in permanent vision problems. Fortunately, with early and appropriate treatment (see below) to slow the leakage and reduce the fluid, macular edema rarely causes blindness anymore. Remember, all of these changes to the retina may be either mild or very severe, or something in between.

Proliferative Diabetic Retinopathy

Sometimes the problem isn't bleeding from existing blood vessels; it's bleeding from a "baby boom" of new blood vessels that have formed in the retina (as mentioned above). These proliferative changes, primarily retinal neovascularization, also cause vision problems. To complicate matters, a person can have diabetic macular edema, proliferative or nonproliferative diabetic retinopathy, or any combination of these.

Nobody knows exactly why these new blood vessels spontaneously begin to grow in the retina (figure 19.4). We do know that the new vessels usually stem from old ones, and that this happens after someone has had diabetes for many years. One theory is that as the retinopathy progresses—to the point of extensive capillary closure, poor blood flow, and severe nonproliferative complications, including venous beading and IRMA—new blood vessels begin to sprout up, as if to reroute blood flow and offer the retina a fresh source of oxygen and nutrients. These offshoots grow either in the peripheral retina or on the optic disc. They develop particularly quickly in patients who have other health problems—breathing problems such as emphysema, for example, or the extra burden of pregnancy. (Pregnancy may also spark new blood vessel growth because of surges in hormones, changes in the body's blood flow, or changes in the blood's oxygen levels.) Interestingly, some eye conditions, such as advanced glaucoma, actually seem to protect the retina from these problems. Carotid disease, which can affect the blood flow to the eye, may also increase or decrease someone's risk of proliferative retinopathy.

This neovascularization is believed to be a response to blood vessel changes caused by diabetes that result in a lack of oxygen. Many investigators have found that the oxygen-starved retina releases a chemical cry for help—a substance that's been termed the vascular endothelial growth factor—to the ailing retinal blood vessels. In response, they grow, spewing tiny new blood vessels into the retina.

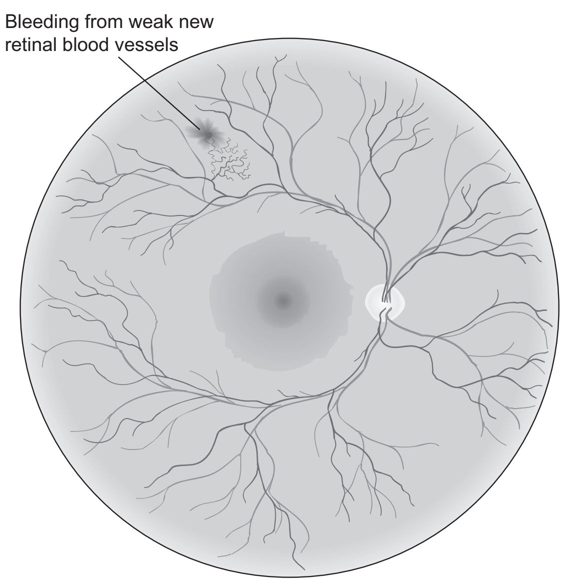

Figure 19.4. View of the retina with proliferative diabetic retinopathy

If you think about it, this process is pretty similar to what the body does elsewhere to repair injuries: we cut ourselves, and then the body efficiently heals the cut, laying a foundation of new blood vessels, connective tissue, and skin cells over the wound. The big problem in the eye is that *these newly formed blood vessels are not normal*. They're tiny, spindly, flimsy blood vessels—not at all like the mature vessels found in a healthy retina. Also, they grow in a haphazard pattern, with an unfortunate tendency to poke through the retina into the vitreous gel. In short, they're puny imitations of the original blood vessels, with a bad habit of breaking and bleeding into the retina and vitreous.

It is this awful bleeding of the new crop of blood vessels that leads to proliferative diabetic retinopathy's most devastating complications. These new vessels appear to rupture at the drop of a hat—in response to sudden jerks of the head, for instance, or even to eye movements like those in normal REM (rapid eye movement), or "dream," sleep. Coughing, throwing up, or sneezing—not to mention anything really traumatic, such as having a baby—can cause these blood vessels to break. Then they bleed, either directly into the retina or between the retina and vitreous jelly, resulting in *intraretinal* or *preretinal hemorrhages*. Blood can also gush out into the vitreous, producing a *vitreous hemorrhage*.

Whatever the cause for this bleeding, or wherever the hemorrhage, the change in vision is usually immediate. Patients may have a localized loss—a "hole" in part of their visual field—or they may see "spots" and "cobwebs," which gradually worsen to a dense haze or, in the case of a vitreous hemorrhage, a total loss of vision.

Given enough time, the body can usually remove this blood from the retina or vitreous. However, it may not necessarily accomplish this quickly enough—or, even worse, the body's "cure" may be as bad as or worse than the initial problem. As cells inside the eye begin the cleanup process, they may also produce scar tissue in the retina and vitreous. (Scar tissue is the body's basic way of healing itself after almost any injury.) Sometimes this scar tissue gets carried away, attaching itself to various areas of the retina, optic disc, and vitreous gel.

As scar tissue heals, it tends to contract. In the eye this contraction can tug on the retina, leading to a retinal detachment (see chapter 16). This kind of tractional retinal detachment is particularly devastating when it occurs in the macula. At its worst, it may result in permanent and severe vision loss.

Who's at Risk?

Although most people with diabetes eventually develop some degree of diabetic retinopathy, some have relatively minor trouble while others may wind up with severe impairment (but again, most never go blind from it).

By far the most significant risk factor is *how long someone has had diabetes:* the longer the diabetes has a chance to cause trouble—and here, people with type 1 are at a major disadvantage—the greater the odds of developing some form of retinopathy.

Can severe damage be prevented? Actually, there is much you can do to lower your risk of eye complications from diabetes. One huge favor you can do for yourself is to *control your blood sugar* and closely monitor your hemoglobin A1c (HbA1c), a test reflecting your blood glucose levels over the past 2 to 3 months. The Diabetes Control and Complications Trial, a national clinical study of the effect of glucose control on diabetic complications, showed that in people with type 1 diabetes, intensive insulin therapy delayed the onset and slowed the progression of diabetic retinopathy. Another clinical trial, the United Kingdom Prospective Diabetes Study, confirmed this same finding in type 2 diabetics. Keeping a tight watch on your blood sugar and lowering your HbA1c levels with medication or insulin injections and a careful diet appears to make a major difference in both the progression of diabetic retinopathy and the prevention of vision problems in general.

High blood pressure, obesity, infections, and pregnancy are also known to raise someone's odds of having serious complications from diabetic retinopathy (or from diabetes in general, for that matter). Most of these are within your control: watching your weight and blood pressure, and promptly attending to any infections. Though not always easy, such control is certainly possible to achieve—particularly when the consequences of *not* doing so can threaten your eyesight.

In addition to taking care of your body, take special care of your eyes. Get a routine eye examination at least once a year (and more often if you're having vision problems). The American Academy of Ophthalmology (AAO) has made recommendations, summarized in table 19.1, for when a person with diabetes should get their *first* eye examination:

Table 19.1 American Academy of Ophthalmology Diabetes Examination Guidelines

Diabetes Type	Recommended First Exam	Routine Follow-up
Type 1	5 years after diagnosis	Annually
Type 2	At time of diagnosis	Annually
Type 1 or 2 and Pregnancy	Soon after conception and early in first trimester	Ranging from every month to every 12 months, depending on the severity of your retinopathy (consult your eye doctor)

The AAO has also established guidelines for how frequently a person with diabetes should have subsequent follow-up eye examinations. The latter guidelines are largely based on the severity of diabetic retinopathy and can be found at www.aao.org/ppp or by contacting the AAO.

Here's the bottom line: Find an eye doctor who's very familiar with diabetic eye disease and its many complications. If you have any doubts, *seek a second opinion*. The stakes—your eyes—are too high for anything less than expert medical care.

Diagnosing Diabetic Retinopathy

As always, an eye examination should begin with a careful history. This should include a discussion of any eye trouble you may be noticing right now: fluctuations in blood sugar often cause intermittent bouts of blurred vision, difficulty with night vision, and trouble reading. (If your diabetes has only recently been diagnosed, you may also experience these problems as your blood sugar is being regulated. Therefore, it's probably best to wait a couple of months after your blood sugar is under control before you get a new prescription for glasses.)

Your doctor should also learn the specifics of your disease: how long you've been known to have diabetes, how well it's been managed over the years, any other medical problems—such as hypertension or kidney disease—you've experienced, and anything else that may be important, including any medications you're currently taking and any allergies you may have. (Also, if diabetes runs in your family, be sure to tell your eye doctor if any other relatives have had diabetic retinopathy.)

In the eye examination, your doctor will probably want to examine your visual acuity with and without your glasses or contacts, checking your distance and reading vision. Using a slit lamp (see chapter 4) to illuminate your eye, your doctor will especially look for any evidence of external eye infections, glaucoma (which is more common in people with diabetes), or cataracts. After this, your doctor will probably dilate your eyes to get a complete view of the retina. Your doctor may also use a *direct ophthalmoscope* (a handheld tool that looks like a flashlight) or a small magnifying lens at the slit lamp to examine your optic disc, macula, and retinal blood vessels and an *indirect ophthalmoscope* (the "coal miner's lamp" that shines a high-powered light through a special lens) to see the retina's far edges.

(For more on what to expect from a detailed eye exam, see chapter 4.)

These days, some doctors are choosing not to dilate your eyes to screen for diabetic retinopathy, instead taking pictures of the back of your eye using special retinal cameras and imaging equipment to look for changes. Sometimes other techniques are needed to measure someone's degree of retinopathy—particularly when macular edema is suspected but not obvious, or if the edema is so extensive that it's tough to distinguish the exact areas of leakage. If this is the case, you may also need a test called a *fluorescein dye study*, which involves intravenous injection of a dye into the blood vessels. Your doctor will take a timed series of photographs of your retina, tracing the dye's progress as it enters the blood vessels, passes through them, and exits the eye. If you have macular edema, this study will show your doctor where the trouble spots are by highlighting the leaks.

This study is painless, with few side effects—the most common one being that the orange dye temporarily gives the skin a mildly jaundiced tint and turns your urine a startling shade of yellow for about 12 hours. Some people also feel a brief twinge of nausea at the time of injection, as the dye rapidly circulates through the body. Approximately 5 percent of people may develop an allergic reaction, which can range from hives to more severe reactions like hypotension, shock, laryngeal spasm, and even death. All centers performing fluorescein dye studies should be aware of these potentially serious adverse reactions and be properly equipped to handle them.

SD-OCT, a noninvasive imaging technique mentioned in chapter 10 in association with its use in AMD to detect choroidal neovascular membranes, is also extremely useful in the diagnosis, classification, and treatment monitoring of diabetic retinopathy, especially looking for macular edema.

Treating Diabetic Retinopathy

The good news is that, thanks in large part to extensive research efforts and numerous clinical trials, we've made great strides in treating this complicated problem over the past 50 years—so much progress, in fact, that today most people with diabetic retinopathy don't suffer severe visual impairment from it.

Treating Macular Edema

When diabetic changes in the retinal blood vessels cause them to become more porous, leading to leakage of fluid out of the vessels into the nerve tissues of the retina, we call this diabetic macular edema (DME). DME can lead to an abnormal fluid buildup in the retinal tissues and result in visual impairment, particularly when it occurs in the center of the macula, the portion that is most important for fine vision. This leakage can occur at any severity of diabetic retinopathy, and early detection is often the key to successful treatment.

When the first edition of *The Eye Book* was written, argon laser photocoagulation of the retina was the "breakthrough weapon" against macular edema. Not true now. Photocoagulation, although still accepted as a well-proven treatment with minimal side effects such as scarring of the retina, has now been largely replaced by anti-VEGF therapy. As discussed in chapter 10, VEGF has been identified at high levels in sick, oxygen-deprived retinal tissue and appears to play a role in the loss of blood vessel integrity, which leads to their leakage of fluid into the retina. VEGF also plays a key role in the complex cascade that incites retinal neovascularization, an insidious process we will talk about in a later section. Researchers have developed many new drugs for injection into the vitreous that work to block VEGF's effect on blood vessels. These anti-VEGF drugs include aflibercept, bevacizumab, pegaptanib, and ranibizumab, and there is yet promise for others in the future. Clinical trials have demonstrated that anti-VEGF drugs, like those mentioned above, are well tolerated and beneficial for eyes with DME and provide superior visual acuity outcomes compared to laser treatment for DME involving the center of the macula. Not surprisingly, anti-VEGF intravitreal injections have now become the "first-line therapy" for most patients with DME. But don't expect that one injection will solve the problem. It generally takes repeated intravitreal injections to have an effect on macular edema—so anticipate multiple office visits for "touch-up" injections until your retinal specialist is satisfied that the fluid has resolved.

Laser treatment, corticosteroid eye injections, and even retinal surgery such as pars plana vitrectomy still have roles in the treatment of diabetic macular edema, making it very important for diabetic patients with retinopathy to always see an eye doctor who is very familiar with the latest treatments for diabetic retinopathy. Furthermore, macular edema can be especially difficult to treat in people with poorly controlled diabetes, people with hypertension or fluctuating blood sugars, and people who are pregnant or who have kidney problems or infections such as bacterial foot ulcers. Seek the counsel of your general medical doctor or other health care provider, or diabetic care specialist too. Whatever you can do to improve the rest of your health will certainly boost your odds of having successful treatment.

Treating Proliferative Diabetic Retinopathy

Many years ago, eye doctors noted that people with diabetes who had large areas of retinal scarring—from such problems as infection or trauma—seemed less likely to develop proliferative diabetic retinopathy. This led investigators to create artificial scars on the retina, to see if this had the same protective effect.

It did. In the late 1970s, after encouraging results from earlier studies, the National Eye Institute's National Diabetic Retinopathy Study confirmed the theory: somehow, scarring—done with argon lasers—slows or stops out-of-control blood vessel growth in proliferative diabetic retinopathy. The study's results were striking. Years after undergoing argon laser treatment, patients were *less likely to develop severe vision loss* than those who hadn't received this treatment. *Note:* Again, as with macular edema, the laser is not a cure-all for proliferative diabetic retinopathy; it's not guaranteed to prevent severe vision loss, but it does significantly lower the odds.

Laser treatment for proliferative diabetic retinopathy is more extensive than the "spot-welding" used for macular edema (although many features of the procedure are the same; see above). The technique here is called *panretinal photocoagulation*; instead of fifty to one hundred laser "spots," or burns, it may involve eight hundred to two thousand pinpoint-sized burns and may take two or three sessions to finish. (For more on the side effects of laser treatments, see below.)

The idea, basically, is to scar most of the retinal tissue. Nobody quite understands *why* this helps slow rampant growth of new blood vessels. Whatever the reason for its effect, this treatment had been tremendously helpful for people faced with proliferative disease, but laser photocoagulation for proliferative diabetic retinopathy now has largely been supplanted by anti-VEGF therapy.

VEGF is part of the complex cascade of factors felt to be important in the process of angiogenesis. The type of angiogenesis seen in proliferative diabetic retinopathy is the growth of new blood vessels in response to the retina's cry for help (for oxygen). If these new blood vessels were normal and up to the job of supplying the ailing and hypoxic diabetic retina with oxygen, the story would be quite different from the reality. In reality, these new blood vessels are abnormal and fragile, do not supply enough oxygen to the diseased retina, and can break and bleed, leading to still other problems. Anti-VEGF agents that inhibit this new blood vessel development are injected into the vitreous and have been found to be as successful as laser photocoagulation for the control of proliferative diabetic retinopathy, with less risk of side effects. These medications can sound like they are derived straight from the periodic table of chemical elements—pegaptanib, ranibizumab, aflibercept, bevacizumab—and have miraculously spared many patients from the severe vision loss often associated with proliferative diabetic retinopathy. New drug delivery systems are being tested, but for now, these treatments often require monthly intravitreal injections. These injections are well tolerated with only rare ocular complications, such as elevated eye pressure, retinal detachment, vitreous hemorrhage, and endophthalmitis (a serious infection inside the eye), and without the side vision loss and other potentially vision-threatening side effects seen with laser photocoagulation.

Treating Vitreous Hemorrhage and Tractional Retinal Detachments

As discussed above, the fragile offshoot blood vessels of proliferative diabetic retinopathy bleed at the slightest provocation. When they spill blood in the retina and into the vitreous cavity—producing a vitreous hemorrhage—they can cause scarring on the surface of the retina and in the vitreous jelly. Unlike the deliberate scarring done with the laser to combat proliferative retinopathy, this scarring is dangerous for vision. Over time it gradually contracts, as all scar tissue does, and takes the retina along with it, causing it to separate from the back of the eye. This is a tractional retinal detachment (see chapter 16), a serious process that can severely impair vision and even lead to blindness.

However, we now have a successful way to treat vitreous hemorrhage: a procedure called *vitrectomy*. Using specially designed instruments—scissors, picks, and tiny lights for guidance—retinal surgeons can now remove the vitreous hemorrhage from the back of the eye, carefully stripping away scar tissue and relieving its tension on the retina. The success of this surgery was investigated and confirmed more than 30 years ago by the National Eye Institute's Diabetic Retinopathy Vitrectomy Study (DRVS). This large study particularly showed the benefit of early vitrectomy for a severe vitreous hemorrhage in a person with type 1 diabetes, but not in a person with type 2 diabetes. A lot of advances have been made in vitreoretinal surgery since the DRVS to make vitrectomy faster and safer. These advances have led retinal surgeons to perform vitrectomies earlier now than in the past for nonclearing vitreous hemorrhages, especially when a retinal detachment is present and needs repair. Laser photocoagulation or cryotherapy of the retina may also be used during vitrectomy surgery to treat any underlying proliferative retinopathy.

Coping with Diabetic Retinopathy

Diabetes takes its toll on the whole body—including one's emotional well-being, which can have a great influence on the course of the disease. Depression and anxiety are very common in diabetes, and understandably so—particularly in people who are newly diagnosed or who have just been told they have diabetic retinopathy. Sometimes emotional problems and difficulty coping—which may be triggered by having *any* chronic disease—can sap patients' motivation and jeopardize their ability to control the diabetes. If there's a possibility that your emotional reactions may be interfering with the management of your illness, don't hesitate to seek professional help. Also, your eye doctor, internist, family medical doctor, endocrinologist, or other health care provider may be able to recommend local support groups. It can help tremendously to simply talk about what you're going through with people who are experiencing the same kinds of problems.

Some Questions You May Have about Laser Treatments for Diabetic Retinopathy

Do laser treatment or anti-VEGF intravitreal injections have any side effects?

Usually only minor, temporary ones, such as mild swelling, blurred vision, and light sensitivity. However, laser treatments for macular edema, if placed close to the center of the macula or in a pattern to cause a dense scar, sometimes result in small areas of "blind spots," which are usually most noticeable when you're reading. Panretinal treatment for proliferative diabetic retinopathy, because it's performed mainly in the peripheral retina, can make it more difficult to see at night and may slightly reduce your peripheral and color vision. Clinical studies have demonstrated that laser treatments for diabetic retinopathy may also cause a slight loss of visual acuity. Multiple clinical studies have compared the treatment benefits and side effects of laser treatment against anti-VEGF intravitreal injections for macular edema and proliferative diabetic retinopathy. Although it is always difficult to generalize and all treatment should be based on an individual patient's circumstances, due to its effectiveness and generally favorable safety profile, anti-VEGF therapy is now considered a reasonable first-line treatment for diabetic macular edema and proliferative retinopathy. Like any procedure, laser treatment isn't without its risks—which may include bleeding, increased macular edema, improperly placed laser burns that result in severe vision loss, and increased retinal scarring—and you shouldn't go into it without a thorough understanding of these. There are also risks associated with ant-VEGF intravitreal injections such as elevated eye pressure, bleeding, retinal tears, retinal detachment, and even endophthalmitis (a serious infection inside the eye). As we've said before, because this is your eyesight at stake, you should have the utmost confidence in your surgeon. However, the risks and complications of laser treatment and anti-VEGF injections in diabetic retinopathy are rare. For most doctors and patients, they're far outweighed by the good that these treatments do in preventing retinopathy from getting any worse.

Will laser treatments or anti-VEGF injections improve my vision?

Possibly. The main goal of treatments for diabetic retinopathy is to slow or halt the progression of this eye disease—in other words, *to keep your vision from getting any worse*. So you shouldn't get laser treatments or anti-VEGF injections expecting to come out with perfect vision—and if your doctor leads you to believe that this is a possibility, you may want to rethink letting them anywhere near your eyes with a power tool. It's true that a percentage of people who receive anti-VEGF injections often do notice a visual improvement after treatment for macular edema, *particularly when this injection is coupled with laser treatment*.

Vitreous hemorrhages often cause annoying symptoms of "cobwebs," spots, or floaters in the eye, and laser treatments or anti-VEGF injections can't do anything to get rid of them; they're in the jellylike vitreous. As the blood is gradually absorbed, or as it settles, the hemorrhages may become less noticeable, but rarely do they resolve completely. A vitrectomy, if necessary, can remove this blood from the back of the eye and replace the vitreous with water. (This surgical procedure *can* diminish floaters or spots in the eye.) But again, as with any surgical procedure, a vitrectomy is not without its own set of risks and should not be performed until you have thoroughly weighed them against the benefits.

How many laser treatments or anti-VEGF injections will I need?

It depends on your eyes. Some people may require only one, two, or three laser treatment sessions per eye to treat macular edema. Others may need ten or twelve treatments over the course of months to years to control macular edema and proliferative retinopathy. Multiple injections on a monthly basis are much more likely with anti-VEGF therapy, although newer drug delivery vehicles are being developed that may eventually change how these medications are administered to the eye and how often.

Perhaps more important than how many sessions you'll need—whatever that number may be—is that you and your doctor talk about it thoroughly first, and that you have a reasonable idea of what to expect. It's easy to get frustrated if you expected a couple of sessions to clear up a problem that turns out to need many more treatments. You'll also need your fair share of patience because healing doesn't happen overnight; your eye will need time to recover—weeks or months—after each session before your doctor can determine whether you need another one.

Hypertension

An estimated seventy-two million Americans have hypertension, or high blood pressure. For most of them, controlling blood pressure is a daily struggle. Over time, hypertension takes its toll throughout the body, particularly in the brain, heart, kidneys, and eyes.

In the eye, hypertension hits the retina hardest, causing tiny arteries there to become even narrower, impeding blood flow. Although we consider these to be "classic" changes of high blood pressure, they're often difficult to distinguish from similar "arteriosclerotic" changes that come with normal aging. (Arteriosclerosis, or generalized narrowing of the arteries, is certainly not limited to the eye; it happens in blood vessels throughout the body.) In fact, hypertensive and arteriosclerotic changes can even be seen *in the same eye*. And hypertension can make arteriosclerosis even worse.

Over a span of years, even relatively mild elevations of blood pressure take their toll on the body's vasculature, and we can see evidence of this in the eyes. The consequences of skyrocketing blood pressure, especially if it rages uncontrolled for months or even years, can be dramatic and severe: retinal hemorrhages, infarcts (total blockages that prevent blood from reaching tissue) in the nerve fiber layer, and even retinal exudates (fluid leakage into the retina from these blood vessels). One good note, from a diagnostic standpoint, is that these last changes aren't subtle and rarely go undetected during an eye exam. They're almost impossible to miss—which means we can work with your general medical doctor or other health care provider to begin treatment for your blood pressure as soon as possible.

Carotid Artery Disease

The carotid arteries are to the brain what the aorta is to the heart: a lifeline—actually, twin lifelines that carry oxygen-rich blood to the head. As they travel upward, these great rivers branch, forming the internal and external carotid arteries. The *internal carotid artery* is important here because one of its own branches, the *ophthalmic artery* (again, there are two—one for each eye), supplies blood to each eyeball. The ophthalmic artery, in turn, divides again, becoming the *central retinal artery*, whose job it is to nourish the inner retina, and the *posterior ciliary arteries*, which feed the choroid, among other structures. Without life-sustaining blood, these tissues become diseased or die—which is why any ailment affecting the carotid artery can have great ramifications for the eyes, including gradual vision loss, aching pain, prolonged vision recovery after exposure to bright lights, new blood vessel growth in your iris or anterior chamber angle (think neovascular glaucoma; see chapter 9), and even swelling and inflammation in your eye.

Atherosclerosis ("hardening of the arteries") is the most common malady of the carotid arteries. As in the atherosclerosis that leads to heart attacks, this most common cause of artery disease is a historical record of a lifetime's worth of habits. Every fatty meal, every day or week or decade without exercise, every pack of cigarettes puffed—it's all here, in the greasy, brittle buildup of cholesterol and fibrous tissue lining the walls of these blood vessels. Over time, atherosclerosis leads to a narrowing of the artery's opening (called the *lumen*) and a drop in blood flow to the retina and brain. Imagine a garden hose that becomes clogged inside with dirt: the water has trouble getting through. When this happens to blood in the brain, the results can be serious and may include transient ischemic attacks (TIAs), or "mini-strokes"; temporary weakness or loss of sensation on one side of the body; aphasia (difficulty with speech or writing); a loss of vision in one eye (called amaurosis fugax); and severe eye pain (not unlike the intense pain of angina in the heart).

Amaurosis Fugax

Amaurosis fugax is a form of TIA, or "mini-stroke," that occurs in one eye. An artery is blocked, and tissue is damaged, but the blockage is only fleeting; it clears itself, and blood flow is restored. Amaurosis fugax is the most common symptom of carotid artery disease. You're driving a car or working in your yard, and all of a sudden your vision becomes dim or dark in one eye—like a "blackout," a "brownout," or a gray veil or curtain. Mercifully, this usually lasts only about 5–10 minutes, and seldom more than 30 minutes. Vision returns to normal slowly, as if a veil or curtain were being gradually lifted from the eye. There may be another episode within a few days. *Note:* This event is not usually accompanied by other problems such as dizziness, lightheadedness, headache, trouble talking, or forgetfulness. If you have more prolonged or permanent dysfunction involving, for example, your speech or vision or the use of an arm or a leg, this may be due to a stroke.

This temporary vision loss is a warning sign—so don't ignore it. About 10–15 percent of people with TIAs or amaurosis fugax will have a stroke within 90 days, with approximately half occurring within 48 hours. Amaurosis fugax is often caused by small particles—chunks of cholesterol or bits of platelet—that break off from a "hardened" artery and float up to the eye. Usually they become lodged in the small retinal vessels and block blood flow for a few scary minutes before becoming dislodged and moving on downstream. If this doesn't happen—if they don't move on—they can cause a branch or central retinal artery occlusion (see chapter 16), a far more severe blockage. (It happens in the eye just as in the brain: a TIA is a small stroke that usually does no lasting damage, but a major stroke can result if there is no return of blood flow—if, in other words, the blockage is not temporary and the damage is more extensive.)

So again, don't disregard a temporary loss of vision. You will need a thorough medical history and physical examination by your general medical doctor or other health care provider. It may be that your problem is not caused by carotid artery disease. Several other disorders can also produce temporary vision loss, including giant cell arteritis (see chapter 18), migraines, elevated intraocular pressure, blood-clotting problems, and low blood pressure. In any case, this is not something to leave "to take care of itself."

Ocular Ischemia

Atherosclerosis is a nasty, troublemaking condition in the eye. Amaurosis fugax is one of the problems it causes; ocular ischemia is another. Remember the clogged garden hose described above? In this case the poor hose's opening becomes increasingly narrowed for prolonged periods, and the garden it's supposed to water becomes increasingly parched. Here, the hose is the carotid artery, and the garden is the eye itself. ("Ischemic" tissue is parched as well; it's starved for blood, oxygen, and nutrients.) Ocular ischemia can be devastating: it can lead not only to loss of vision but even to loss of an eye.

Many patients with ocular ischemia may never realize they've got a problem. Here's another reason for regular eye exams: *Eye doctors can usually detect the problem early enough to treat it.* On a routine eye examination, we can see small, scattered hemorrhages (tiny red dots) and other changes in the retina that suggest poor blood circulation in the eye.

Other patients may have a symptom that's impossible to ignore: the eye's version of angina. Like angina associated with heart disease, *ocular angina* is an intense, intermittent pain caused by ischemia. (Think of this pain as the ischemic tissue's very loud cry for help.) Recurrent eye pain that improves when you lie down can be typical of ocular ischemia due to carotid artery disease. Other people with poor ocular circulation may experience transient blurred vision, chronic eye inflammation and redness, and even a few minutes of visual difficulty when they go from dark areas into bright light. (However, this may also be due to other ocular problems such as cataracts, age-related macular degeneration, or even the need for a new eyeglass prescription; see chapter 16.)

In advanced ocular ischemia, neovascular glaucoma may also develop. This can lead to uncontrollably high eye pressures, causing chronic severe eye pain and discomfort, and result in blindness. In order to preserve eyesight, some people need special treatment: pressure-lowering eye drops, carotid stenting, carotid endarterectomy, anti-VEGF intravitreal injections, laser photocoagulation, or a retinal freezing technique called *cryoablation*, for controlling neovascular glaucoma.

Diagnosis of Carotid Artery Disease

If your eye doctor or other health care provider suspects that you have carotid artery disease, you'll need a complete medical history and physical examination. Your carotid arteries will need to be examined specifically, and this may involve several tests. The most widely used of these tests are *carotid ultrasonography* (*duplex scanning*), *magnetic resonance angiography*, and *computed tomographic arteriography*. Carotid ultrasound, a medical version of the sonar used on submarines (and a technique used on pregnant women to monitor their unborn babies), can help your doctor check blood flow in the carotid artery. You may require still other tests, such as *carotid arteriography*, in which a doctor injects dye into the blood vessels and takes special pictures as the dye flows through the carotids.

(You may have heard of an arteriogram, used to measure heart disease; this is the same technique.) Although more definitive than Doppler studies, "invasive dye studies" also carry more risks, including bleeding, infection, and potential formation of a blood clot. Thus, they're not the first line of diagnostic testing and are used only in special cases.

Treatment of Carotid Artery Disease

The first step in treating carotid artery disease is to minimize your chances of further damage from poor blood flow. So, how to improve blood flow to your eye? One approach your general medical doctor or other health care provider may recommend is "thinning" the blood with medications, including antiplatelet medications such as aspirin and clopidogrel (Plavix) or dipyridamole (Persantine) and anticoagulation medications such as warfarin (Coumadin). Another approach is mechanical: "cleaning out" the clogged artery, in a procedure such as *carotid endarterectomy*. It's the carotid version of a plumbing technique: a surgeon opens the blocked artery and removes the gunk accumulated on its wall.

Endarterectomy also has been successful in helping people with poor blood flow to the eye as seen in ocular ischemia (see above). In these people, the procedure helped maintain their vision, relieved angina-like eye pain, and even, in severe cases of ocular ischemia, preserved the eyeball. With endarterectomy, patients with ocular ischemia and significant carotid artery disease can regain useful vision if the conditions are caught early enough.

Headaches

Headaches, like fingerprints or snowflakes, are unique. Nobody's is exactly like anybody else's—in fact, even in the same person, rarely are two headaches exactly the same.

Headaches can be contained, or localized, to a particular area of the scalp or head; they can be dull or sharp, intermittent or prolonged. They may be accompanied by other symptoms such as nausea, vomiting, dizziness, or "visual phenomena"—seeing wavy lines, or having double vision. Because of the infinite variety here, your eye doctor, general medical doctor, or other health care provider isn't going to be able to help much unless you get specific. Your description of your pain and other symptoms, plus their thorough questions, will help establish the type of headache and its cause (see box p. 409).

Your doctor or other health care provider may ask you to keep a headache diary, recording such things as the time of day, any events that happened just before the headache, and the duration. Also, if you have chronic, recurrent, or severe headaches, you may need a thorough physical checkup, plus blood tests, sinus X-rays, and an MRI or CT scan of the head.

Tension Headaches

Most headaches are caused by tension. Your basic tension headache begins as the muscles tense up in the back of your head or neck. This pulling then radiates to both sides of your head and around the front, to your forehead. This has been called a "viselike" or "bandlike" tightness because it feels as if someone's clamping a vise around your head. It can also occur in migraine sufferers, sometimes making it difficult to distinguish between the two types of headache. However, although the symptoms may be similar, *tension headaches typically occur at the end of the day and often may be related to stressful moments.* They don't get worse or better if you turn your head or body a certain way, as migraines can. They usually aren't affected by light or accompanied by *photophobia* (abnormal sensitivity to light) or other associated neurologic symptoms such as nausea, dizziness, loss of vision, numbness, or muscle weakness.

If it's any comfort, you're not alone. Almost everybody gets a tension headache at least once in a while. Also, this form of headache can almost always be relieved by over-the-counter painkillers—aspirin, acetaminophen (Tylenol), ibuprofen (Advil, Motrin), and the like. (However, if your tension headaches are persistent and if they're affecting the quality of your life, you may need additional medication or therapy.)

Sinus Headaches

Another common cause of eye pain and headache is acute or chronic sinusitis. The sinuses are empty cavities in the skull. (These empty air-filled cavities evolved, scientists believe, to help lighten the load, since a skull of solid bone would be a bit heavy to balance on our relatively frail necks.) Among other things, the sinuses warm the air we breathe and play a role in speech. There are several sinuses in the skull, most of them located over, under, and next to the eye; some sinuses even share an adjoining wall with the orbit. Therefore, because they're such close neighbors of the eye, any infection or inflammation in the sinuses can also irritate the eye or eye muscles next door. If you have a history of sinusitis, and if you're experiencing occasional eye pain or pressure, the two might be related. You should see your eye doctor or general health care provider. Such inflammation or infection is typically treated with decongestants and/or antibiotics, but if chronic or recurrent, the condition may require surgery.

Refractive Error Headaches

What's a refractive error? It's a problem with the way your eyes focus light—in other words, why most of us need eyeglasses or contacts to help us see. This is not a major cause of headaches, and finding the right prescription for nearsightedness, farsightedness, or astigmatism rarely puts an end to persistent headaches. Therefore, before

ESTABLISHING THE TYPE AND CAUSE OF A HEADACHE

Here are a few questions you can expect your doctor or other health care provider to ask you about your headache:

- Where was the pain? In the temples? The top of the head?
- When did it start? How bad was it? (In other words, were you still able to function, or did you need to lie down?)
- How long did it last?
- How often do you get such headaches? Twice a month? Once a week?
- Do you have any other symptoms when you get a bad headache?
- Has any medication—aspirin, acetaminophen (Tylenol), ibuprofen (Advil, Motrin), an antihistamine—helped or not helped?
- Does anything seem to trigger it—stress, reading, medications, certain seasonings or foods (such as any food or drink containing caffeine)?
- Do the headaches seem to occur at a certain time of day?
- Does the headache wake you up from sleep?
- Do you awaken in the morning with the headache?
- Does it vary with changes in position? (A "yes" to these last three questions may suggest headaches due to elevated intracranial pressure.)
- Does anyone else in your family suffer from bad headaches? (A family history of headaches can help your doctor or other health care provider diagnose a migraine.)

simply writing you a new prescription, your eye doctor needs to make sure something else isn't going on here, either another medical problem or another eye problem. You'll need a complete eye evaluation, including a dilated retinal examination, to rule out other eye ailments, including conjunctivitis, corneal abrasions and ulcers, iritis, cyclitis, posterior scleritis, acute closed-angle glaucoma, optic neuritis, eye tumors, and other eye inflammatory diseases. All of these can cause headaches or eye pain. (See the general index for specific page references to these problems.)

How do you know if it's a refractive headache? Does it happen when your eyes are hard at work—for example, reading, doing needlework, or looking at a tiny map on your smartphone? Since these headaches are usually due to someone's need for glasses—in most cases reading glasses—or the need for a different prescription, you may experience "tired eyes," or discomfort around or behind the eyes after prolonged reading or computer work.

You don't get refractive headaches first thing in the morning, when your eyes are relatively refreshed. You don't get them when your eyes are relaxed—on weekends, for example, when you're leisurely gardening in your backyard. Headaches related to the eyes are dull and aren't associated with the nausea, vomiting, or "visual phenomena" found in migraines. However, they can lead to a tension headache from the anxiety they cause.

Migraines

Believe it or not, although the name is synonymous with headaches, you don't have to have a headache to have a migraine. You could just see things—geometric shapes, flashbulbs, jagged lines, heat waves, sparkling, watery images, "Swiss cheese" patterns, and other phenomena.

Nobody really knows what causes migraines. However, scientists think they're caused by a release of signaling proteins secreted by cells at the vascular endings of cranial nerve V, causing changes in blood vessels within the brain such as blood vessel dilation, increased leakiness, and also possible inflammation in their walls. The release of signaling proteins can be triggered by a dazzling variety of stimuli, including stress, caffeine (coffee, tea, cola, chocolate), cheese, nuts, shellfish, red wine, MSG (monosodium glutamate, common in certain Asian food), or aspartame-based sweeteners. All of these, in people who are prone to migraines, can cause chaos: the visual problems mentioned above, or feelings of nausea and dizziness, or a terrible, disabling headache, or combinations of these symptoms. Symptoms may even change from episode to episode, and many people who experience visual or other migraine symptoms never even get a headache. There seem to be infinite variables at play here.

Migraines can strike at any age and annually affect approximately 6–8 percent of men and 15–18 percent of women in North America and Europe. There is often a family history of migraines; in addition, people with migraines often report having had motion sickness as a child. Although hormonal change has been linked to the onset of migraines, the exact role of estrogens and oral contraceptives is uncertain but may be a trigger in some people. The types of migraines and headaches that can involve the eye and vision are numerous and too extensive to all be included here, but below I will briefly describe some of the more common ones.

Migraines without Aura

Typically migraines are severe headaches that usually begin on one or both sides of the head as pounding, stretching, or throbbing. They can spread to involve half or all of the head. The intense headache pain can even occur behind the eyeball, mimicking sinus or other eye problems. Migraines can be extremely incapacitating headaches, lasting hours or even days, often causing people to seek refuge in a quiet, dark room until the pain goes away. They may be associated with nausea, conjunctival redness, watery eyes, a "foreign-body" sensation in the eyes, or ultrasensitivity to light.

People who suffer from migraines without an aura have no premonition that they are about to be hit with a migraine headache.

There is no preceding neurologic incident that gives a warning like a visual event, a mood change, a series of yawns, or trouble with speech. Unfortunately, this form of migraine just happens, and it is estimated to occur in 65 percent of all migraines, making these migraines often difficult to distinguish from common tension-type headaches.

Migraines with Aura

Migraines with an aura have defined warning symptoms. These migraines also tend to include visual or "sensory-motor" disturbances, such as numbness or weakness of an arm or leg, before or during the headache. Sufferers describe a visual aura such as shining lights, flashbulbs, sparkles, geometric patterns, zigzag lines, heat waves, or "Swiss cheese" areas of vision loss. These visual phenomena can last minutes, hours, or even days and are always bilateral (which may not be appreciated by a person at the time). People may even experience a buildup, crescendo, or march of these phenomena—in other words, the little wavy lines may begin as a small area off to one side of your vision and gradually increase until they involve half or all of your visual field in each eye. Sometimes the aura before the headache isn't visual; instead, people may experience numbness around the mouth, an unusual sensation over half of the body, dizziness, or even temporary disorientation. These migraine attacks may modify their presentation over the years: as they age, some people may still experience the visual or sensory-motor aura but, mercifully, escape the headache. People who suffer from atypical aura without a headache are thought to represent 5 percent of all migraine cases. Doctors and other health care providers should perform a physical exam; carefully examine an individual's complete history, including medical, social, and dietary information; and perform other testing to distinguish this type of migraine from a transient ischemic attack.

Like other types of migraines, these migraines tend to occur at any age and often run in families; also as mentioned above, a history of motion sickness is not uncommon. For most sufferers of migraines, mild over-the-counter analgesics do absolutely nothing; stronger medications are often needed. As with other forms of migraines, attacks can be precipitated by a variety of things, including stress, smells, bright light, loud noise, caffeine (coffee, tea, cola, chocolate), certain spices and seasonings, certain foods, unusual diets, and hormonal therapy. (Identifying the precipitating event is an important part of the treatment, as you may imagine.)

Cluster Headaches

Cluster headaches are part of a group of headache disorders called trigeminal autonomic cephalgias, which occur with pain on one side of the head in the trigeminal nerve area, along with symptoms on the same side such as eye watering and redness or drooping eyelids. Cluster headaches are five times more likely to occur in men than women, most commonly in middle age. These are often unilateral headaches (occurring on only one side), described as excruciating, burning, sharp, or a deep ache. They begin and end quickly, lasting only 1 or 2 hours. However, they don't stay away long; on really bad days they can return several times within a 24-hour period (hence the term *cluster*). Eye-related symptoms may include those mentioned above—a droopy eyelid, tearing, and a red eye. The droopy eyelid goes away once the headache has ended.

Other Variations on the Theme

There are a variety of temporary or permanent symptoms and patterns of vision phenomena worth mentioning here that may or may not be associated with a headache.

Typical auras without a headache, formerly known as *acephalagic migraines*, usually have visual symptoms like the auras described above but, by definition, don't come with a migraine headache. These migraine auras occur in adults with a prior history of migraines with an aura. Visual symptoms can include blurred vision, spots of flickering light blocking vision in each eye, and transient visual field loss or constriction. Other symptoms may include numbness or tingling, difficulty with speech or reading, dizziness, confusion, and trouble hearing. Visual phenomena resulting in permanent visual field loss, headaches *before* the aura, headaches or aura always occurring on the same side, or an atypical aura lasting less than 5 minutes or more than 60 minutes should raise suspicion of another underlying process and provoke further evaluation, including brain imaging.

In the first edition of *The Eye Book*, we discussed a transient monocular vision loss as an ocular (retinal or ophthalmic) migraine. The new thinking is that these are not migraines at all but rather the result of a spasm of a retinal artery in the eye. The spasm causes a painless but profound vision loss in one eye, generally in people under age 40. The vision loss usually goes away in less than half an hour. The vision returns to normal between attacks, and the prognosis is usually good. The diagnosis of vision loss from spasm of a retinal artery is a diagnosis of exclusion, meaning that other conditions must be considered before you can make this diagnosis, conditions such as potential sources of retinal emboli, as well as blood hypercoagulation and hyperviscosity. Permanent vision loss, by definition, is not seen with transient vasospasm of a retinal blood vessel and is more likely due to ischemic optic neuropathy (see chapter 17), central and branch retinal artery occlusions, central retinal vein occlusion, and central serous retinopathy.

Pain in and around the eye can be caused by many ocular conditions, such as dry eye, acute angle closure glaucoma (not to be confused with the more common variety of glaucoma called open-angle glaucoma), scleritis, and eye and orbital infections. Systemic conditions causing eye and facial discomfort must be considered when an obvious ocular cause cannot be identified. These include sinusitis, trigeminal neuralgia ("tic douloureux"), temporomandibular disease, and shingles (herpes zoster). If you are experiencing eye, orbital, or facial discomfort without an obvious reason, don't stop looking for an answer and don't be afraid to consult specialists other than your eye doctor. A new perspective on your problem may be just what you need.

Giant Cell Arteritis

In people over 65, giant cell arteritis or temporal arteritis can cause headaches, tenderness in the temples and scalp, and other more generalized symptoms such as fever, weight loss, fatigue, and muscle pain and stiffness, particularly in the shoulders and hips. See chapter 18 for a full description of this medical emergency.

Brain Tumors and Headaches

How do we know it's a brain tumor? We don't, at first. Although headaches occur often in people with brain tumors—and for many, headaches are the first symptom of a problem—there is no "classic brain-tumor headache." In fact, in many cases the pain isn't even on the same side of the head as the tumor.

These chronic headaches characteristically are typically constant, not in one spot, and worse in the morning; they tend to get worse with exercise or positional changes like bending or moving the head, and they don't respond to headache medications. They may be associated with nausea and vomiting, as well as visual changes—which, again, makes them tough to distinguish from certain forms of migraine. Some people with brain tumors can be awakened from sleep by their headaches.

Again, we make the "diagnosis of exclusion," which involves a complete medical and eye examination, often including brain imaging. (For more on brain tumors and other visual problems, see below.)

Strokes

Here's what happens in a stroke: Blood, which normally courses through an artery, suddenly can't get where it needs to go. It's blocked by a clog in the artery. Suddenly the tissue on the *other* side of the obstruction—which needs the oxygen and nutrients in blood to stay alive—begins to die; it becomes ischemic, or oxygen starved. If the clog opens in time, the tissue survives. If not, it dies.

We've already discussed strokes inside the retina (see "When the Eye's Blood Supply Is Blocked" in chapter 16). These blockages of blood flow can also occur outside the eye, at sites along the visual pathways including the optic nerves, the *chiasm* (the meeting place in the brain at which the nerve fibers from each eye come together), and the cerebral cortex. Also, strokes can occur deeper in the brain; of these, the ones most commonly affecting eyesight occur in the parietal, temporal, and occipital lobes.

All strokes are not equal: the location of a blockage is crucial in determining the extent of the damage. A shutoff of blood supply to the retina or optic nerve—such as amaurosis fugax or ischemic optic neuropathy (see below), or a tumor along the optic nerve up to the chiasm—usually results in partial or total loss of sight in one eye. Like two roads that intersect, optic nerve fibers meet at the chiasm before continuing on their journey toward the occipital lobe (see figure 1.8). An injury or stroke here at the chiasm or even deeper in the brain damages visual fibers of *both* eyes—and may result in partial loss of vision in both eyes, also called *bilateral vision loss*.

A blockage or stroke in the parietal or temporal lobe can also result in partial loss of vision in both eyes. To make matters worse, the blow to eyesight usually isn't the only damage. Most strokes here also cause specific neurologic problems, depending on the area of the brain that's damaged. (In fact, the particular symptoms help doctors and other health care providers pinpoint the exact location of the stroke.)

A parietal lobe stroke usually produces a similar pattern of visual field or peripheral vision loss in each eye, concentrated in the lower half of the field of vision. Also, the degree of loss usually varies; one eye may have more damage than the other. After a parietal lobe stroke, someone may also have difficulty with visual perception and spatial orientation—becoming disoriented in a familiar place, for example, or having trouble reaching for a glass of water.

An occipital lobe stroke usually causes a person to lose one-quarter or one-half of their field of vision in each eye, or to lose sight in the central visual field. Unlike parietal and temporal lobe strokes, this particular loss is often highly symmetrical—the damage in one eye is a carbon copy of that in the other. (This is because in the occipital lobe both eyes' nerve fibers exist almost side by side and may be equally affected by ischemia.) A temporal lobe stroke can cause partial vision loss too. As with all strokes, the damage caused by those that affect eyesight may improve somewhat with time. Usually, however, at least some of the damage is permanent.

Tumors

Tumors can also harm eyesight. These, like strokes, may occur anywhere, from the optic nerve in the front to the occipital cortex at the back of the brain. Here, too, the specific visual and neurologic problems can help pinpoint the area of damage.

Among the most common and significant of the tumors that affect eyesight are *pituitary tumors*. The pituitary gland is located below the optic chiasm, the place where the two sets of optic nerves come together in the brain. Think of the optic chiasm as a crossroads: The nerve fibers from one part of each eye's retina (the temporal portion) pass straight through, on their way to the brain's occipital lobe. The fibers from another part of the retina, the nasal portion (the fibers that transmit images from our peripheral vision), cross here.

If a pituitary tumor grows large enough to press on the chiasm, it can disrupt these crossed fibers and cause someone to lose vision, typically side vision. If your eye doctor suspects that you might have a pituitary tumor, you'll probably need visual field testing (see chapter 4), an evaluation of your hormones levels, and a brain imaging of the pituitary by an MRI scan. The good news here is that there are several good treatments for pituitary tumors depending on the type of tumor and its size, including medication, radiation, and surgery. Following treatment, many people are able to return to normal activity—including driving and playing sports—and many have a near-complete restoration of their vision.

Collagen Vascular Diseases (Arthritis and Its Relatives)

The broad term *collagen vascular diseases* encompasses many disorders, all linked because they cause inflammation and scarring of connective tissue (the cells and fibers that make up the body's framework and system of support—things like cartilage, bone, and elastic tissue). In many of these disorders the body appears to attack itself. This *autoimmune* reaction usually occurs throughout the body, and it frequently involves the eye—which is why regular eye examinations and prompt attention to any eye problems are essential. The most common of these diseases and their consequences in the eye are summarized in table 19.2 (these symptoms are covered separately elsewhere in this book).

Thyroid Disease

The thyroid gland sits in the neck, over the trachea, just below the larynx, or "Adam's apple." It has two halves, one on each side of

Table 19.2 Common Collagen Vascular Diseases and Their Symptoms

Disease	Symptoms
Rheumatoid arthritis	Dry eyes, episcleritis, scleritis, or an unusual thinning or "melting" of the cornea and/or sclera
Sjögren syndrome	Dry eyes, uveitis, optic neuritis, inflammation of the retinal blood vessels
Behçet disease	Uveitis, inflammation of the retinal blood vessels and choroid
Reiter syndrome	Conjunctivitis, iritis
Psoriatic arthritis	Iritis
Scleroderma	Dry eyes, inflammation of the retinal blood vessels, iritis, cataract
Ankylosing spondylitis	Uveitis
Sarcoidosis	Uveitis, swelling of the lacrimal gland, and localized conjunctival swelling; optic nerve involvement

the trachea, connected by a thin isthmus of tissue. (Most people can't feel their thyroid. But as a diseased thyroid gets bigger, it can become easier to feel, especially when you swallow. A massively enlarged thyroid, also known as a *goiter*, is hard to miss.)

The thyroid gland secretes thyroid hormone, which is crucial for metabolism and body regulation. Its intricate effects on the body are too numerous to describe here, but the thyroid keeps us at an even keel. Basically, producing too much thyroid hormone (a condition called *hyperthyroidism*) makes someone anxious and overactive; producing too little (*hypothyroidism*) makes someone tired and lethargic. An increase in thyroid hormone causing hyperthyroidism can occur in several ways, including Graves disease, abnormal thyroid tissue growth, or even pituitary tumors. Approximately one-third of patients with Graves hyperthyroidism have clinically recognizable thyroid eye disease when they are initially diagnosed with hyperthyroidism.

How does the eye become involved? Well, Graves hyperthyroidism, as in collagen vascular diseases, is believed to be an autoimmune disorder. In autoimmune disorders, as the name implies, the body turns on itself; it creates *antibodies* (cells designed to fight off infection and disease) that act against normal tissue. In Graves disease, the body's confused immune system attempts to protect or immunize itself against normal thyroid tissue. The consequences of this "mistaken identity" can be serious, for as the body fights its own thyroid gland, it also attacks other tissues—perhaps mistaking them for thyroid tissue as well. Some of these chemical weapons specifically target the eye. This leads to an inflammatory reaction in the connective tissue of the eye's muscles, fat, and soft tissues. The result: fibrous scarring and fluid swelling.

There are many medical names for what's happening in the eye, including Graves ophthalmopathy or Graves eye disease (after one of the early investigators of this condition), infiltrative ophthalmopathy, endocrine ophthalmopathy, and thyroid eye disease. There are also many symptoms, including bulging eyes (called *proptosis*); edema, or swelling, of the eyelids; retraction of the eyelids; swelling of the conjunctiva; drying and ulceration of the cornea; problems with double vision; and optic nerve damage.

Thyroid eye disease affects more women than men, and it usually strikes people in their thirties and forties. A family history of hyperthyroidism is not uncommon. Stress and smoking have been linked to an increased chance of developing thyroid eye disease.

Thyroid eye disease is very unpredictable in its onset, progression, severity, and duration. Often it moves slowly, with remissions and advances lasting from months to years. But sometimes it's fast and relentless. Treatment is directed at returning thyroid function to normal. One of the most frustrating aspects of thyroid eye disease—and a difficult feature for doctors and other health care providers as well as patients to understand—is that *regulating the thyroid gland itself can sometimes have little or no effect on the course of* *the eye disease*. And, if you have any kind of thyroid irregularity, your eyes may still be at risk. In fact, the eyes can become affected even decades after the thyroid disease has been under control. Thus, if you have thyroid disease, regular eye examinations are crucial. Thyroid eye disease can occur even in people with normal or low levels of thyroid hormone. When this disease occurs in people with normal thyroid function, it is called *euthyroid Graves*.

Treatment of Thyroid Eye Disease

In the early stages of thyroid eye disease, lubrication with tear substitutes (drops and ointments), along with increased humidity (see chapter 14), can be very helpful in easing symptoms. More lubrication may be needed if the eyes begin to bulge. Taping the eyelids shut at night may help keep the eyes from drying out during sleep; in some cases, special goggles can help keep the eyes moist. If the eyelid's ability to close is poor, then tarsorrhaphy, a surgical technique that partially closes the eye, may also help. In advanced cases, oral steroids, radiation, and surgery for decompression and lid positioning may help.

Acne Rosacea

Acne rosacea—a skin condition in adults similar to the acne most of us suffered as teenagers—mainly targets the forehead, nose, cheeks, and chin. But the eyelids have skin too, and they're not immune from this annoying problem. (Eyelid acne rosacea is often seen in people with facial acne rosacea.) The symptoms here can range from mildly irritating to disabling. Many people with this condition develop a chronic blepharitis with a mild conjunctivitis (see the discussion of conjunctivitis in chapter 13) and recurrent chalazia; if the problem isn't treated, however, it can lead to corneal scarring, ulceration, and new blood vessel growth, which may eventually impair vision.

Rosacea of the eyelids is very difficult to treat, and treatment usually takes months. An oral antibiotic, such as one of the tetracyclines, is the basis of therapy, along with lid “shampoos,” warm compresses, and an antibiotic eye drop or ointment for concurrent blepharitis. (See the discussion of blepharitis in chapter 11.) Even after the condition is under control, you may need to continue this daily regimen for years.

Parkinson Disease

Parkinson disease is characterized by progressive, involuntary tremors, caused by a loss of chemical-producing nerve cells in the brain. People with this disease develop a “wooden” face, with decreased blinking, little eye movement, and the appearance of a fixed stare. Because blinking is one of the eye’s ways of maintaining moisture, a perpetual lack of blinking causes dryness. Tear substitutes (drops and ointments), along with increased humidity, can be very helpful here. Another problem, stemming from the convergence insufficiency often seen in Parkinson disease and the decrease in head and eye movement, is difficulty in using bifocals. Many people with Parkinson disease find it helpful to keep two pairs of eyeglasses, one for distance and the other for near vision, on hand.

Myasthenia Gravis

Myasthenia gravis is a neuromuscular disorder, characterized by intervals of weakness and fatigue. It can occur at any age, and it strikes women twice as often as men. Here, too, as in thyroid eye disease, the body inexplicably turns on itself, attacking certain muscles with antibodies that impair neuromuscular transmission—particularly those in the eye, face, throat, and chest—and interfering with their function. Although myasthenia gravis is usually a systemic condition, ocular signs and symptoms are often present at diagnosis; in fact, the most common sign of myasthenia is unilateral or bilateral droopy eyelid (ptosis). Double vision (*diplopia*) due to eye muscle weakness is also commonly seen in myasthenia gravis, and, as with ptosis, it will wax and wane over the course of the day, becoming especially worse in the evening. Fatigue makes the symptoms worse.

Although the diagnosis of myasthenia gravis is largely based on someone's medical history and the physical exam, we now have a chemical test that can confirm its presence. It's called a *Tensilon test*, and it works by helping to overcome the antibodies' effect on the muscles, allowing them to function normally again. (Longer-acting versions of this drug are also used to treat myasthenia gravis.) Other studies can also be important in helping diagnose myasthenia gravis, such as the sleep test, the ice pack test, acetylcholine receptor antibody serum assays (positive in 90 percent of people with generalized myasthenia gravis and in 50–70 percent of people with ocular myasthenia gravis), and electromyography.

Acquired Immunodeficiency Syndrome

Acquired immunodeficiency syndrome (AIDS) is an infectious disease that besieges the body's immune system, destroying its ability to fight off infection. It targets *T cells*, cellular warriors that attack viruses and bacteria—anything the body perceives as an enemy.

AIDS is caused by an insidious virus called *human immunodeficiency virus* (HIV), and having HIV infection is not the same thing as having AIDS; according to the guidelines of the Centers for Disease Control and Prevention, AIDS is defined as the stage of HIV infection when the T-cell count has dropped very low. Today, HIV infection is managed as a chronic illness thanks to improved combination antiretroviral therapies.

When initially infected with HIV, many people experience a constellation of symptoms referred to as the acute retroviral syndrome—fever, swollen lymph nodes, sore throat, rash, muscle and joint soreness and discomfort, and headaches. Then, nothing. People with HIV may go through a latent period before the signs of AIDS begin to appear.

Most of the HIV-related problems that do affect vision are indirect, the by-product of a compromised immune system that can no longer stave off infections from opportunistic microorganisms (the "bugs" most of us come into contact with, and fight off, every day). Of these, the most serious threat to vision is *cytomegalovirus* (CMV).

In the eye, the most common manifestation of AIDS is the development of cotton wool spots in the retina. The problem here is that retinal blood vessels get inflamed, decreasing the blood flow to the nerve fiber layer and damaging the surrounding tissue. Cotton wool spots usually go away on their own within 4–6 weeks and rarely affect vision.

CMV attacks the retina and is the most common ocular opportunistic infection in adults with advanced AIDS, especially when the number of T cells in the bloodstream plummets. CMV ravages the retina as it spreads like wildfire, destroying tissue and causing bleeding and retinal detachment. Symptoms of CMV include floating spots or "spider webs," flashing lights, blind spots, and blurred vision. If you have any of these symptoms, see your eye doctor immediately. However, CMV infection can occur in the eye without any symptoms—an important reason for all people with HIV to have regular eye examinations.

There are two drugs used to treat CMV: Gancyclovir and Foscarnet. These drugs are administered systemically or intravitreally, initially at high doses and later in a maintenance dose, until immune reconstitution of the body's T cells occurs.

TEARS AND HIV/AIDS

AIDS cannot be transmitted by routine social contact with an infected person. You can't get it from being coughed on, or shaking hands, or using the same computer. As viruses go, HIV's transmission is pretty limited; it can be passed on only by intimate acts: by unprotected sexual intercourse with someone infected with the virus, by contact with infected blood or tissue (via a shared hypodermic syringe, for example, or a transfusion of tainted blood), or by being born to a mother infected with HIV (and even here, the virus isn't passed on to all babies of HIV-infected mothers). Although HIV has been found in the body's secretions—tears, saliva, urine, and bronchial fluids—transmission of HIV from these secretions has not been reported as of this writing.

Having said that, even though tears are not considered a risk factor, your eye doctor will still (as all doctors and other health care providers should) take precautions to keep the examination and all equipment as sterile as possible. It is recommended that tonometers (for intraocular pressure testing) be disinfected and that any reusable diagnostic contact lenses be cleaned with chemical disinfection to kill HIV. Many doctors use disposable contact lenses for diagnostic fitting whenever possible.

Other infections common in AIDS are herpes zoster and ocular toxoplasmosis. AIDS complicates the way we treat all of these infections. Usually a drug does only part of the work in fighting a "bug"; the body's immune system shoulders a large part of the load as well. But in AIDS, because the body's immune system is failing, normal dosages of drugs are inadequate. Even megadoses—as much as five times the normal potency—don't always work. Lingering conjunctivitis is also common. Less common is Kaposi's sarcoma, a noncancerous kind of tumor (which doesn't threaten vision). This purple-red bump may appear anywhere on the body, even on the eyelid or sclera (the "white" of the eye), and can be treated with radiation, lasers, or cryosurgery (a freezing technique). If you have AIDS, it's extremely important—for the sake of your vision—that you have regular eye checkups to catch and treat any eye problems at their earliest signs.

Lyme Disease

The culprit in Lyme disease is a deer tick, a minuscule relation—it's about as big as the point of a pencil—of the big dog ticks you may have found on your pets.

Many deer ticks are infected with *Borrelia burgdorferi*, a form of bacteria. The result is Lyme disease—named for Lyme, Connecticut, where this problem was first discovered, although the ticks are found all along the Atlantic coast, from Maine to Maryland, in the upper Midwest in Wisconsin and Minnesota, and along the West Coast in California and Oregon. It is believed to be the most common vector-borne infection in the United States. It's characterized by distinctive skin lesions, most commonly a round red "bull's-eye" rash at the site of the tick bite. Its effects can be widespread; early symptoms can include malaise, fatigue, fever, headache, stiff neck, myalgia (muscle soreness), migratory arthralgia (joint soreness), and lymph adenopathy (swollen glands). *Note:* Lyme disease is not contagious; you can't get it from someone who has it. You can only get it from being bitten by a tick.

Although Lyme disease can cause ocular inflammation, it's relatively uncommon. It can cause keratitis, anterior uveitis (see chapter 15), vitritis, retinal vasculitis, and swelling of the optic nerve. If not treated, Lyme disease can drag on for months or even years—a terrible thing, when you consider that when caught early Lyme disease is easily treated with antibiotics (such as doxycycline or amoxicillin, usually taken for 3–4 weeks). Similarly, the ocular inflammation can be treated with antibiotic eye drops and ointments, along with other topical and oral medications. More advanced cases may require the administration of intravenous antibiotics.

Shingles

Remember getting chickenpox when you were a kid? That same virus that causes chickenpox, the varicella zoster virus, will live in your body forever once you get infected with it. It is kept in check by a normal immune system, but with illnesses that suppress our immune system such as cancer, or problems that result in us needing immunosuppressive medications such as steroids, and even with normal aging, which lowers the immune system, the virus can decide to rear its ugly head. When this happens, it's called herpes zoster, or shingles, as most people more commonly know it. Generally, this outbreak looks like chickenpox but is on one side of the body, in a location that corresponds to a distribution of nerves called a dermatome. Depending on the nerves that are affected by the virus, shingles can have devastating consequences on the body, including chronic pain, deafness, and even death. Treatment involves prompt institution of antiviral medications.

When the first branch of the trigeminal nerve (V1) is affected in a herpes zoster outbreak, a reddish rash with vesicles that look like small cysts typically appears on one side of the forehead, possibly extending to the eyelid and the tip of the nose. This is termed herpes zoster ophthalmicus (HZO), and in 10–20 percent of people it can affect the eye. If it involves the eye, the viral outbreak can cause conjunctivitis, keratitis, uveitis, and even retinitis, which can all, in severe cases, lead to vision loss. For HZO, initial treatment is the same as above, with prompt institution of antiviral medications. Eye involvement can require a tricky regimen of topical steroids, which needs to be carefully monitored.

Leukemias and Lymphomas

Although leukemias and lymphomas can cause eye problems like bleeding in the retina or growths on the surface of the eye, most of the ocular issues that arise for people with one of these cancers are from the treatments. When patients have bone marrow transplants for these cancers, they are at risk for graft-versus-host disease, where the donated bone marrow or blood stem cells see the patient's body is foreign and they attack the body. This can happen in the skin, mouth, organs, and, of course, the eye. In the eye, acute symptoms include redness, tearing, and discharge on the outside of the eye, which can lead to scarring and dry eyes. The dry eyes that result from cancer chemotherapy treatment can be very severe, so timely diagnosis and the institution of tear substitutes and additional dry eye therapy are of paramount importance. Similar ocular issues can be seen with treatments used for many other cancers too.

Chapter 20

LIVING WELL WITH LOW VISION

With Michelle Bianchi OTR/L, CLVT

When we think now of the advances made for people with low vision since the first edition of *The Eye Book*, we are reminded of the song by Loretta Lynn, "We've Come a Long Way, Baby." Occupational therapy and occupational therapists have reshaped our attitude and approach toward people who are challenged by low vision. We have also witnessed that technology has developed a wide range of new devices, not just for evaluating someone with low vision but for improving their daily lives too.

The good news today is that there are many ways to help so that people with low vision can continue to do things that are important to them. Losing vision does not mean giving up activities, but it may mean learning new ways to do them.

Living well with low vision is quite possible. Although one's perceptual view of the world changes, it is possible to improve your ability to navigate this new reality by using different optical devices, tools, and technology. The key is to understand your visual abilities, optimize your visual skills, and explore what you need in certain situations to find a customized solution for yourself.

What Is Low Vision?

In the most basic sense, low vision means that the simplest, most mundane things you do—reading a text on your phone, making coffee, paying the bill at a restaurant, or navigating a shopping mall—become difficult owing to your vision. It means that because you can't see well, life gets challenging.

The American Academy of Ophthalmology refers to low vision as what results when “vision loss cannot be corrected by medical or surgical treatments or conventional eyeglasses.” But that’s a woefully inadequate and general way of describing something that affects so many people and in so many different ways. Since low vision is such a relative term, individualized to each person and their needs, it is understandable why it is difficult to come up with a “one size fits all” definition.

Typically, we think of low vision as a loss of visual acuity—you can’t make out certain letters on the eye chart. But even people who can see clearer than 20/70 in their better-seeing eye with eyeglasses may be candidates for low vision counseling. These people may face other visual challenges such as difficulty with contrast or color vision (think about how a person with a red-green color vision difficulty needs to learn how to “see” a traffic light). Limited side vision or constricted visual fields caused by tunnel vision as in advanced glaucoma (see chapter 9) or problems due to visual blind spots in age-related macular degeneration (see chapter 10) are other challenges that people with low vision face.

Does Low Vision Mean Legal Blindness?

Breathe easy. Low vision does not mean that you are blind. And although low vision may lead to further deterioration of vision and legal blindness in some people with progressive eye problems, these people are the exception and not the rule.

Legal blindness is a confusing term. In the 1930s, the US government coined this term to describe the criteria for citizens to receive government benefits. Today, it is more commonly used to define a range of vision loss from severe to total blindness. More specifically, the United States Social Security Administration under Title XVI of the Social Security Act considers a visually impaired individual who is eligible for disability as someone whose field of vision is at or below 20 degrees, who wears corrective glasses but who sees 20/200 or less in their best-seeing eye, or who has no eyesight at all. According to the American Optometric Association, these people are legally blind, so they are eligible for disability considerations and certain tax deductions.

Note: Legal blindness is based on the visual acuity or visual field in your best-seeing eye. Some people will improperly state that they are legally blind when their vision is poor in only one eye, with their other eye seeing just fine.

To label someone legally blind often carries with it a negative connotation. As with all people with low vision, those with this level of visual loss can also achieve great degrees of independence with individualized visual rehabilitation focused on their specific visual needs.

Banding Together with Low Vision

It may be some comfort to know that you are not alone. Just ask around and you will find others challenged by changes in their vision. In 2012, over four million Americans aged 40 or older had some degree of vision impairment, with 20/40 or worse vision in their best eye or severely constricted visual field loss. In fact, aging is the single best predictor of who is at risk for developing low vision. Two-thirds of people with low vision are over age 65, and the incidence of low vision increases with each decade of life. Prevalence statistics from the National Eye Institute (NEI) in 2010 revealed that the prevalence rates of low vision in the United States (defined by the NEI in this analysis as a visual acuity of less than 20/40 in the better-seeing eye) gradually increased after age 65 from 1.13% (65–69), 2.08% (70–74), 4.07% (75–79), with a marked increase to 17.26% in people over age 80.

It is important to note that vision loss in the low vision population does not typically occur by itself. Most older adults have at least one chronic health condition they are managing, and the visual changes add insult to injury. Imagine trying to measure your insulin when you cannot read the syringe. Or imagine having a profound stroke and then having difficulty seeing, speaking, and moving. On top of low vision, one may have cardiovascular disease, arthritis, hearing loss, diabetes, or neurodegenerative changes. This highlights the need for all people with low vision to seek out professional assistance, as well as reach out to each other, sharing resources and suggestions. You are not alone.

The Emotional Challenge

A person's low vision journey will often begin with a change in vision, followed by a visit to the eye doctor. Frequently, this visit is followed by a referral to an eye specialist. After seeing one or more specialists, and having different treatments to preserve your vision, it can be quite shocking to learn that your vision loss is not something that can be *fixed*. This realization opens a floodgate of emotions, and it is important to acknowledge your feelings of sadness, anger, and frustration. It is not surprising to learn that loss of vision has a profound effect not just on the person diagnosed with low vision but on family members and the community too. Next to cancer, older people especially fear the loss of vision, even more than they worry about losing their memory or hearing. Many people also associate low vision with being blind, and in today's high-tech and visual world, people can come to feel that they are left out and marginalized as being "blind."

As with any loss, as mentioned above, the person with vision loss can be expected to express normal emotions such as denial and disbelief, anger, frustration, depression, and fear. The person with vision loss may also experience a loss of mobility, leading to less independence, which may make them withdraw from social activities and become isolated. Having to give up one's driver's license could be a huge setback, even though this can be supplanted with mobility services, cabs, ride-booking services like Uber and Lyft, or rides from a friend or family member. But these transportation alternatives signal a culture change that requires adaptation. And when financial and other personal matters must be handled by others, the resulting loss of autonomy and privacy can be devastating to people who are used to doing these things for themselves. Therefore, low vision rehabilitation (discussed later in this chapter) offers an opportunity to simplify financial transactions through services such as automatic bill pay and assistance in reviewing bank statements until they can learn to access the information with adaptations to their low vision.

An overall loss of independence is often a catalyst for reduced self-esteem, productivity, and motivation. Although the period for passing through the emotions of loss varies in length, almost everyone eventually moves from saying "I won't" through believing "I can't" to learning "I can." A successful adjustment and rehabilitation of the person experiencing new sight loss will involve family, friends, and significant others. The key to coping with this vision loss is to assist the person with this loss in identifying the most important issues that they need to address and then help them to meet an initial goal. Once someone begins the process of achieving their goals, they start to feel better and learn to adapt. When this happens, the person can begin seeking solutions to life's new challenges. During this critical period, family and friends need to be encouraging and find ways to help the person become more independent.

Building a Rehabilitation Plan for a Low Vision Patient

As with any medical examination, a careful history assessment is important, not just for an understanding of your difficulties due to low vision but also to help establish treatment goals. Before we can help you, you need to help us understand what you used to be able to see, how this has changed, and how fast it has changed. For example, some people report that they can no longer see people's faces, use their mobile phone, read a newspaper, cook on their stove, control their thermostat, read their mail, use their computer, or pay for things in the store or restaurant.

Occupational therapy is the medical field that takes a holistic approach to the low vision patient, using evidence-based science to coordinate a therapy team. Specifically, occupational therapists strive to help people with low vision of all ages to live life to its fullest by assisting them in promoting their health and preventing or living better with injury, illness, or disability.

The occupational therapy process begins with an evaluation. The purpose is to collaborate with you to develop a plan that will make your life better in spite of these visual changes. Your occupational therapist will complete an occupational profile, which may include the following:

1. the reason you are seeking low vision rehabilitation and any concerns about your vision;
2. your personal interests and values;
3. your work history;
4. your routines and habits;
5. any physical limitations you may have, such as shoulder injury, arthritis, etc.;
6. what social support you have from family and friends;
7. any relevant cultural or religious values that may affect your care;
8. your personal history such as age, marital status, education, and financial situation;

9. the time of year and how this may affect your rehabilitation plan;
10. virtual barriers such as difficulty using email or technology such as a mobile phone, reading tablet, or computer.

Be sure to be specific about which areas you are having difficulty with. Is it easy for you to read, but you have problems when driving? Discuss a plan that focuses on realistic priorities and your desired target outcomes with your low vision rehabilitation specialist.

Note: Visually impaired people can report seeing images of objects that are not real. These images can look like wallpaper or barbed wire and can even resemble people or landscapes. Although this form of hallucination may cause people with low vision a lot of anxiety and concerns about their mental health, it actually occurs in up to one-third of visually impaired people and is referred to as *Charles Bonnet syndrome*. This is a diagnosis of exclusion, which can be made when visually impaired people have vivid, recurrent hallucinations, which they understand as hallucinations and which cannot be explained by another neurologic or psychiatric disorder. Reassurance often helps affected individuals cope with these images.

Examining the Low Vision Patient

After the history assessment and establishment of needs, the next step in building a rehabilitation plan for the low vision patient is an eye examination and an analysis of occupational performance. There will be testing of functional vision to better understand the impact visual changes have had on a person's abilities and environment. Also, occupational performance assessments may be used to look at areas of occupation, performance skills, and patterns.

Low vision eye examinations, like all eye examinations, begin with checking your visual acuity using an eye chart. Standard eye charts may be too difficult for low vision patients to see, so alternative eye charts and different viewing distances are used to assess visual acuity. Typically, a person with low vision will be under the impression that all they need to see better is a "stronger" pair of eyeglasses, when in reality only 10 percent of people with low vision will see any benefit from a change in their eyeglass prescription. Still, a careful refraction should be attempted on all low vision patients, paying attention to a person's fixation, which may be off-center in the retina owing to a retinal scar or scotoma, as well as using different refraction techniques to find the best pair of glasses for patients. Contrast sensitivity, the ability to discern contrast, should also be checked in all low vision patients. Tests can be done on paper or on a computer, and patients found to have poor contrast sensitivity can benefit from electronic enhancement and magnification. Additionally, a person with low vision can benefit from increasing contrast in tasks such as using a black felt marker on white paper with task lighting or eating white or lightly colored food (like white mashed potatoes) off of a black plate or bowl. Assessment of a low vision patient's central and peripheral visual field can be very revealing if there are central scotomas or constricted visual fields. Glare testing, color vision, binocularity, eye dominance, eye movements, and accommodations should all be considered as your low vision rehabilitation plan is being written. Lastly, a low vision rehabilitation evaluation should consist of a visual assessment of your ability to perform visual tasks that you report as difficult for you. Watching people with low vision read, use a mobile phone or computer, write, or even walk can provide insight into what is needed as part of an individualized low vision rehabilitation plan.

The Low Vision Rehabilitation Toolbox

There is life beyond normal reading glasses. Perhaps the biggest changes in the field of low vision since the first edition of *The Eye Book* have been in the development of new devices as part of the low vision rehabilitation toolbox. If your vision is reduced to a level where regular print is difficult to read with normal reading glasses, there are several "low vision devices" that can help make books, magazines, newspapers, and mail easier to read. They're worth considering, and they really can help.

Devices That May Help

We are living at a time when technology, especially mainstream technology, can be easily customized to match your visual abilities. Furthermore, accessibility is built into mobile phones, tablets, computers, household appliances, and office equipment that can be adapted to maximize your visual potential and that can be enhanced for nonvisual adaptations, if needed.

There are five main types of optical devices: handheld magnifiers, high-powered reading glasses (much stronger than ordinary reading glasses), stand magnifiers, telescopes, and electronic magnifiers. Additionally, there are optical character recognition (OCR) devices that can scan and read print and even experimentally can read some handwritten material. These come in the form of dedicated low vision devices, computer accessibility programs, and apps for mobile phones and tablets. These OCR devices can display information visually in your preferred presentation and/or auditorily. Some of the newest products that are currently on the market are head-worn or wearable devices such as OrCam, IrisVision, NuEyes, Jordy, and eSight. In the future there are likely to be even more helpful devices available, as scientists and engineers collaborate to design and produce rehabilitative devices.

Handheld magnifiers come in a variety of shapes and sizes. One advantage here is that whatever you're reading—a book, a newspaper, or a magazine—can be held at the normal reading distance. You can buy low-power magnifiers, which magnify by about one time (1×) to three times (3×), at most drugstores. Higher-powered models are prescribed at specialized low vision centers. For help finding a low vision center in your area, see "For More Help" at the end of this chapter—or ask your eye doctor. It is important to note that illumination in low vision can often be just as important as magnification. Hence, while power is important, built-in lighting or task lighting can be essential as well.

High-powered reading glasses are stronger than your normal reading prescription and are available in the form of prismatic lenses or microscopes. One drawback is that because the prescription is so strong, the print must be held very close (or else it looks distorted). For some, this working distance may be uncomfortable, but since you don't have to hold these high-powered reading glasses, your hands are free to hold the printed page. An adjustable direct-source light, beamed on whatever you're reading, may also help. LED lighting can customize the color and intensity of the light. Additionally, there are powerful illuminated typoscopes such as Jasper Ridge's Frolik (with white or green LEDs) that can clip onto a baseball cap or a pair of eyeglasses to optimally illuminate the reading material.

Stand magnifiers rest directly on the printed page. They provide a comfortable working distance but a somewhat limited field of view (you can't scan an entire magazine page at once, for example). These magnifiers come as both illuminated and nonilluminated models. Typically illuminated models are preferred, but it is important to note that the batteries fade over time. If an illuminated magnifier is not as bright as needed, the batteries may need to be replaced. Other people can benefit from a clear stand magnifier with a separate lighting source, which permits more control of the angle and concentration of light on what is being viewed.

SOCIAL TIPS FOR DEALING WITH PEOPLE WHO ARE BLIND OR VISUALLY IMPAIRED

Some people feel awkward when meeting a blind or severely visually impaired person. Suddenly, every conversational gambit becomes a potential foot in the mouth. Our first bit of advice? Relax. Don't worry if you mention the ballgame you watched last night, or the movie you just saw. Talking about everyday things isn't going to make you seem insensitive. Just be yourself.

Having said that, however, there are certainly some things you can do to make things easier for both of you:

- When you start up a conversation, even if you've met before, introduce yourself by name. It can be hard to recognize voices, especially in a crowd.
- Make eye contact, just as you would when talking to a sighted person. It's obvious, from the way your voice sounds, when you're looking around the room instead of at the person you're talking to.
- For heaven's sake, don't speak louder than normal unless you have confirmed they have a hearing deficit. This happens more often than you might think; some people have a tendency to shout at blind people, as if a certain decibel level were all that's needed to penetrate the vision problem.
- Because your hand gestures won't be seen, be more descriptive in your conversation; take time to draw a verbal picture.
- If you're ending a conversation, say something to that effect.
- Always announce yourself when you are entering or leaving a room. Your acquaintance won't be able to see you come in or walk away.
- When walking with a visually impaired person, offer your arm for assistance as a "human guide." When you're

(*cont.*)

approaching a chair to help the person sit down, describe the type of chair and gently take their hand to touch the seat, arms, and back of the chair for orientation. At a meal, describe the table and the location of the plate, glass, and utensils. Some people appreciate it if someone tells them where the food is located on the plate as it relates to a clock face (for example, “The chicken is at six o’clock”).

- Just rearranged your living room? Speak up; your visually challenged friend will need to make a new mental picture of the room they will be navigating.
- Finally, be honest. If you feel awkward in a new situation and are not sure how to act or be of help—a crowded train or street corner, for instance—just say so. Chances are, you’ll both be glad you did.

Telescopes can help you see objects farther away. For many people, telescopes are invaluable for seeing bus numbers, street signs, chalkboards, a computer screen, or a baseball game. These can be handheld or can be clipped on or permanently attached to eyeglasses. There are even newer visual enhancement lenses called *bioptics* or *bioptic telescopes* that have an electronic focusing mechanism for variable distances. The nice thing about bioptics is that for some of these telescopes you can switch in a hands-free way from viewing through the carrier lens and the magnifying bioptic lens. In thirty states it’s even legal to drive while wearing these bioptic telescopes mounted to glasses. Requirements vary: in Maryland, for instance, people with mild visual impairment (20/100 or better) may be eligible; they must also have a visual field of 150 degrees horizontally, if they have functioning vision in two eyes, or of 100 degrees if they can see out of only one eye. (Check with the Motor Vehicle Administration in your state for the specific requirements.) It may take some training and time to master driving with bioptics, but many people find the continued independence well worth the effort. It is important to note that a bioptic lens creates a constricted field, so people who use it while driving look in it only briefly to occasionally spot details, rather than using it the whole time.

Electronic magnifiers: Closed-circuit television has been adapted for use by people with low vision. This system scans reading material and projects an enlarged image onto a television screen, allowing for enhanced magnification, brightness, and contrast. These systems can be costly to buy but come in different sizes and with different functions. There are both basic models and more advanced versions that include OCR and "diamond edge" viewing. If OCR is used, even if not using it to read out loud, it can reassign the letters to a patient's preferred font, size, contrast/color, and even view. Lines of text can be presented strategically. They can be scrolled in the center of the screen, presented in a "page view," or even presented one word at a time in the center of the screen. OCR is a computer's brain, so if a letter is smudged, it reports what it sees, not the letter one could infer. Additionally, people can utilize their camera on their mobile phone or tablet to magnify information. Special apps for these devices can also scan, print, and read it to people. These devices have proven invaluable for some of our patients, allowing them to adjust brightness, contrast, and size and to invert text. There are even specialized stands available to hold the phone or tablet, making it easier to position the device and to accommodate physical challenges.

More Tools in the Low Vision Rehabilitation Toolbox

Other Visual Aids

There is a separate compartment in our low vision toolbox containing tools that are not like the optical devices mentioned above, but rather time-tested and practical tools and items that can help you see. These visual aids include large-format watches, specialized telephones, adaptive remote controls, large-print playing cards, and even low vision checks or check templates. Other aids and items that can be helpful are talking watches, clocks, scales, and timers; needle threaders; bold-lined paper; templates for writing; adaptive pens; and dark black markers for writing on a white sheet of paper. People with intact sensory input in the fingers and motivation can learn *braille*, a form of written language for the blind and visually impaired based on the pattern recognition of characters represented as raised dots. For people who know braille, there are braille playing cards, dice, and watches, as well as a wide variety of other aides.

Blind Rehabilitation and Sight Substitution

When a person has either no vision or extremely limited vision, blind rehabilitation with sight substitution is needed. Some of the previously mentioned devices can be adapted and used by these people. Electronic text-to-speech readers and knowledge of braille are very helpful at this stage of vision loss. Currently a lot of work is being done in the area of prosthetic retinal implants. Although the "vision" generated by these implants is extremely primitive at this time, they still offer hope that one day the dream of regaining sight will become a reality for many people with extremely low vision or blindness.

Occupational Therapy and Low Vision Training

There's no "perfect" low vision device that can restore the vision you had before, but there are many options. The art of selecting the best devices, aids, and recommendations for you involves taking the time to understand the functional vision you have and how to optimize visual function in the situations that mean the most to you. Identifying the best choice for you requires considering your visual and physical abilities, as well as your preferences. A mobile phone app may make perfect sense to someone who is in high school and doesn't want to be different, as well as to a grandparent who now is using the same type of smartphone as their granddaughter. However, someone else who has never had a mobile phone may prefer a simple specific device or workstation to accomplish a similar result. To this end, low vision centers—and there are many of them throughout the country—can be invaluable. They can also help you learn other "tricks of the trade" to help make everyday activities—such as self-care, cooking, identifying money, financial management, and writing—more doable and less frustrating.

Most of these centers are staffed by an interdisciplinary team that might include an ophthalmologist, optometrist, optician, occupational therapist, low vision therapist, orientation and mobility specialist, technology specialist, and experts in rehabilitation who can show you how to perform your daily tasks and use the low vision devices and aids prescribed by your team. For example, a low vision occupational therapist may make a home visit to address your specific goals. Also, they can perform a home safety assessment to help adapt your home to both visual and physical challenges, help you to adapt your appliances, develop a medication management system, and incorporate low vision and adaptive visual devices where you will be using them. This visit may also result in helpful recommendations for eliminating glare, improving lighting, adapting to changes in light when you get up in the middle of the night, smart home technology, and generally making life easier.

The American Occupational Therapy Association offers the following guidelines on how an occupational therapist can help people with low vision maintain their independence and lifestyle:

- advise on how to decrease the risk of accidents and injuries in the home;
- instruct people on how best to use their current vision and visual field;

- suggest changes in tasks and in the environment to make life easier and more manageable;
- encourage overall participation in enjoyable activities for recreation and leisure.

Designing a Low Vision Rehabilitation Plan

After taking a complete history and doing a thorough examination of the low vision patient, low vision specialists face the challenge of specifically tailoring a rehabilitation plan for the individual person. This is why low vision rehabilitation plans should be designed and implemented by specially trained low vision professionals, like occupational therapists. Medicare and other health insurers in the United States cover low vision services performed by an occupational therapist, in the same way that rehabilitation services are covered for orthopedic and neurologic conditions. Therapists are skilled at setting up a plan of care for each individual, mapping out the specific treatment procedures, and setting up definable goals using functional outcome measures in the context of their life and other comorbidities. Often the low vision rehabilitation treatment plan will include visual skills training and exercises, both at the clinic and at a person's home. As mentioned above, a home visit will also determine whether it is necessary to make modifications to the home environment to maximize safety and foster an independent lifestyle.

The Need for Ongoing Eye Care

People with low vision often feel lost and alone when they initially realize the extent of their vision loss and potential loss of independence. We then often get the question, "Well, why do I even need to come back to see you if you can't do anything for me?" But this is far from the reality since we encourage all people with low vision to regularly see their eye doctors. Although we as eye doctors may no longer be able to improve your vision, we want to help you keep the sight you have for as long as possible and to watch for elevated eye pressures (glaucoma) or even progressive field loss or retinal changes, which might be arrested by eye drops, injections, or surgery. We will continue to evaluate and medically treat you for other eye problems that can still arise and cause you additional difficulty, discomfort, or disfigurement such as eye infections, corneal abrasions, eye swelling, and even cosmetic changes to the eye and surrounding eye tissues. As your eye doctor, it is our responsibility to stay attuned to any new developments that might be beneficial for restoring your sight in the future and also always be available to you and your family for questions and concerns. We realize more than most sighted people what you are facing, and our care of you and for your well-being goes far beyond our exam room and extends into your life.

Some Handy Tips to Get You Started

There's no big secret as to what the problem is: you can't see very well. Now, let's start working on the solution: how you can maximize the vision you have and make your home a better fit for your functional vision. Here are some tips, based on the experiences of many people who are in the same boat, that may help. Remember: utilizing high contrast and illumination can enhance vision.

In the Kitchen

- Increase contrast, enhance lighting, and provide tactile cues. Make sure you have *task lighting*, lighting focused on a specific area to make a visual task easier, such as a special lamp or under-cabinet lighting. Use bump dots or contrasting-color puff paint to adapt the dials of your oven, washing machine, and thermostat. As the saying goes, "Remember, if you mark everything, you have marked nothing." Additionally, an occupational therapist can perform task analysis and help you design a solution that works for you. This includes both visually challenging tasks and tasks that are physically or cognitively challenging. Newly emerging smart home technology that can assist people with low vision includes appliances that can be controlled by voice or from a mobile phone. For example, products such as the Nest thermostat visually reverse contrast, making them both easier to see and easier to control.

- During mealtimes, use a white plate on a black placemat, or vice versa, and keep your needed utensils on the "parking space" of your placemat. It is also helpful to add task lighting directed at your plate; just be conscientious that there isn't a cord that presents as a fall hazard. Alternatively, a clear plate can be used on top of an ultra-thin portable LED light box (a relatively inexpensive online purchase), which enables you to see your food more clearly. For eating neatly, you can use small bowls, sectioned plates, or specialized adaptive feeding equipment with backstops and strategies for cutting. For example, one strategy could be to ask in a restaurant to have your steak precut, if that is a challenge. Another option is to cut your own meat using a nonvisual strategy. First, touch the "island of meat" with both of the utensils to orient to the size. Begin by cutting off one small piece at a time from the edge that you feed yourself with the fork, while keeping the knife in contact with the meat.
- For pouring coffee, a lot of people use single-serve coffee makers like Keurig that are designed to make coffee in specific

sizes that will fit their cup. Visually, you can pour dark coffee into a white cup. Likewise, you can pour white milk into a cup with a dark interior. If it is hot liquid, there are liquid level indicators, or you can use the New Orleans custom of a floating dollop of whipped cream, which can be seen rising in your coffee.

- When pouring yourself a cool drink, line up the spout of the pitcher so that it makes contact with the rim of the cup or glass. Then, so you don't spill, place an index finger just inside the rim. Stop pouring when you feel the liquid. Another option would be to use a ping-pong float and see it rising.
- It's easier to feel the skin of the vegetables you're about to peel when they're wet. Also, use task lighting in the form of a lamp or built-in under-cabinet lighting, as well as a contrasting-color cutting board. For example, cut onions on a dark wood or black cutting board.
- Force yourself to keep your cabinets and pantry organized. It's infinitely easier to find items that are always kept in the same place. Use bins and organizing compartments to keep everything in its place, and if others are in your environment or put things away for you, it is helpful to label where things go even if you cannot read the label.
- Label your spices with a thick permanent marker, using a label maker, or using an auditory labeling system such as the PenFriend 2 Voice Labeling System. Use an easy abbreviation, such as "cin" for cinnamon, in letters and in a size that you can see. Also, if you prefer a larger size than what can fit on the bottle, you could use an index card. Punch a hole in the card and run a rubber band through it, and then attach it to the cinnamon bottle. Another way to make spices easier to tell apart is to put different spices in different-sized containers.

Lighting

- Too much glare from the windows? Try diffusing the light with sheer curtains, window film, tinting, or other window treatments, including remote-controlled or voice-controlled blinds to diffuse the light. Additionally, you could put on indoor glare filters to help you cope with the glare. These are typically prescribed from your low vision evaluation and tried in your home or in a simulated environment.
- Too dark? Look to improve your lighting, especially task lighting. There are lights that can adapt color and intensity. You want the light to be directed at the area you will need for the activity.
- Need more light? Keep several LED flashlights around the house to help when the room lighting is just not enough.

Miscellaneous Tips

- Why make doing business harder with regular bank checks? Low vision checks are available through your bank or through check companies like Deluxe. They're typically business-sized checks that are yellow and black, with raised lines that act as guides. Additionally, you can get templates for your regular or low vision checks.
- Throw out your pencils and regular pens. Instead, use darker liquid gel or bold black markers to jot down phone numbers or make your grocery list. Write in optimal size on bold lined paper or using special writing templates or guides. There are envelopes, writing pages with different spacing and sizing, and signature templates available online.

- There are agencies, such as Maryland Relay, that can provide a free phone that can accommodate for vision and/or hearing deficits.
- Walk with care. Place a nonskid, brightly colored strip of tape on the edge of each step to help you negotiate stairs. Consider adding motion detection lighting there as well. Grab bars and rails are also physically helpful, but additionally they can orient you to where you are in space, particularly when selected in a contrasting color.
- Take advantage of free services. Every state has at least one library for the blind and print disabled that provides audio books with an MP3 player, BARD audio books, large-print books, and magazines in digital format—*all for free*. BARD, the Braille and Audio Reading Download, offers thousands of specially formatted books, magazines, and sheet music that can be downloaded over the internet from the National Library Service for the Blind and Print Disabled (NLS; see below).

For More Help

For starters, consider trying one of these agencies, or ask your eye doctor to recommend helpful resources in your area:

Audio Books and Magazines (by mail or by downloading to a device)

- National Library Service for the Blind and Print Disabled (NLS), 800-424-8567 (books and player provided free)
- In Canada: Contact your local library or CELA (Centre for Equitable Library Access), 855-655-2273

- Bookshare accessible online library: $50 annually; free for students. Bookshare.org audio books can be read on your computer, or on specific audio devices, tablets, or smartphones with a variety of apps
- Choice Magazine Listening (quarterly issues of recorded magazine selections, unabridged), 888-724-6423

Large-Print Materials and Visual Devices

- LS&S, 800-468-4789
- MaxiAids, 800-522-6294
- Independent Living Aids, 800-537-2118
- New York Times Large Print Weekly, 800-631-2580
- American Printing House for the Blind, 800-223-1839

Technologies: Computers, Mobile Phones, Video Magnifiers

- Search “voice-to-text software”
- Apple and Mac devices
  – Apple accessibility information, 877-204-3930
  – AppleVis user community
- Microsoft accessibility tutorials, 800-936-5900
- Search online for a list of accessible mobile phones for the visually impaired
- Computers for the Blind, 214-340-6328
- ZoomText magnification computer software
- Video magnifiers offered by the American Foundation for the Blind and other organizations and retailers

National Organizations for Support, Information, Research Updates

- AMD Alliance International, +44 20 73 91 2064
- American Diabetes Association
- American Foundation for the Blind, 800-232-5463
- American Macular Degeneration Foundation
- Association for Macular Diseases / Ophthalmic Edge partnership, 888-205-2311
- Centers for Disease Control and Prevention: fall prevention brochure
- Glaucoma Research Foundation, 800-826-6693
- Hadley School for the Blind online courses, 800-323-4238
- Macular Degeneration Foundation, 888-633-3937
- Macular Degeneration Partnership, 888-430-9898
- Macular Degeneration Association, 855-962-2852
- MD Support: support group list and video: Learning to Live with Low Vision, 888-866-6148
- National Eye Health Education Program, English and Spanish
- Vision Aware

Vision Rehabilitation Self-Help Materials

- American Foundation for the Blind consulting services, 212-502-7633
- A Self-Help Guide to Nonvisual Skills (PDF), D. Roberts, 2011

- *Making Life More Livable: Simple Adaptations for Living at Home after Vision Loss*, M. Duffy (NY: American Foundation for the Blind, 2002); 800-232-3044
- *Macular Degeneration: The Complete Guide to Saving and Maximizing Your Sight*, L. Mogk, MD, and M. Mogk, PhD (NY: Ballantine Books, 2003)
- *The First Year—Age-Related Macular Degeneration*, D. Roberts (NY: Da Capo Press, 2006)
- *Overcoming Macular Degeneration: A Guide to Seeing beyond the Clouds*, Y. Solomon, MD, and J. Solomon (NY: BookSurge Publishing, 2009)

Pediatric and Youth Resources

- AFB FamilyConnect
- AERBVI: organization for professionals who work with blind and visually impaired children and adults
- APH: materials for children and teachers
- CVI Scotland: for children with cerebral/cortical visual impairment and their families
- Perkins School for the Blind
- Texas School for the Blind and Visually Impaired

Camps and Organizations

- Space Camp for Interested Visually Impaired Students
- US Association of Blind Athletes—Empowering Americans

Veterans (all veterans can receive services and devices free of charge)

- US Department of Veterans Affairs: 844-698-2311

More Good Resources

American Foundation for the Blind (AFB)
1401 South Clark Street
Suite 730
Arlington, VA 22202
212-502-7600
https://www.afb.org

Association for Macular Diseases
210 East 64th Street
New York, NY 10021
212-605-3719
212-606-3795
association@retinal-research.org
http://macula.org/about-us

Association for Education and Rehabilitation of the Blind and Visually Impaired (AER)
5680 King Centre Drive, Suite 600
Alexandria, VA 22315
703-671-4500
703-671-6391
aer@aerbvi.org

The Foundation Fighting Blindness
6925 Oakland Mills Road, Suite 701
Columbia, MD 21046
800-683-5555

National Association for the Visually Handicapped
22 West 21st Street, Sixth Floor
New York, NY 10010
888-205-5951
212-889-3141
212-727-2931 (fax)
navh@navh.org
www.navh.org

National Center for Vision and Aging
The Lighthouse
250 West 64th Street
New York, NY 10023
800-284-4422

National Federation of the Blind
200 East Wells Street *at Jernigan Place*
Baltimore, MD 21230
410-659-9314
410-685-5653 (fax)
nfb@nfb.org

National Library Service for the Blind and Print Disabled
Library of Congress
1291 Taylor Street NW
Washington, DC 20542
800-424-8567
nls@loc.gov
A source of large-print and braille materials; audio books or publications such as *Reader's Digest* and *Newsweek Magazine*; and educational aids, tools, and supplies.

Chapter 21

COMMON MEDICATIONS THAT AFFECT THE EYES

Very few medications work like a rifle, taking aim at a particular target and hitting it with elegant precision. Instead, most take the shotgun approach—generally hitting the mark, but scattering plenty of buckshot in the process.

This leads to the concept of *side effects*—medicine's unintended impact on various parts of the body, including the eyes. Taking just about any kind of medication usually means a trade-off—weighing the good that the medicine does, particularly for serious illnesses, versus the extra mischief it causes.

For most medications, the side effects are minimal—a little drowsiness, for example, or changes in appetite, or dryness in the mouth. In fact, sometimes a drug's manifestations, particularly those that affect the eye, are so subtle that it takes us days or weeks to figure out the connection (if we ever do). This is why when you seek medical help for such symptoms as blurry vision, distorted vision, double vision, red eyes, dry eyes, or light sensitivity, it's extremely important to discuss your medical history and indicate any medications, including herbal supplements, you're currently taking. If the medicine is indeed to blame—and if it's not possible to switch to an alternative drug to avoid these unwanted effects—then your eye doctor may need to monitor your eyes as long as you're taking that particular drug.

Of the thousands of medications available today, there are a few—many of them prescription drugs—that cause eye problems for many people. These include antibiotics, antidepressants, antihistamines, appetite suppressants, blood pressure medications, daily hormone supplements, and steroids. In the rest of this chapter you'll find a roundup of the most common drugs that affect the eyes and their side effects.

Antibiotics

Antibiotics applied to the eye (used topically) have the potential to cause allergic conjunctivitis, which shows up as red conjunctival infection, tearing, and itching. Occasionally there will be associated orbital redness and swelling of the skin around the eyes due to an allergic dermatitis brought on by the eye drops. Topical neomycin eye preparations cause an allergic reaction in a high percentage of the people who use them.

Systemic (oral, intramuscular, or intravenous) antibiotics used in treating an acute bacterial infection generally produce few side effects in the short term. However, when they're used for weeks or months to treat chronic infections, they can cause eye problems. Fortunately, most of these side effects are rare, and they go away when you stop taking the drug.

Synthetic penicillins (amoxicillin and ampicillin): These drugs are known to cause an allergic reaction in the eyes that shows up as mild redness of the conjunctiva, itching, and dry eyes in some people who take them. They can also cause a drug-induced anemia that can lead to subconjunctival and retinal hemorrhages. These hemorrhages usually are not harmful, do not affect vision, and require no treatment.

Tetracycline: This antibiotic can cause blurred vision from transient myopia, double vision, and pigmentary changes of the sclera, conjunctiva, and eyelids. There is also an association between tetracycline use and idiopathic intracranial hypertension (pseudotumor cerebri)—mild and transient vision loss and swelling of the optic nerve head due to elevated intracranial pressure (papilledema). Idiopathic intracranial hypertension requires immediate treatment.

Sulfonamides: Many people are allergic to "sulfa drugs," and these allergies can manifest themselves in a variety of side effects. In the eyes, these may include blurred vision (secondary to a transient myopia similar to that seen with tetracycline and which resolves with discontinuation of the drug), eye irritation (resulting in watery eyes that are extrasensitive to light), and hemorrhages similar to those caused by penicillin.

Antidepressants

Antidepressants are a group of medications designed to change how information is processed in the nerves, or neurons, in the brain. Some of these drugs are used to treat other problems, such as migraine headaches. *Any medication that alters neurological function has the potential to affect the eye.* (Fortunately, most antidepressants, such as sertraline [Zoloft], have few significant eye-related side effects.) Antidepressant medications include the following:

Tricyclic antidepressants: This is the class of antidepressants (including such drugs as amitriptyline, desipramine, imipramine, and nortriptyline) that causes most of the unwanted side effects in the eye, including blurred vision, loss of accommodation (the ability to focus your eyes), dilated pupils, photosensitivity (trouble with bright lights), and dry eyes. If these side effects are intolerable, there are other medications to try that may be as effective with less severe side effects—or even none.

Selective serotonin reuptake inhibitors: Fluoxetine hydrochloride (Prozac), sertraline (Zoloft), and paroxetine (Paxil) are antidepressants, but not in the tricyclic group. However, because these antidepressants influence neural pathways, they can cause some similar side effects, including blurred vision, dilated pupils, double vision, and dry eyes. They also can cause eye pain, conjunctivitis, and photophobia. This is a "risk-versus-benefit" situation that can be resolved only by having a dialogue with your general medical doctor or other health care provider and making a decision based on your needs.

Antihistamines

Almost everyone has taken antihistamines at one time or another, particularly during hay fever season. The racks at any drugstore, grocery store, or even convenience store have a dazzling array of choices—some with decongestants, some that make you drowsy, some that don't, and some that also fight cold symptoms. One thing they have in common is that most of the antihistamines have a drying effect on the eye, just as they do on a runny nose. And drying, as discussed in chapter 14, often makes vision blurry, lights seem too bright, and contact lenses much less pleasant to wear. If a decongestant—another drying agent—is added to the pill, these symptoms are often made worse. In very rare instances, antihistamines can cause the pupils to dilate or become unequal in size. This can make light sensitivity even worse. For people with "narrow angles" (see chapter 9), dilated pupils can lead to something far more serious: closed-angle glaucoma. Most of these side effects go away when you stop taking these drugs, with the exception of closed-angle glaucoma, which can persist and require treatment.

Appetite Suppressants

Appetite suppressants include amphetamines, dextroamphetamines, methamphetamines, and phenmetrazine compounds. These drugs are marketed under many different names throughout the world. Systemic use of these appetite suppressants can cause such side effects in the eye as impaired vision, pupil dilation, a widening of the palpebral fissure, and decreased accommodation and convergence—making it difficult to read. In people who have narrow anterior chamber angles—many farsighted people, for example, and those with a family history of an acute onset of painful glaucoma—the use of appetite suppressants can lead to closed-angle glaucoma.

Blood Pressure Medications

Imagine a hose with water running through it so fast that it's about to burst. You need the water, but you want to lower the pressure. One way to do this is to adjust the *volume*, so that there's less water running through the hose at all times; or you could adjust the *rate*, so that only a certain amount of water can go through the hose at any given time; you could also use a bigger hose, so that there's more room for the water to flow. That's pretty much the situation with the drugs used to control hypertension, or high blood pressure: they can deplete the fluid volume in the body, regulate the heart rate and pumping volume, or dilate the blood vessels that carry the blood.

However they work, antihypertensive medications can produce some side effects in the eyes. These go away when you stop taking the drugs; however, because these high-powered medications are also lifesaving, you should never stop taking them without talking to your general medical doctor or other health care provider first. Stopping "cold turkey" could cause much more harm than having never started taking them at all.

Diuretics: Diuretics cause the body to excrete excess fluid (which is why many women take them to ease premenstrual and menopausal symptoms). In the blood vessels, less fluid means less pressure. But in the eyes, less fluid means dry eyes, blurred vision, myopia, color vision abnormalities, and retinal edema. These symptoms are reversible when the medication is discontinued. *Note:* Women seem particularly susceptible to dry eyes because of hormonal changes as they get older, and diuretics may make this problem worse.

Regulators: These drugs, typically beta-blockers such as propranolol (Inderal), work via neural pathways—and again, whenever the neural pathways are affected, the eyes are also at risk for side effects. Eyes may feel dry, and the pupils may be dilated (just like the blood vessels); blurry vision and increased light sensitivity can result from either of these. Because neural pathways in the eye also control eye muscles, these drugs can create double vision by interfering with how the eyes work together. If necessary, another medication can be substituted that may have less troublesome side effects.

Hormonal Supplements

Because these hormones can lessen the life-altering symptoms of menopause (night sweats, sleeplessness, hot flashes), estrogen and progesterone are taken (individually or in combination, in a variety of dosages) by some women.

For women on supplemental hormones (also known as hormone replacement therapy), dry eyes are a common and annoying problem; however, changes in the tear quality are to blame for this. Poor tear quality can cause the corneal surface to become pockmarked from dryness, known as *superficial punctate keratitis* (SPK). These changes can lead to eyes that burn or feel dry, gritty, irritated, and tired. If these corneal changes are significant enough, they can make wearing contact lenses an unpleasant chore. SPK also heightens a person's sensitivity to bright light as the dry spots scatter light and cause glare. Artificial tear supplements help to resolve SPK and its symptoms. Other hormone-caused complications—which actually affect the central nervous system, the brain and spinal cord—may seem like eye problems, including headaches, fatigue, dizziness, and difficulty concentrating. Many people wrongly blame these symptoms on eyestrain—from, for instance, a bad prescription for glasses or contact lenses—when they are actually caused by the hormones' effect on the body.

Still other eye-related complications of supplemental hormones may spring from side effects in the vascular system (the heart and blood vessels). One of the most serious of these is thrombosis, or formation of a blood clot. Sometimes a blood clot breaks free, blasts into the bloodstream, and lodges somewhere else (this is called an *embolism*), blocking blood flow in that area. Embolisms that reach the retina can cause oxygen-deprived tissue there to die; this in turn may lead to vision loss (see the discussion of artery occlusions in chapter 16). *Note:* If you have any pain—in your leg, for example—that you think might be caused by a blood clot, call your general medical doctor or other health care provider immediately. Prompt treatment may save your vision—as well as your life.

Finally, in rare instances hormone supplements can cause other side effects, including double vision (caused by loss of function of the extraocular muscles, the muscles that move our eyes), optic neuritis (inflammation of the optic nerve), optic nerve swelling (papilledema), color vision abnormalities, increases in myopia (nearsightedness), and damage to the macula (the part of the retina that provides central vision) secondary to fluid swelling. Except when there has been retinal photoreceptor damage, these side effects are reversible when the medications are discontinued. Women taking hormonal supplements should see their eye doctor routinely.

Steroids

Steroids, such as prednisone, mimic the action of the body's own hormones (particularly those produced by the adrenal glands to control inflammatory reactions in the body). They're most often prescribed for diseases in which there's major inflammation in multiple areas of the body—including rheumatoid arthritis, giant cell arteritis, Crohn's disease, sarcoidosis, and systemic lupus erythematosus. Long-term steroid use can cause many other problems, including posterior subcapsular cataracts and changes in intraocular pressure.

Posterior subcapsular cataracts often occur in people taking prednisone orally but can also occur with topical, inhalation, periocular, or intravitreal administration. These cataracts can be very dense and cause a rapid loss in vision. Even worse, they don't go away if you stop taking the medication, and they are only treatable by surgical removal (see chapter 8).

Changes in intraocular pressure, although not as common as cataracts, are still a serious problem. Steroids—whether inhaled, taken orally or topically, or injected in or around the eye—can lead to glaucoma by causing an elevation in eye pressure, usually after prolonged use. When the eye's fluid pressure builds beyond the normal range, this can cause significant damage to the nerves in the retina that process visual images and can lead to glaucoma (see chapter 9). The good news is that this intraocular pressure usually returns to normal if the steroid is discontinued. The bad news is that any damage to the optic nerve caused by the increased intraocular pressure remains.

Steroids can also damage the eyes indirectly. For example, prolonged steroid use can raise someone's blood sugar, causing diabetes. Skyrocketing levels of sugar in the blood can produce a shift in the focusing power of the eye's crystalline lens, making nearsightedness worse (or actually causing farsightedness to improve); it may also cause vision to fluctuate. Other ocular changes from diabetes can result as well. (For more on the ocular effects of diabetes, see chapter 19.)

Steroid use can raise someone's blood pressure, and as we discussed in chapter 19, this can harm blood vessels within the retina, causing hemorrhaging and damaging nearby nerve tissue. People on high doses of steroids should see their eye doctor every 3–6 months.

Other Medications That Can Cause Problems in the Eye

Chloroquine and Plaquenil

As far as the eye goes, chloroquine and hydroxychloroquine (Plaquenil) are serious, potentially toxic drugs (although Plaquenil seems to cause considerably fewer eye problems than chloroquine), and if you're taking one of these medications, such as chloroquine for malaria or Plaquenil for skin or arthritic problems, we recommend that you be checked thoroughly for any signs of side effects *at least yearly for the first 5 years and thereafter every 6 months.*

The big worry here is retinal toxicity (drug-caused damage to the retina). Fortunately, regular eye exams can detect changes in the retina (mainly in the pigmentation) very early, and these changes can diminish or go away altogether after you stop taking the drugs.

Regular eye exams are so important because in their earliest stages these retinal changes cause no symptoms. (Rarely, the visual field can be damaged even if there aren't any obvious retinal changes.) The most common vision problems attributed to the retinopathy, or retinal changes, include difficulties with reading and seeing (such that words, letters, or parts of objects appear to be missing), blurred distance vision, missing or blacked-out areas in the central or peripheral vision, light flashes, and streaks. Difficulty seeing red targets (sometimes called *premaculopathy*) may also be an early warning sign; this usually goes away when therapy is stopped. In fact, most of these side effects seem to be reversible.

(However, for some people they actually continue to progress, and unfortunately, there's nothing that can be done.)

Another unfortunate twist is that in a few people taking chloroquine, retinal damage has shown up *several years* after the antimalarial drug therapy was stopped—another reason why regular eye exams are so important, whether you're having symptoms of any trouble or not.

Tamoxifen (NOLVADEX, Zeneca)

As part of their treatment for breast cancer, some people take the chemotherapy drug tamoxifen. In a very small segment (less than 1 percent) of them, tamoxifen produces certain side effects in the eyes.

The most common eye problem tamoxifen may cause is a retinopathy, characterized by small deposits—thought to be byproducts of retinal nerve tissue dysfunction—found in the retina's inner layers. Although not particularly troublesome by themselves, these deposits often serve as signposts of more significant trouble because they are sometimes linked to macular edema and retinal hemorrhages that may compromise vision. *These retinal lesions usually go away once a person stops taking the drug.*

Other side effects can include corneal and lens changes. In the cornea, tamoxifen deposits can build up, leaving superficial erosions and opacities; these usually regress when tamoxifen is stopped. In the lens—again, very rarely—these tiny deposits may cause irreversible cataracts, which may require surgery.

All of these side effects seem to be dose dependent: people who take conventional doses of tamoxifen have much fewer, *and much more minor*, drug-related eye problems than those taking higher doses.

Tamsulosin (FLOMAX, Boehringer Ingelheim)

Relaxing is a good thing, except in the eye. Tamsulosin is an alpha-blocker that relaxes smooth muscles in the body. This medication is commonly used in patients with an enlarged prostate to relax the smooth muscle of the prostate and bladder neck, improving urinary flow. Although dry eyes have frequently been reported with this medication, cataract surgeons must always be on the lookout for patients on Flomax or related medications. Inside the eye, the iris has smooth muscle. At the time of cataract surgery, a relaxed iris due to Flomax can lead to poor pupillary dilation and impair visualization of the cataract for removal. Furthermore, relaxation can also lead to a “floppy” or flaccid iris, making the surgery additionally challenging.

Sildenafil (VIAGRA, Pfizer)

We have all heard the commercials and the claims, but what about the side effects, particularly on the eye? Viagra works on erectile dysfunction (ED) by blocking the enzyme PDE5. This enzyme is found in platelets, a component of blood, and in some muscles around blood vessels. The drug disrupts the way blood cells and vessels normally function, leading to increased perfusion—hence its benefit for men suffering from ED. This increased blood perfusion can occur in other parts of the body too, accounting for commonly reported side effects such as headache, flushed skin, and indigestion. Furthermore, it has been reported that up to 3 percent of men on Viagra can experience visual side effects, including bluish or blurry vision and sensitivity to light. These visual side effects are felt to be the result of the blockage by Viagra of PDE6, an enzyme found in high concentration in the retinal photoreceptors and closely related to the enzyme PDE5. Because of this drug’s potential effect on the eye, people with retinal eye conditions such as retinitis pigmentosa are cautioned not to use this medication.

Chapter 22

COSMETICS AND THE EYES

In 2017, the global cosmetic products market was valued at $532.43 billion. This global market is expected to grow over the next decade to more than $800 billion. And guess who is the primary driving force behind this growth? Our aging population trying to stay looking young. Makeup sales ($932 million) in 2017 led global beauty sales, followed by skincare sales ($844 million) and fragrance sales ($501 million).

Most cosmetics, when applied carefully around your eyes, are safe. So, let's first list some commonsense rules about using eye cosmetics in general:

1. *Only use cosmetics that say that you can use them around the eye.*

2. *Never share your eye makeup, and especially be careful when trying samples of makeup in a store.* Be sure to use fresh applicators. You don't want to bring home someone else's eye infection.

3. *If you develop an eye infection, throw away your eye makeup (and your contact lenses too).* Buy all new makeup and wait until the infection is gone before you start using it again.

4. *Clean your eyelids and eyelashes carefully before and after each application of eye cosmetics, especially at night before sleeping.* Makeup removers help remove cosmetics from your eyelids and eyelashes, but additional cleaning of your eyelids and eyelashes will help prevent infections and styes. See chapter 11 for a baby shampoo technique for

eyelid and eyelash cleaning. Eyelid scrubs are also commercially available.

5. *If you notice any tenderness or swelling of your eyelids, don't apply cosmetics that day.* At the first sign of eyelid trouble, clean your eyelids and eyelashes (as above) and apply warm compresses. Chances are you may have an early stye or hordeolum (see chapter 11), and the number one treatment for these eyelid problems is warm compresses, 20–30 minutes at a time, three to four times a day. If the discomfort, redness, or swelling persists, see an eye doctor because the longer you wait, the harder an eyelid infection may become to treat.

But how about products to extend or grow eyelashes, improve eyeliner application, and even whiten your eyes? Are these products safe? Let's discuss a few of these products as well.

Eyelash Enhancement

Did you ever wonder about the purpose of your eyelashes? They don't seem to do much good just fluttering up and down with each blink, although conceivably they can keep some particles out of the eyes and away from the cornea. They can also trigger a blink to help you avoid oncoming dirt or dust. But when it comes to cosmetics, these minor players in our vision play a central role in enhancing our appearance. First, though, let's discuss the dreaded loss of eyelashes.

Eyelashes Falling Out

There are many local and systemic reasons for eyelash loss, some of which can be corrected, so before considering how to regrow or replace them, the mystery of their loss should first be addressed. You may not realize it, but eyelashes grow just like the hair on the head. In fact, there are about 100–150 eyelashes on an upper eyelid and about 70–80 eyelashes on a lower eyelid, which all go through a normal cycle—lash growth, falling out, and regrowth—all over a 6- to 10-week period. It has been estimated that each day on average you lose a few lashes. Therefore, it is not uncommon for you to notice a lash on your cheek, see one on your pillow in the morning, or even get an annoying eyelash in your eye. On the other hand, eye doctors get concerned when you lose eyelashes rapidly, when you lose large numbers at a time, and when regrowth is slow because abnormal eyelash loss can be a sign of local or systemic health problems.

Here are some local and systemic issues that can lead to abnormal eyelash loss:

1. Eyelid inflammation (see chapter 11), such as from blepharitis; rosacea of the eyelid margins; styes; hordeolum; chalazion; eyelid infections from mites, bacteria, and fungi; and even inflammation related to cosmetics can cause abnormal eyelash growth and/or loss. After all, it is not natural for an eyelash to be smothered under cosmetics all day, especially when left on at night too. What's a poor eyelash hair follicle to do when caked over with mascara? So, don't leave makeup on overnight and treat the eyelashes gently, particularly when using lash extenders (see below) and eyelash curlers.

2. Abnormal tissue growths on the eyelid margin can lead to abnormal lash growth and loss. Loss of eyelashes on an eyelid can even be a sign of skin cancer and should be evaluated by an eye doctor.

3. Plucking the eyelashes or eyebrows (trichotillomania), like biting the fingernails, provides comfort and relief for some people from stress and other negative feelings. This

unfortunate habit can lead to inflammation of the eyelid margins and slow regrowth of the eyelashes. Treating a person's underlying emotional discomfort with behavioral therapy (psychotherapy or talk therapy), and possibly medication, is the recommended approach for this condition, but locally applying eye ointments to the eyelashes can help prevent further plucking and give the eyelashes a chance to regrow.

4. When eyelash loss does not appear to have a local cause, a person should seek a systemic medical evaluation since this can be a sign of problems elsewhere in the body. Alopecia, an autoimmune condition that can attack the hair follicles anywhere on the body, can lead to eyelash loss. This condition can be temporary, activated by a surgery or systemic illness, or can be part of a more generalized systemic process, often hereditary. Less frequently, eyelash loss can be seen in other systemic immunologic conditions such as rheumatoid arthritis, lupus, and psoriasis. Abnormalities of the thyroid and other hormones, particularly around menopause, as well as nutritional deficiencies and therapies, such as many systemic medications, chemotherapy, and radiation treatments, can also lead to abnormal eyelash loss.

White Eyelashes (Poliosis)

You look, and then you look again. Are those a few white eyelashes on the eyelid? How did that happen? What do they mean? Well, first catch your breath and stop staring. White or grey patches of hair on any part of the body, even on the eyelid, are a benign condition called poliosis. This whitening can occur at any age and has been associated with a wide variety of medical disorders including genetic conditions, medication use, infection, and extreme psychological stress or pain. Despite the benign nature of poliosis, it can serve as a warning sign for serious systemic conditions such as skin melanoma, uveitis in the eye, a multisystemic inflammatory disease called Vogt-Koyanagi-Harada disease, and thyroid disease. Most people just ignore the actual whitening of their eyelashes, although dye can be of temporary help. The application of dye to the eyelashes is often time-consuming, tedious, and expensive. More importantly, a person with poliosis should see their general medical doctor or other health care provider to be carefully evaluated for an underlying medical condition that may have led to this condition.

Achieving Celebrity Eyelashes

Dreaming of having the eyelashes of a movie star? How do they do it? The normal eyelash is only about three-eighths of an inch and not dramatic. Aside from curling your eyelashes and applying mascara, *eyelash extenders* in a variety of sizes, shapes, colors, and materials—including mink—are available and popular. These artificial eyelashes should be applied by a professional because sticking them to your eyelid will require a steady pair of hands and a special, semipermanent glue. You need to be concerned not only with getting poked in the eye during application but also with hygiene, so be careful that you don't leave with longer eyelashes and an eye infection too. An allergic reaction to the glue or other eye problems can also arise, which makes having access to a professional familiar with eyelash extenders and knowledgeable about managing potential issues very important.

As many people with glaucoma know, eye drops such as latanoprost, bimatoprost, and travoprost can cause eyelashes to darken and even grow. This serendipitous finding as a side effect of the class of glaucoma drops known as prostaglandin analogs led to the development of *bimatoprost ophthalmic solution 0.03 percent* for the thickening and darkening of eyelashes. First approved by the

FDA in 2008 and marketed under the name Latisse, bimatoprost (now available as a generic) has been shown to be an effective and relatively safe treatment for eyelash growth not only in adults but in healthy adolescents too. "How effective is it?" you may ask. A quick internet search will provide you with thousands of testimonials and happy customers. But buyer beware. Side effects can occur, such as darkening the color of the iris or, more often, allergic conjunctivitis.

If extenders and bimatoprost don't do the trick and help you achieve gorgeous eyelashes, how about a *lash lift*? A lash lift is similar to the beauty parlor or hair stylist permanent for the hair that people may have gotten in the past for their prom or wedding, but this is a permanent applied only to the eyelashes. Needless to say, perming the eyelashes should only be performed by a professional. These professionals, usually licensed cosmetologists, must pay particular attention to protecting the eyes, especially the cornea. After covering the eyes with a pad, the cosmetologist glues the eyelashes to a silicone curler and applies a perming solution (usually containing ammonium) to reshape the eyelashes. This application can last under 15 minutes and can be followed by additional solutions applied to your eyelashes to keep them in position for up to 6–8 weeks, as well as to enhance the eyelash texture and color.

Is a Permanent Eyeliner Tattoo for You?

Each morning, a common bathroom refrain in many households is, "You're lucky. You only have to shave, but I have to put on makeup." The morning makeup struggle is compounded by a person being half awake (yet to have their first cup of coffee), an unsteady hand, and contortions trying to find the right focus and magnification in a mirror to apply their eye makeup. This scenario is particularly true for the careful application of eyeliner—that thin line above and below the eyelid margins that deceptively helps people look more alert and awake than they at times feel. If this struggle in putting on eyeliner sounds familiar, permanent eyeliner tattooing can come to the rescue.

The art of tattooing dates back to ancient Egypt and is speculated to have served religious and mystical protective purposes. Tattooing today seems to satisfy other needs, including as a potential time-saver in the form of a permanent eyeliner tattoo. In our modern world, cosmetic tattooing, also known as micropigmentation, has been increasing in popularity since the 1980s. Enhancing eyes, lips, and other areas of the body, tattooing in the right hands can provide amazing results.

First, I need to clarify that *tattooing* here does not refer to a particular line of cosmetics with "tattoo" in the name but instead refers to injecting pigment or ink through a hollow needle, in a repetitive fashion, into the skin to achieve a desired result. I am also not referring to semipermanent eyeliner where pigment is applied to the eyelid using a different technique, but thanks to the cosmetic industry, this can easily be confused with the tattooing procedure described above. Since "permanent" is the operative word when getting an eyeliner tattoo, a person must check exactly what is being marketed and the credentials of the aesthetician. Check their license and insist on seeing before-and-after photographs of their work, even 2–3 years after the procedure. Are their facilities clean? Do they wear gloves? Careful application of the tattoo by a steady hand should produce a great result, especially after a few weeks as the skin swelling resolves and the pigment fades a bit, reaching a permanent shade.

Permanent eyeliner can look very natural and make the morning routine a lot less arduous. Complications—which can include chemical and mechanical injury of the eye and surrounding tissues, pigment migration, eye irritation, and infection—are less frequent than might be expected given the popularity of permanent eyeliner tattooing.

Do your research before committing to eyeliner tattooing. Regular eyeliner may take extra time to apply each morning, but it can be changed and updated over the years. Not so with permanent eyeliner, especially since removal is difficult, costly, and potentially dangerous. Semipermanent eyeliner can last longer than regular eyeliner, but a lot of the same warnings apply to this technique as with permanent eyeliner tattooing. Therefore, like with any cosmetic procedure, ask around and search the internet. Given your lifestyle and needs, permanent eyeliner may be for you—only you can decide.

Eyeball Tattooing

Just when you thought you had seen tattoos everywhere possible on the human body, a new space has been discovered for the tattooing business to fill: the eyeball. Remember, the sclera is the white part of your eyeball. For reasons that one can only imagine, some people have sought out tattoo artists to turn the white sclera of their eyes to a different color, like black or blue. But tattooing of the sclera is not a standardized or established procedure and certainly has not been carefully tested. At this writing, there is also no formal training, licensing, or certification for people performing this procedure. And although it may sound cool to some people, the potential complications are devastating and real.

As mentioned above, tattooing is done by injecting pigment or ink through a hollow needle, in a repetitive fashion, in this case under the conjunctiva, so the ink then colors the sclera below. If the needle is not at the right depth, ink can be injected inside the eye, into the retina and even into the vitreous cavity. Reported complications include decreased vision or complete blindness, retinal detachment, infection, chronic eye inflammation, sensitivity to light, foreign body sensation in the eye, and even loss of the eye.

Therefore, it's no wonder that scleral tattooing has been outlawed in several states, as well as in the Canadian province of Ontario.

If you want a safer way to change your eye color, please consult an eyecare professional who is familiar with custom-colored contact lenses. These contact lenses have their risks as well and should not be bought online or in a costume store. They should only be fit and dispensed with a prescription for these lenses, and only by an eyecare professional familiar with the proper wearing of these specialty lenses.

As I've said before, you only get one pair of eyes, so please take care of them.

Eye Whitening

Suppose a person has a fever and takes an aspirin to bring down their temperature. Or suppose they have a chronic productive cough and just suppress it with cough medicine, without ever getting a chest X-ray. In both cases, they are treating the symptoms, without discovering and treating the cause of the fever or cough. Now think of the eye. People regularly visit the eye doctor with chronically red eyes. Their eye just always seems to be some shade of red or look bleary. They are tired of looking tired and having people tell them that they look tired. And they come to the eye doctor for help. The first challenge for the eye doctor is to figure out whether their red eye, like a fever or cough, is pointing to a problem that needs to be treated. Could their chronic redness be due to allergies (seasonal or environmental), dryness, staring at a computer screen too long, or simply poorly fit or overworn contact lenses? The cause of the redness must be addressed, and if a cause is discovered, it must be treated before it has a chance to lead to more serious eye problems.

If no cause is found for a person's chronically red eyes, it is reasonable to consider specifically treating the redness. Fortunately for these people, we are no longer limited to eye drops like Visine and similar medications that whiten eyes with tetrahydrozoline, a chemical that can lead to rebound redness and a vicious cycle of red eye, Visine, a redder eye, more Visine, etc. Today we have new eye whitening drops, like Lumify. Similar to the serendipitous discovery of bimatoprost for eyelash growth, here again another glaucoma drug, brimonidine, was found to whiten eyes and has been reformulated for this indication. By acting on a different blood vessel receptor than tetrahydrozoline, brimonidine eye drops avoid the frustrating rebound redness effect.

Short-term studies of brimonidine for eye redness have been encouraging, but as of this writing, the effects of long-term use are still unknown. To get the red out quickly and safely, this drop may be the answer for those suffering from chronically red eyes—but before starting this eye whitening agent, people should first visit their eye doctor to make sure that they will not be masking a serious underlying eye problem by using it.

For many years, eye doctors have tried various surgical treatments to whiten eyes. These procedures usually include some variation of cutting away the conjunctival and related tissues coating the outside surface of the eyeball and applying topical drugs like mitomycin-C (MMC) to control scarring and regrowth of these tissues. You'll recall MMC from chapter 9, where its use during glaucoma filtration surgery to decrease scarring was mentioned. MMC has been used for control of scarring and tissue regrowth in eye whitening procedures too, but with much debate given the potentially severe complications that have been seen with this cosmetic procedure. Although some reports from doctors who perform eye whitening procedures that include surgical and topical treatments like MMC show high patient satisfaction and low complications, other reports have found complications in as high as 80 to 90 percent of patients, with many of these complications termed as "severe." Severe complications include changes in the sclera that can lead to annoying calcium deposits, thinning, and even irreversible breakdown. Although banned in some countries, this eye whitening procedure is still advertised and performed. Ophthalmic societies have cautioned anyone interested in a surgical whitening procedure performed in combination with topical drug treatment to carefully scrutinize the risks and benefits before undergoing the procedure.

Eye Prostheses for a Natural Look

Custom colored contact lenses, scleral shells, and artificial eyes are available after permanent disfigurement or loss of an eye to replicate the color, depth, and detail of a real eye and help create a natural look. Experienced optometrists and ocularists can professionally custom-fit and artfully design the right prosthesis for each patient, and although these prostheses do not restore vision, enhancing a person's appearance can dramatically change their life. For more information about these options, see the websites of Custom Color Contacts (https://www.customcontacts.com/prosthetic-contact-lenses); Northwest Eye Design (https://nweyedesign.com/eyes/scleral-shells/); and the American Society of Ocularists (https://ocularist.org/doctors_refer.asp).

Appendix A

Vision Myths

As in other aspects of life, many myths have sprung up around the area of vision, and they have been passed on from generation to generation, causing confusion and sometimes fear. Let's explore some of these bits of accepted wisdom as good examples of the bad information I hope to replace with this book.

READING IN DIM LIGHT CAN HURT YOUR EYES

Picture Anne Sullivan, the dedicated, selfless teacher of Helen Keller, who was blind and deaf, reading night after endless night in a half-lit bedroom, straining her own eyes to the breaking point. Makes you wish for indoor flood lamps, doesn't it? And yet, although inadequate light can cause temporary eye fatigue, it can't permanently damage your eyes. If it could, Abe Lincoln, who studied by candlelight—as did every scholar in the centuries before Thomas Edison brought us the light bulb—would have had poor vision. But why do it? Everyone ought to use good lighting—especially as we get older, when cataracts and other problems can dim our vision. Also, good lighting always makes it easier for your eyes to focus on what you are reading and helps to lessen fatigue.

EYE EXERCISES CAN IMPROVE VISION

Sadly, for almost all of us, this one isn't true either. There are muscles in the eye, but they don't "shape up" like a flabby belly on a regimen of sit-ups. Only a small percentage of eye problems respond to eye exercises. Also, eye exercises can't prevent you from ever needing eyeglasses. *Note:* If an eye doctor recommends a course of eye exercises for you, please seek a second opinion; these ocular workouts are useful in some circumstances, but they have their limitations.

WEARING THE RIGHT SUNGLASSES CAN PREVENT CATARACTS

Many products—natural foods, herbal medicines, expensive lens coatings, special eye drops, high-tech sunglasses—have been marketed as means of preventing cataracts, and there's some science to back this up: UV toxicity can harm the eyes, but not nearly as commonly or easily as sunlight damages the skin and causes skin cancer. But we also have to note that most people have some cataract development as they get older. In some people, cataracts develop quickly and need treatment; in others, they don't. Thus—because the sheer numbers are so great—statistically, any product that claims to prevent, or at least slow, cataract development will appear to work fairly often. Do they really? Probably not.

It's entirely reasonable to ask what practical steps can be taken to prevent your vision from deteriorating, but the bottom line is that many eye problems are simply the luck of the genetic draw. For example, myopia, like heart disease, has a major genetic component. If your family reunion looks like a LensCrafters commercial, then you probably ought to resign yourself to the fact that myopia runs in your family. But there are some things you can do: Try to avoid injuries. Take care of your general health—especially if you have diabetes or high blood pressure. And get regular eye exams throughout your life. Many eye problems are highly treatable, but only if they are caught in time.

EATING CARROTS HELPS YOU SEE BETTER

Carrots are rich in vitamin A, which is indeed important for eyesight. But carrots haven't cornered the market on vitamin A; many other foods—green vegetables and yellow squash, for instance—are also rich in it. And we don't need that much vitamin A, anyway; a well-balanced diet, with or without carrots, provides all the nutrients we need for good vision.

However, severe *lack* of vitamins A, C, and E—a problem often found in people living in underdeveloped countries—can lead to serious eye disease. And studies have also found that the risk of developing vision loss in early forms of macular degeneration, a common cause of visual difficulty in many older people, can be reduced by vitamin and zinc supplementation. The message here for the rest of us is this: Take your vitamins in reasonable doses (not megadoses). Take one multivitamin daily. And eat your vegetables.

SITTING IN FRONT OF A COMPUTER SCREEN FOR HOURS ON END CAN DAMAGE YOUR EYES

Well, it sure doesn't do them any good, but fortunately the eyestrain and fatigue caused by overuse of computers and video display terminals are only temporary. Eyestrain and fatigue can be unwelcome by-products of *any* close-up task that requires prolonged use of the eye muscles. What can you do to relieve the strain? Take frequent breaks. Rest your eye muscles by periodically looking up or across the room. Keep the monitor 24 inches away. You may find it helpful to use a pair of "computer glasses," so that your eyes don't have to work so hard. (See your eye doctor.)

IF YOU LOOK CROSS-EYED LONG ENOUGH, YOUR EYES WILL STAY THAT WAY

They won't.

Appendix B

A Guide to Eye Medications and Related Drugs

For an overview of the more common medications used to treat eye conditions, see table B.1. It will help put in perspective some of the drops, ointments, and pills you may use or hear about. Using this table, you will be able to identify these medications by category (such as antibiotics or glaucoma medications) and by both their generic names and their aliases, or "brand names."

In the first edition of *The Eye Book*, we included mention of common side effects encountered with ocular medications on our list. Since the first edition, the internet has become the go-to place for checking the side effects of any medication. Therefore, rather than once again attempt to provide lists of side effects of each ocular medication, we refer you online to sites like drugs.com, webmd.com, and pdr.net. The reality, however, is that most side effects of ocular medications occur infrequently. Moreover, your eye doctor would not prescribe a medication for you unless they felt that the benefit of the treatment far outweighed the risk of developing a reaction. Of course, if you are allergic to sulfa or have a history of reactions to any of these drugs, you should discuss this with your doctor. Package inserts, online medication information, and information provided at the time of drug dispensing are also very important, and you should read such information carefully to check the safety of the medication for you. After all, the best person to watch out for you is you. Don't be afraid to ask questions if something does not sound right or if something concerns you.

There are basically two types of reactions to medications: allergic and toxic. In *allergic reactions* the eye recognizes the medication as foreign and attacks it. These reactions are generally mild, causing symptoms of eye irritation and itching that are often accompanied by conjunctival redness and swelling. Once the medication wears off or is washed out, the eye feels a lot better. *Toxic reactions*, on the other hand, are usually more severe and may damage or inhibit function of the eye or other organs. Many toxic reactions are usually reversible once there is no longer any contact between the tissue and the medication, but recovery from a toxic reaction—such as a reaction that causes damage to corneal epithelial cells or retinal pigment epithelium, for example—can take days to months. Fortunately, most ocular side effects from a medication, whether allergic or toxic, usually go away without doing permanent damage to a person's sight.

When taking any medications, it is essential that you discuss any unusual signs or symptoms with your prescribing doctor or other health care provider as soon as you notice them.

Table B.1 Common Medications Used to Treat Eye Conditions

Type	Generic Name	Brand Name
Anesthetics (For professional use only)		
	Bupivacaine	Marcaine Sensorcaine
	Lidocaine	Akten (gel) Lidocaine/Phenylephrine (ophthalmic injection)
	Proparacaine	AK-Taine, Alcaine, Ophthaine, Ophthetic
	Tetracaine	AK-T-Caine, Pontocaine, Altacaine, TetraVisc Forte

Type	Generic Name	Brand Name
Anti-infectives		
Antibacterials (also known as antibiotics; see also "Combination drugs")	Bacitracin	
	Besifloxacin	Besivance
	Chloramphenicol	Chloromycetin, Chloroptic
	Ciprofloxacin	Ciloxan
	Erythromycin	Ilotycin
	Gatifloxacin	Zymar/Zymaxid
	Gentamicin	Garamycin, Genoptic, Gentacidin, Gentak, Gentasol
	Neomycin	
	Norfloxacin	Chibroxin
	Ofloxacin	Ocuflox
	Moxifloxacin	Vigamox
	Polymyxin B	
	Sulfacetamide	AK-Sulf, Bleph-10, Cetamide, Isopto Cetamide, Ocu-Sul 10, Ocu-Sul 15, Ocu-Sul 30, Ocusulph-10, Sodium Sulamyd, Sulfac 10%, Sulfacet Sodium
	Sulfisoxazole	Gantrisin
	Tobramycin	AK-Tob, Tobralcon, Tobrasol, Tobrex, Tomycine
Antifungals	Amphotericin B	Amphocin, Fungizone
	Miconazole	Monistat
	Natamycin	Natacyn
	Nystatin	Mycostatin, Nilstat, Nystex, Bio-Statin

Type	Generic Name	Brand Name
Antivirals	Trifluridine	Viroptic
	Vidarabine	Vira-A
	Ganciclovir	Zirgan
Anti-inflammatory drugs		
Steroids (see also "Combination drugs")	Dexamethasone	Decadron, Maxidex, Ozurdex, Dexycu
	Fluorometholone	Flarex, Fluor-Op, FML, FML Forte
	Loteprednol	Lotemax, Alrex, Inveltys
	Medrysone	HMS
	Prednisolone	Inflamase Forte, Inflamase Mild, Pred Forte, Pred Mild, Ocu-Pred, Ocu-Pred Forte, Ocu-Pred-A, Omnipred
	Rimexolone	Vexol
Nonsteroid anti-inflammatories	Diclofenac	Voltaren
	Flurbiprofen	Ocufen
	Suprofen	Profenal
	Ketorolac	Acular
Ocular decongestants		
	Naphazoline HCl	Albalon, Allerest Eye Drops, Clear Eyes, Naphcon, Vasoclear, Vasocon, AK-Con
	Oxymetazoline HCl	OcuClear, Visine LR

Type	Generic Name	Brand Name
	Phenylephrine HCl	AK-Dilate, AK-Nefrin, Altafrin, Mydfrin, Isopto Frin, Prefrin Liquifilm, Neo-Synephrine, Neofrin, Ocu-Phrin, Phenoptic, Refresh Redness Relief
	Tetrahydrozoline HCl	Altazine, Clarine, Eye Moisturizing Relief, Eye-Sine, Geneye Extra, Geneyes, Murine Plus, Opti-Clear, Optigene 3, Tetrasine, Tetrasine EX, Visine Extra, Visine Maximum Redness Relief, Visine Original, Vision Clear, Vision Eye
Anti-allergy		
	Antazoline phosphate with naphazoline	Vasocon-A
	Cromolyn sodium	Crolom, Opticrom
	Ketorolac	Acular, Acuvail
	Alcaftadine	Lastacaft
	Levocabastine	Livostin
	Lodoxamide	Alomide
	Olopatadine hydrochloride	Patanol, Pazeo, Pataday
	Pheniramine maleate with naphazoline	Naphcon-A, Opcon-A
Corneal edema		
	Sodium chloride	Adsorbonac, AK-NaCl, Muro-128, Sochlor, Altachlore

Type	Generic Name	Brand Name
Combination drugs (a mixture of more than one medication)		
	Gentamicin and prednisolone	Pred-G
	Neomycin and dexamethasone	Neodecadron
	Neomycin, polymyxin B, and dexamethasone	Maxitrol, Dexacidin, Dexasporin
	Neomycin, polymyxin B, and hydrocortisone	Cortisporin
	Neomycin, polymyxin B, and prednisolone	Poly-Pred
	Oxytetracycline and hydrocortisone	Terra-Cortil
	Polymyxin B and bacitracin	Polysporin
	Polymyxin B, neomycin, and bacitracin	Triple Antibiotic, Neo-Polycin
	Polymyxin B, neomycin, and gramicidin	Neocidin, Neosporin, Ocutricin
	Polymyxin B and oxytetracycline	Terramycin
	Tobramycin and dexamethasone	TobraDex
	Trimethoprim and polymyxin B	Polytrim
Drugs used to dilate the pupils		
	Atropine sulphate	
	Cyclopentolate hydrochloride	Cyclogyl
	Homatropine hydrobromide	

Type	Generic Name	Brand Name
	Hydroxyamphetamine and Tropicamide	Paremyd
	Phenylephrine HCl	Mydfrin, NeoSynephrine
	Scopolamine hydrobromide	
	Tropicamide	Mydriacyl
Dyes		
	Fluorescein sodium	
	Rose Bengal Lissamine green Indocyanine green	
Glaucoma medications		
Beta-blockers	Betaxolol	Betoptic
	Carteolol	Ocupress
	Levobunolol	Betagan
	Metipranolol	OptiPranolol
	Timolol hemihydrate	Betimol
	Timolol maleate	Timoptic
Miotics	Carbachol	Isopto Carbachol
	Demecarium bromide	Humorsol
	Echothiophate iodide	Phospholine Iodide
	Isoflurophate	Floropryl
	Physostigmine	Eserine
	Pilocarpine	Isopto Carpine, Pilagan Pilocar, Adsorbocarpine, Akarpine, Ocu-Carpine, Ocusert, Pilopine, Piloptic-2

Type	Generic Name	Brand Name
Alpha-adrenergic agonists		
	Apraclonidine	Iopidine
	Brimonidine	Alphagan
	Epinephrine	Epifrin, Glaucon, Eppy/N, Epinal
Carbonic anhydrase inhibitors		
	Acetazolamide	Diamox
	Brinzolamide	Azopt
	Dichlorphenamide	Daranide
	Dorzolamide	Trusopt
	Methazolamide	Neptazane
Hyperosmotic agents		
	Glycerin	Osmoglyn
	Isosorbide	Ismotic
	Mannitol	Osmitrol
	Urea	Ureaphil
Antimetabolites		
	5-fluorouracil	5-FU
	Mitomycin-C	MMC
Prostaglandins		
	Latanoprost	Xalatan
	Travaprost	Travatan
	Bimatoprost	Lumigan
	Tafluprost	Zioptan
	Latanoprostene	Vyzulta

Type	Generic Name	Brand Name
Rho kinase inhibitors		
	Netarsudil	Rhopressa
Lubricating	Acetylcysteine	Mucomyst
	Artificial tear inserts	Lacrisert
	Artificial tears	Many over-the-counter brands and formulas
	Hydroxypropyl methylcellulose	Goniosol, GenTeal Mild, Gonak, Goniosoft, Goniotaire, Goniovisc, Isopto Tears, Nature's Tears, Systane Overnight Therapy, and many other brands
Immunosuppressant Anti-inflammatory	Cyclosporine	Restasis, Cequa
	Lifitegrast	Xiidra
Reverse dilating drops	Dapiprazole HCl	Rev-Eyes
Vascular endothelial growth factor inhibitors		
	Bevacizumab	Avastin
	Ranibizumab	Lucentis
	Pegaptanib	Macugen
	Aflibercept	Eylea

Signs and Symptoms Index

This index is not a substitute for an eye examination by an eyecare professional nor can it be considered comprehensive. Please use it only to get ideas about your eye issues before consulting an eyecare specialist.

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