diabetic retinopathy, macular degeneration, retinal detachment, and, in young children, amblyopia.

- **Systemic disease** Potentially vision or life-threatening systemic disorders that may involve the eye include diabetes, hypertension, temporal arteritis, and an embolism from the carotid artery or the heart.
- **Tumor or other disorders of the brain** These conditions may threaten both vision and life. Important examples include meningioma, aneurysms, and multiple sclerosis.

BASIC INFORMATION

An understanding of ocular anatomy, visual acuity, anatomic aging changes, and the patient's history all come into play when evaluating ocular complaints.

THE PATIENT'S HISTORY

When a patient presents to a primary care physician with ocular complaints, the first priority is to obtain a thorough ocular history. This is key in making the diagnosis and implementing a treatment plan.

Assessing Risk Factors for Ocular Disease

Obtaining a patient's systemic medical history and family ocular history is important for assessing a patient's risk factors for ocular disease. Just as with other body systems, reliable historical information allows the physician to more appropriately direct the physical examination. Areas to discuss include:

- Family history (blindness, glaucoma, ocular tumor, retinal detachment, strabismus, macular degeneration)
- Poor vision (excluding refractive error)
- History of eye trauma
- Medical history (diabetes mellitus, hypertension, thyroid disease, rheumatoid arthritis, malignancy)

Evaluating Visual Complaints

Knowing the onset, duration, and associated symptoms is invaluable in guiding the examiner to the correct diagnosis. Questions to ask include the following:

- Did the patient have prior good and equal vision in both eyes?
- Is the visual complaint monocular or binocular?
- Is central or peripheral vision affected?
- Is the change in vision acute or gradual?
- Is there any pain?
- Is vision distorted (metamorphopsia)?
- Is there double vision? in one eye or both (monocular or binocular)?

Greater detail is given in later chapters on historical information necessary to help diagnose specific ocular disease.

ANATOMY

Figures 1.1 through 1.4 show key external and internal ocular structures. The principal anatomic structures are described below.

- **Eyelids** The outer structures that protect the eyeball and lubricate the ocular surface. Within each lid is a tarsal plate containing meibomian glands. The lids join at the medial and lateral canthi. The space between the two open lids is called the *palpebral fissure.*
- **Cornea** The transparent front "window" of the eye that serves as the major refractive surface.
- **Sclera** The thick outer coat of the eye, normally white and opaque.
- **Limbus** The junction between the cornea and the sclera.
- **Conjunctiva** The thin, vascular mucous membrane covering the inner aspect of the eyelids (palpebral conjunctiva) and sclera (bulbar conjunctiva).
- **Anterior chamber** The space that lies between the cornea anteriorly and the iris posteriorly. The chamber contains a watery fluid called *aqueous humor.*
- **Iris** The colored part of the eye that screens out light, primarily via the pigment epithelium, which lines its posterior surface.
- **Pupil** The circular opening in the center of the iris that adjusts the amount of light entering the eye. Its size is determined by the parasympathetic and sympathetic innervation of the iris.
- **Lens** The transparent, biconvex body suspended by the zonules behind the pupil and iris; part of the refracting mechanism of the eye.
- **Ciliary body** The structure that produces aqueous humor. Contraction of the ciliary muscle changes tension on the zonular fibers that suspend the lens and allows the eye to focus from distant to near objects (accommodation).
- **Posterior chamber** The small space filled with aqueous humor behind the iris and in front of the anterior lens capsule.
- **Vitreous cavity** The relatively large space (4.5 cc) behind the lens that extends to the retina. The cavity is filled with a transparent jelly-like material called *vitreous humor.*
- **Optic disc** The portion of the optic nerve visible within the eye. It is composed of axons whose cell bodies are located in the ganglion cell layer of the retina.
- **Retina** The neural tissue lining the vitreous cavity posteriorly. Essentially transparent except for the blood vessels on its inner surface, the retina sends the initial visual signals to the brain via the optic nerve. The retina, macula,

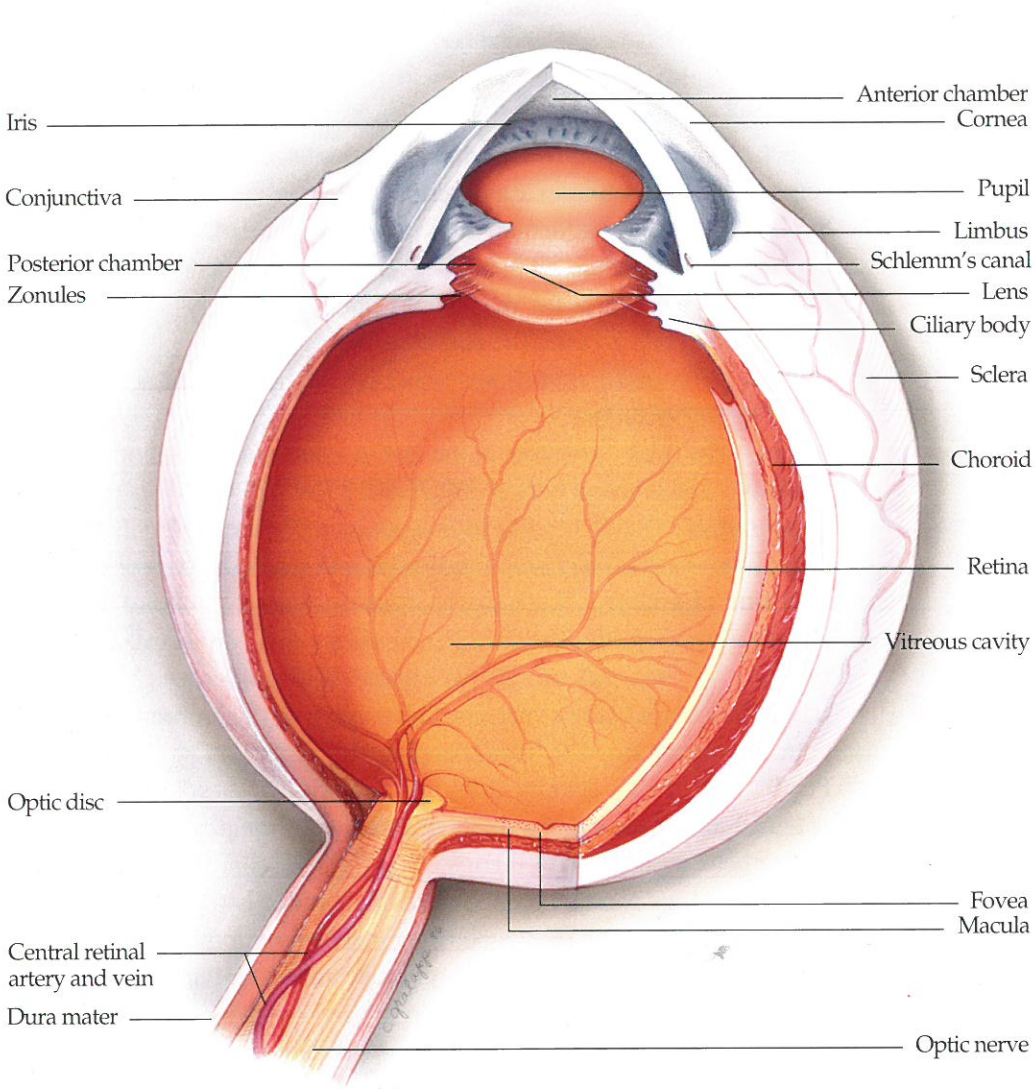

FIGURE 1.1 Cross-section of the eye. *(Illustration by Christine Gralapp.)*

choroid, and optic disc are sometimes referred to as the *retinal fundus* or, simply, *fundus.*

- **Macula** The area of the retina at the posterior pole of the eye responsible for fine, central vision. The oval depression in the center of the macula is called the *fovea.*
- **Choroid** The vascular, pigmented tissue layer between the sclera and the retina. The choroid provides the blood supply for the outer retinal layers.

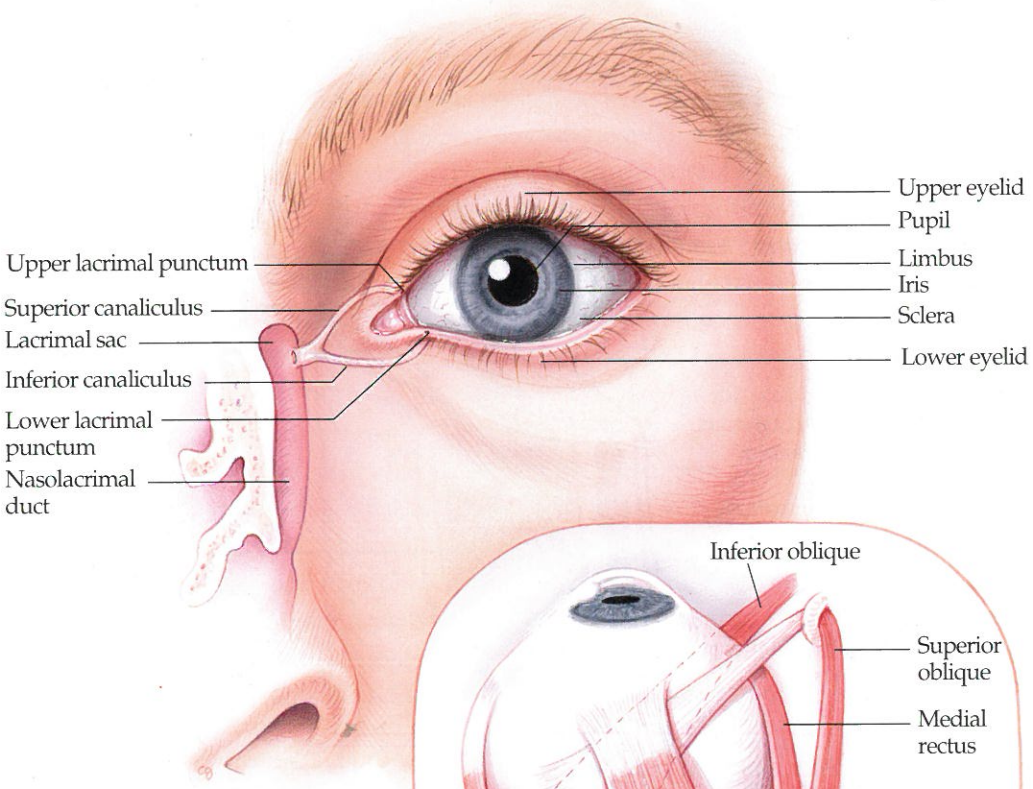

Figure 1.2 External landmarks.
(Illustration by Christine Gralapp.)

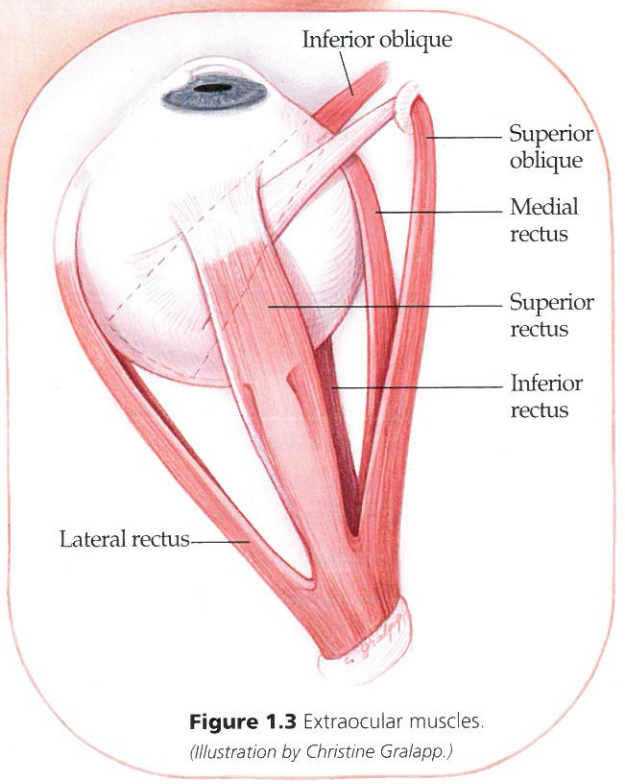

Figure 1.3 Extraocular muscles.
(Illustration by Christine Gralapp.)

- **Extraocular muscles** The six muscles that move the globe medially (medial rectus), laterally (lateral rectus), upward (superior rectus and inferior oblique), downward (inferior rectus and superior oblique), and torsionally (superior and inferior obliques). These muscles are supplied by three cranial nerves: cranial nerve IV, which innervates the superior oblique; cranial nerve VI, which innervates the lateral rectus; and cranial nerve III, which controls the remainder of the extraocular muscles.

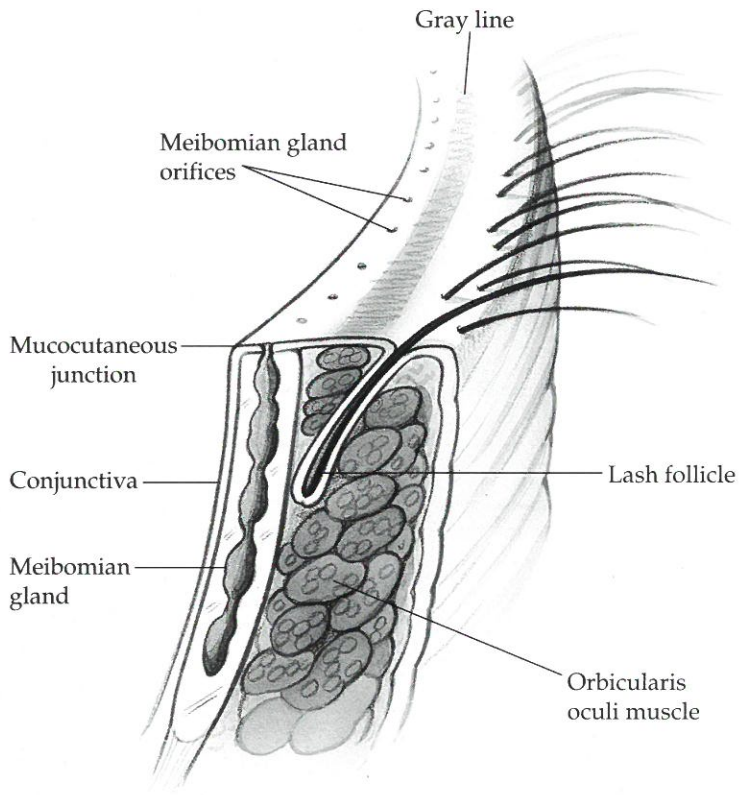

FIGURE 1.4 Eyelid margin anatomy. *(Illustration by Christine Gralapp. Reprinted from BCSC Section 7. San Francisco: American Academy of Ophthalmology; 2003:141.)*

ANATOMIC AGING CHANGES

There are a multitude of involutional aging changes in the eye and adnexa. As the skin loses elasticity and succumbs to the effects of gravity, the brow sags over the superior orbital rim (brow ptosis). The levator aponeurosis, a tendinous insertion from the levator muscle of the upper lid, may detach from the superior tarsal plate allowing lid ptosis to weigh the lid into the visual axis and restrict peripheral vision. The lower lid suspensor ligaments likewise become lax, and the lid margin may rotate toward the cornea (entropion) or gape away from the globe (ectropion). Interruption of the normal lid architecture may predispose the patient to chronic tearing (epiphora) due to dysfunction of the lacrimal pump drainage apparatus (lid movement that propels tears toward the puncta). The lashes may be misdirected and rub on the cornea (trichiasis) independently or in conjunction with entropion.

The conjunctiva loses both accessory lacrimal glands and goblet cells, increasing the incidence of chronic dry eye. Older patients have likewise been shown to have a smaller tear lake. Of these patients age 65 and older, 15% to 20% report multiple persistent symptoms of dry eye.

With advancing age, the crystalline lens continues to grow, crowding the anterior chamber angle and predisposing the patient to angle-closure glaucoma, particularly in the hyperopic patient with a narrow anterior chamber. The filtration of the trabecular meshwork slows, allowing a progressive increase in intraocular pressure and in the incidence of open-angle glaucoma.

The vitreous jelly develops pockets of liquefied vitreous in the previously homogenous gel. This vitreous syneresis predisposes to a separation of the vitreous from the retina and optic disc, called *posterior vitreous detachment* (PVD). A PVD (Figure 1.5) in turn can predispose the patient to retinal traction, tears, and detachment.

Arteriosclerotic changes predispose the patient to vasculopathic cranial III, IV, and VI nerve palsies, retinal artery and vein occlusions, and anterior ischemic optic neuropathy.

The aging eye functions differently as well. Subjective testing in patients age 50 or older reveals a loss of visual acuity, contrast sensitivity, and visual fields. Vertical smooth-pursuit eye movements and simultaneous vertical eye–head tracking decrease. Many older patients have trouble looking up as well as moving the head up and looking up with the eyes at the same time. Aging delays regeneration of rhodopsin, slows rod-mediated dark adaptation, and may lead to relative difficulty with night vision.

Aging does not condemn the elderly to a loss of functional vision, however. According to the Framingham Heart Study, an ongoing investigation of cardiovascular disease, acuity of 20/25 or better was maintained in at least one eye in 98% of patients ages 52 to 64, 92% ages 65 to 74, and 70% ages 75 to 85. The Framingham study found that subjective changes with age include dryness, grittiness, fatigue, burning, glare, floaters, flashes, and an increased risk of falls.

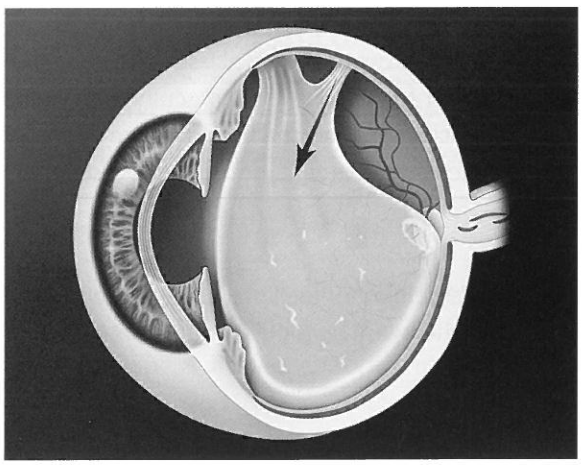

FIGURE 1.5 Posterior vitreous detachment. Partial collapse of the vitreous gel with a localized area of firm retinal adhesion and traction. *(Illustration by Christine Gralapp. Reprinted from* Flashes, Floaters, and Posterior Vitreous Detachment. *Focal Points, Module 1. San Francisco: American Academy of Ophthalmology; 2003:4.)*

The study also noted other changes: a loss of corneal endothelial cells, yellowing and opacification of the lens, a smaller and less reactive pupil, and condensation of the vitreous gel. Retinal traction and tears were noted, as well as age-related changes in the retinal vasculature, and fewer neural cells in the retina and visual cortex.

OPTICS

The cornea and the lens make up the refractive surfaces of the eye. The cornea provides approximately two thirds of the refractive power of the eye, and the lens approximately one third to form an image on the retina. Reduced visual acuity will result if the axial length of the eye is either too short (ie, *hyperopia*; also called *hypermetropia*) or too long (ie, *myopia*) for the refracting power of the cornea and lens. Visual acuity also is reduced if the refracting power of the cornea and lens is different in one meridian than in another (ie, *astigmatism*). These optical defects can be corrected by the use of spectacles, contact lenses, or, in selected cases, refractive surgery. A pinhole placed directly in front of the eye will narrow the effective pupillary aperture and thereby minimize the blurring induced by a refractive error. Use of a pinhole device will allow an examiner to estimate a patient's visual potential with proper spectacle correction.

The ability of the ciliary muscle to contract and the lens to become more convex is called *accommodation*. With increasing age, the lens of every eye undergoes progressive hardening, with loss of ability to change its shape. Loss of accommodation is manifested by a decreased ability to focus on near objects (ie, *presbyopia*), while corrected distance visual acuity remains normal. Presbyopia develops progressively with age but becomes clinically manifest in the early to mid 40s, when the ability to accommodate at reading distance (35 to 40 cm) is lost. Presbyopia is corrected by spectacles, either as reading glasses or as the lower segment of bifocal glasses, the upper segment of which can contain a correction for distance visual acuity if needed. Some myopic patients with presbyopia simply remove their distance glasses to read, because they do not need to accommodate in an uncorrected state.

VISUAL ACUITY

Visual acuity is a measurement of the smallest object a person can identify at a given distance from the eye. The following are common abbreviations used to denote visual acuity:

- **VA** visual acuity
- **OD** (*oculus dexter*) right eye
- **OS** (*oculus sinister*) left eye
- **OU** (*oculus uterque*) both eyes

WHEN TO EXAMINE

All patients should have an eye examination as part of a general physical examination by the primary care physician. Visual acuity, pupillary reactions, extraocular movements, and direct ophthalmoscopy through undilated pupils constitute a minimal examination. Pupillary dilation for ophthalmoscopy is required in cases of unexplained visual loss or when fundus pathology is suspected (eg, diabetes mellitus).

Distance visual acuity measurement should be performed in all children as soon as possible after age 3 because of the importance of detecting amblyopia early. The tumbling E chart (see Chapter 6) is used in place of the standard Snellen eye chart.

Depending on what the examination reveals and on the patient's history, additional tests may be indicated (listed next). Details on how to perform both basic and adjunctive ocular tests appear in the section, "How to Examine."

ADDITIONAL TESTS

- **Tonometry** Could be performed if acute narrow-angle glaucoma is suspected. The diagnosis of open-angle glaucoma requires more complex testing than simple tonometry.
- **Anterior chamber depth assessment** Indicated when narrow-angle glaucoma is suspected and prior to pupillary dilation.
- **Confrontation field testing** Used to confirm a suspected visual field defect suggested by the patient's history or symptoms; also used to document normal visual field.
- **Color vision testing** May be part of an eye examination when requested by the patient or another agency, in patients with retinal or optic nerve disorders, and in patients taking certain medications.
- **Fluorescein staining of cornea** Is necessary when a corneal epithelial defect or abnormality is suspected.
- **Upper lid eversion** Is necessary when the presence of a foreign body is suspected.

HOW TO EXAMINE

Equipment for an eye examination consists of a few items that can be transported, if necessary, with other medical instruments (Figure 1.6). The slit-lamp biomicroscope is a stationary office instrument that augments the inspection of the anterior segment of the eye by providing an illuminated, magnified view. Standard equipment in an ophthalmologist's office, the slit lamp is also available in many emergency facilities.

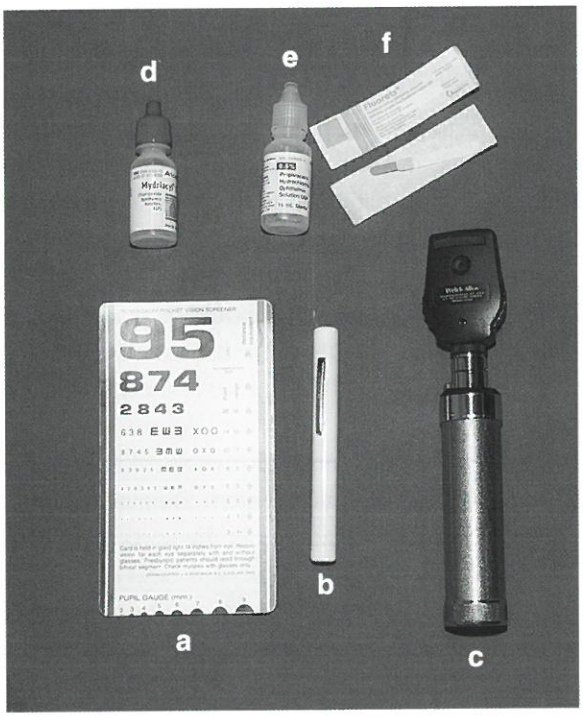

FIGURE 1.6 Equipment for a basic eye examination. **a.** Near vision card. **b.** Penlight. **c.** Direct ophthalmoscope. **d.** Mydriatic. **e.** Topical anesthetic. **f.** Fluorescein strips. *(Courtesy Cynthia A. Bradford, MD.)*

DISTANCE VISUAL ACUITY TESTING

Distance visual acuity is usually recorded as a ratio or fraction comparing patient performance with an agreed-upon standard. In this notation, the numerator represents the distance between the patient and the eye chart (usually the Snellen eye chart, Figure 1.7). The denominator represents the distance at which a person with normal acuity can read the letters. Visual acuity of 20/80 thus indicates that the patient can recognize at 20 feet a symbol that can be recognized by a person with normal acuity at 80 feet.

Visual acuity of 20/20 represents normal visual acuity. Many "normal" individuals actually see better than 20/20—for example, 20/15 or even 20/10. If this is the case, you should record it as such. Alternative notations are the decimal notation (eg, 20/20 = 1.0; 20/40 = 0.5; 20/200 = 0.1) and the metric notation (eg, 20/20 = 6/6, 20/100 = 6/30).

Visual acuity is tested most often at a distance of 20 feet, or 6 meters. Greater distances are cumbersome and impractical; at shorter distances, variations in the test distance assume greater proportional significance. For practical purposes, a distance of 20 feet may be equated with optical infinity.

To test distance visual acuity with the conventional Snellen eye chart, follow these steps:

1. Place the patient at the designated distance, usually 20 feet (6 meters), from a well-illuminated Snellen chart (see Figure 1.7). If glasses are normally worn for distance vision, the patient should wear them.

2. By convention, the right eye is tested and recorded first. Completely occlude the left eye using an opaque occluder or the palm of your hand; alternatively, have the patient cover the eye.
3. Ask the patient to read the smallest line in which he or she can distinguish more than one half of the letters. (If the E chart is being used, have the patient designate the direction in which the strokes of the E point.)
4. Record the acuity measurement as a notation (eg, 20/20) in which the numerator represents the distance at which the test is performed and the denominator represents the numeric designation for the line read.
5. Repeat the procedure for the other eye.
6. If visual acuity is 20/40 or less in one or both eyes, repeat the test with the subject viewing the test chart through a pinhole occluder and record these results. The pinhole occluder may be used over the subject's glasses.

If a patient cannot see the largest Snellen letters, proceed as follows:

1. Reduce the distance between the patient and the chart. Record the new distance as the numerator of the acuity designation (eg, 5/70).
2. If the patient is unable to see the largest Snellen letter at 3 feet, hold up one hand, extend two or more fingers, and ask the patient to count the

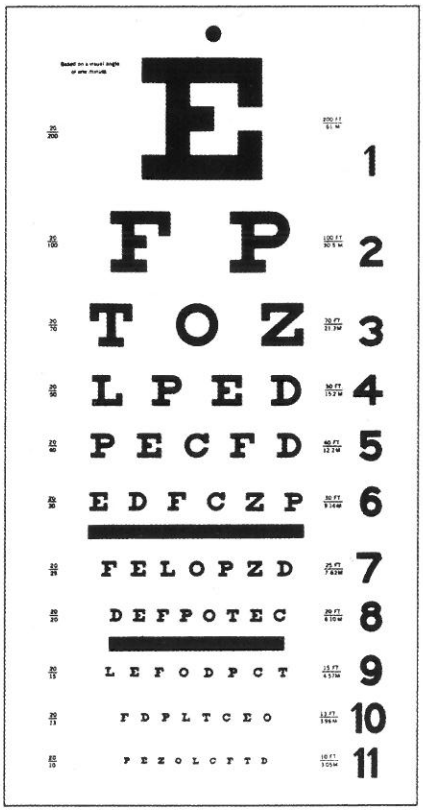

FIGURE 1.7 Snellen eye chart.

number of fingers. Record the distance at which counting fingers is done accurately (eg, CF 1 ft).

3. If the patient cannot count fingers, determine whether or not he or she can detect the movement of your hand. Record a positive response as hand motion (eg, HM 2 ft).
4. If the patient cannot detect hand motion, use a penlight to determine whether he or she can detect the direction or the perception of light. Record the patient's response as LP with projection (light perception with direction), LP (light perception), or NLP (no light perception).

Visual Impairment vs Visual Disability

The term *visual acuity impairment* (or simply *visual impairment*) is used to describe a condition of the eyes. *Visual disability* describes a condition of the individual. The disabling effect of impairment depends in part on the individual's ability to adapt and to compensate. Two individuals with the same visual impairment measured on a Snellen eye chart may show very different levels of functional disability. Table 1.1 summarizes the differences between visual impairment and visual disability.

NEAR VISUAL ACUITY TESTING

Near visual acuity testing may be performed if the patient has a complaint about near vision. Otherwise, testing "at near" is performed only if distance testing is difficult or impossible—at the patient's bedside, for instance. In such situations, testing with a near card may be the only feasible way to determine visual acuity.

If the patient normally wears glasses for reading, he or she should wear them during testing. This holds true for the presbyopic patient in particular. The patient holds the test card—for example, a Rosenbaum pocket vision screener (Figure 1.8)—at the distance specified on the card. This distance is usually 14 inches or 35 centimeters. While the examiner occludes one of the patient's eyes, the patient reads the smallest characters legible on the card. The test is then repeated for the other eye.

Letter size designations and test distances vary. To avoid ambiguity, both should be recorded (eg, J5 at 14 in, 6 point at 40 cm). Some near cards carry distance-equivalent values. These are valid only if the test is done at the recommended distance. If a standard near vision card is not available, any printed matter such as a telephone book or a newspaper may be substituted. Both the approximate type size read and the distance at which the material was held are recorded.

VISUAL ACUITY ESTIMATION IN AN UNCOOPERATIVE PATIENT

Occasionally, you will encounter a patient who is unwilling or unable to cooperate with standard visual acuity testing or who may be suspected of faking

TABLE 1.1 Visual Impairment vs Visual Disability

Visual Impairment	Visual Disability	Comment
20/12 to 20/25	Normal vision	Healthy young adults average better than 20/20 acuity.
20/30 to 20/70	Near-normal vision	Usually causes no serious problems, but vision should be explored for potential improvement or possible early disease. Most states will issue a driver's license to individuals with this level of vision in at least one eye.
20/80 to 20/160	Moderate low vision	Strong reading glasses or vision magnifiers usually provide adequate reading ability; this level is usually insufficient for a driver's license.
20/200 to 20/400 or counting fingers (CF) 10 ft	Severe low vision; legal blindness by US definition	Gross orientation and mobility generally adequate, but difficulty with traffic signs, bus numbers, etc. Reading requires high-power magnifiers; reading speed reduced.
CF 8 ft to 4 ft	Profound low vision	Increasing problems with visual orientation and mobility. Long cane useful to explore environment. Highly motivated and persistent individuals can read with extreme magnification. Others rely on nonvisual communication: Braille, "audio books," radio, etc.
Less than CF 4 ft	Near-total blindness	Vision unreliable, except under ideal circumstances; must rely on nonvisual aids.
NLP	Total blindness	No light perception; must rely entirely on other senses.

blindness. Because the typical visual acuity test will not work for such a patient, you will need to be alert to other signs. Withdrawal or a change in facial expression in response to light or sudden movement indicates the presence of vision. A brisk pupillary response to light also suggests the presence of vision. The exception to this is the patient with cortical blindness, which is due to bilateral widespread destruction of the visual cortex. If there is any doubt, referral to an ophthalmologist is recommended.

Chapter 6 discusses visual testing of infants and toddlers.

CONFRONTATION FIELD TESTING

The examiner takes a position about 1 meter in front of the patient. The patient is asked to cover the left eye with the palm of the left hand; the examiner closes the right eye. Thus, the field of the examiner's left eye is used as a

FIGURE 1.8 Rosenbaum pocket vision screener.

reference in assessing the field of the patient's right eye. The patient is asked to fixate on the examiner's left eye and then count the fingers of the examiner in each of the four quadrants of the visual field. Wiggling the fingers as a visual stimulus is not desirable. After the patient's right eye is tested, the procedure is repeated for the left eye, with the patient covering the right eye with the palm of the right hand, and the examiner closing the left eye.

AMSLER GRID TESTING

Amsler grid testing is a method of evaluating the functioning of the macula. (See Figure 3.17 and Chapter 3 for details.)

EXTERNAL INSPECTION

With adequate room light, the examiner can inspect the lids, surrounding tissues, and palpebral fissure. Palpation of the orbital rim and lids may be indicated, depending on the history and symptoms. Inspection of the conjunctiva and sclera is facilitated by using a penlight and having the patient look up while the examiner retracts the lower lid or look down while the examiner raises the upper lid. The penlight also aids in the inspection of both the cornea and the iris.

UPPER LID EVERSION

Upper lid eversion is sometimes required to search for conjunctival foreign bodies or other conjunctival signs. Topical anesthetic facilitates this procedure. The patient is asked to look down and the examiner grasps the eyelashes of the upper lid between the thumb and the index finger. A cotton-tipped applicator is used to press gently downward over the superior aspect of the tarsal plate as the lid margin is pulled upward by the lashes (Figure 1.9). Pressure is maintained on the everted upper lid while the patient is encouraged to keep looking down. The examiner should have a penlight within reach to inspect the exposed conjunctival surface of the upper lid for a foreign body or other abnormality. A cotton-tipped applicator soaked in topical anesthetic can be used to remove a foreign body. To return the lid to its normal position, the examiner releases the lid margin and the patient is instructed to look up.

OCULAR MOTILITY TESTING

The patient is asked to follow an object in six directions, the cardinal fields of gaze. This enables the examiner to systematically test each muscle in its primary field of action (Table 1.2). Thus, a possible isolated weakness or paralysis of muscle can best be detected. (See Chapter 6 for a description of the cover test for the detection of strabismus, a misalignment of the two eyes, and for an illustration of the cardinal fields of gaze.)

PUPILLARY REACTION TESTING

Inspection of the pupils should be part of the physical examination. The patient's direct and consensual pupillary reactions to light are evaluated in a room with reduced illumination and with the patient looking at a distant object.

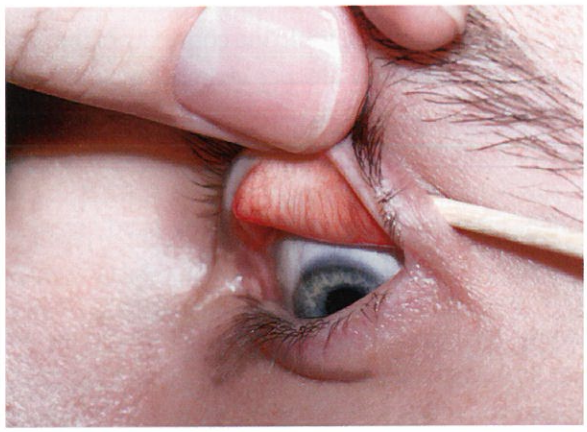

FIGURE 1.9 Upper lid eversion.

TABLE 1.2 Cardinal Fields of Gaze

Right and Up	**Left and Up**
Right superior rectus	Left superior rectus
Left inferior oblique	Right inferior oblique
Right	**Left**
Right lateral rectus	Left lateral rectus
Left medial rectus	Right medial rectus
Right and Down	**Left and Down**
Right inferior rectus	Left inferior rectus
Left superior oblique	Right superior oblique

To test the direct pupillary reaction to light, first direct the penlight at the patient's right eye and see if it constricts (a normal reaction). Repeat for the left pupil. To test the consensual pupillary reaction to light, direct the penlight at the right eye and watch the left pupil to see if it constricts along with the right pupil (a normal consensual response). Repeat for the left pupil, watching the right pupil for the response. Occasionally, this examination may reveal indications of neurologic disease. (See Chapter 7 for greater detail on pupillary examination and a description of the swinging-flashlight test for the detection of an afferent defect in the anterior visual pathway.) Pupillary inspection may reveal active or prior ocular disease with alterations in pupillary shape or size that are the result of local intraocular processes (eg, damage to the pupillary sphincter or adhesion of the iris to the lens).

ANTERIOR CHAMBER DEPTH ASSESSMENT

When the anterior chamber is shallow, the iris becomes convex as it is bowed forward over the lens. Under these conditions, the nasal iris is seen in shadow when a light is directed from the opposite side (Figure 1.10). As the shallowness of the anterior chamber increases, so do the convexity of the iris and the shaded view of the nasal iris. A shallow anterior chamber may indicate narrow-angle glaucoma (also called *angle-closure glaucoma*) or a narrow angle that could close with pupillary dilation.

To assess anterior chamber depth, follow these steps:

1. Shine a light from the temporal side of the head across the front of the eye parallel to the plane of the iris.
2. Look at the nasal aspect of the iris. If two thirds or more of the nasal iris is in shadow, the chamber is probably shallow and the angle narrow.
3. If you are unsure of the extent of shadow, direct the light more from the front of the eye, which will eliminate shadows entirely, and then return the light to the temporal side of the head.
4. Repeat the test for the other eye.

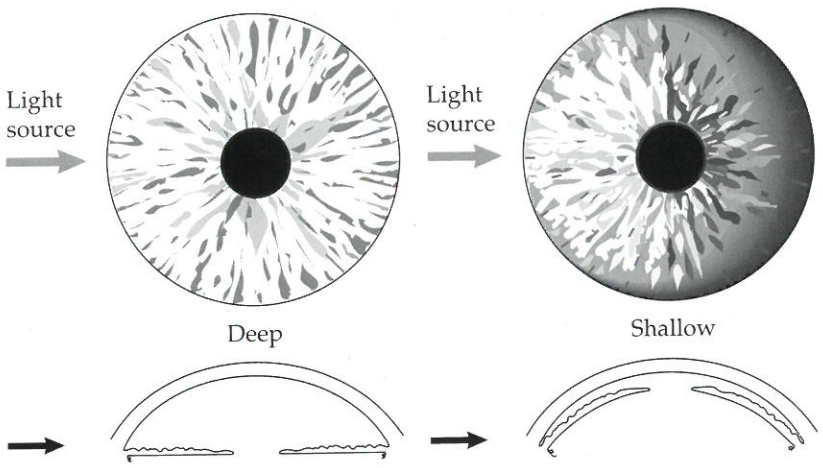

FIGURE 1.10 Estimation of anterior chamber depth.

INTRAOCULAR PRESSURE MEASUREMENT

Intraocular pressure (IOP) is determined largely by the outflow of aqueous humor from the eye. The greater the resistance to outflow, the higher the intraocular pressure. Alterations in the actual production of aqueous humor also have an effect on the intraocular pressure.

Intraocular pressure varies among individuals. An IOP of 15 millimeters of mercury (mm Hg) represents the mean in a "normal" population. However, an IOP in the range from 10 to 21 mm Hg falls within 2 standard deviations of the mean.

Measurement of IOP is part of a glaucoma screening examination, along with ophthalmoscopic assessment of the optic cup. Diagnosing open-angle glaucoma requires additional testing not available to primary care physicians; therefore IOP measurement is not indicated in this setting. However, IOP determination can be useful when the diagnosis of acute angle-closure glaucoma is being considered.

In the past, Schiøtz (indentation) tonometry has been an inexpensive and simple method for primary care physicians to measure intraocular pressure. A Schiøtz tonometer (if available and the physician is skilled in its use) can be used to measure the intraocular pressure in a patient with suspected angle-closure glaucoma. With the patient in a supine position, the Schiøtz device with a given weight is placed on the patient's anesthetized cornea and indents the cornea in an amount related to the IOP. A printed conversion table that accompanies the tonometer is used to determine the IOP in millimeters of mercury.

Currently, handheld electronic tonometers are available in some hospital emergency departments to measure intraocular pressure (Figure 1.11). These

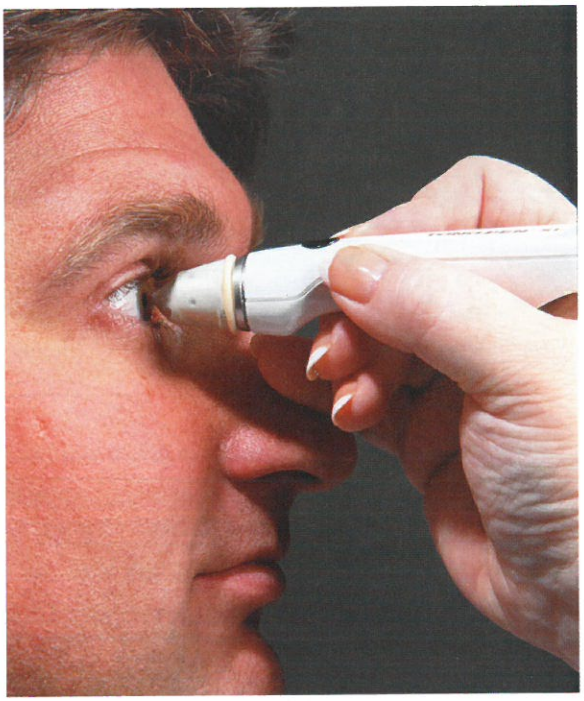

FIGURE 1.11 Electronic tonometry. Electronic tonometry can be performed with the patient in any position. *(Courtesy Mentor.)*

battery-operated devices can be used with the patient in any position, as opposed to other devices that require the patient to be either seated or supine. The intraocular pressure results are obtained rapidly with the electronic tonometer and correlate highly with those obtained by the Goldmann applanation tonometer (a slit-lamp–mounted instrument used by ophthalmologists). Electronic tonometers are expensive and require daily calibration.

To perform electronic tonometry, the practitioner instills topical anesthetic in the patient's eyes, separates the lids, and gently applies the calibrated tonometer to the patient's cornea. The pressure reading and reliability rating displayed on the device are noted in the patient's record.

Topical anesthetics applied for tonometry have little effect on the margins of the eyelids. If the tonometer touches the lids, the patient will feel it and squeeze the lids together, impeding IOP measurement. This can be avoided by holding the patient's lids wide apart with the free hand while applying the tonometer tip with the other hand. Take care not to apply digital pressure to the eyeball while holding the lids apart, as it may produce a false high pressure reading. Prior to measuring the intraocular pressure, contact lenses must be removed. Tonometry should never be attempted in a patient suspected of having a ruptured globe; doing so could result in further damage to the eye.

COLOR VISION TESTING

The normal retina contains three color-sensitive pigments: red-sensitive, green-sensitive, and blue-sensitive. A developmental deficiency in either the concentration or the function of one or more of these pigments causes various combinations and degrees of congenital color vision defects. Most such defects occur in males through an X-linked inheritance pattern. Color vision abnormalities also may be acquired in individuals with retinal or optic nerve disorders.

Color vision testing is performed with the use of pseudoisochromatic plates (eg, Ishihara plates), which present numbers or figures against a background of colored dots. The person with abnormal color discrimination will be confused by the pseudoisochromatic plates, which force a choice based on hue discrimination alone while concealing other clues such as brightness, saturation, and contours.

The patient should wear glasses during color vision testing if they are normally worn for near vision. The color plates are presented consecutively (to each eye separately) under good illumination, preferably natural light. Results are recorded according to the detailed instructions provided with the plates. Usually, a fraction is specified, with the numerator equivalent to the number of correct responses and the denominator the total plates presented. The type of color defect can be determined by recording the specific errors and using the instructions provided with the plates.

FLUORESCEIN STAINING OF CORNEA

Corneal staining with fluorescein (a yellow-green dye) is useful in diagnosing defects of the corneal epithelium. Fluorescein is applied in the form of a sterile filter-paper strip, which is moistened with a drop of sterile water, saline, or topical anesthetic and then touched to the palpebral conjunctiva. A few blinks spread the fluorescein over the cornea. Areas of bright-green staining denote absent or diseased epithelium (Figure 1.12). Viewing the eye under cobalt-blue light enhances the visibility of the fluorescence (Figure 1.13).

Two precautions to keep in mind when using fluorescein are

1. Use fluorescein-impregnated strips instead of stock solutions of fluorescein because such solutions are susceptible to contamination with *Pseudomonas* species.
2. Have the patient remove soft contact lenses prior to application to avoid discoloration of the lenses.

OPHTHALMOSCOPY

When examining the patient's right eye, hold the direct ophthalmoscope in the right hand and use your right eye to view the patient's eye. Use your left

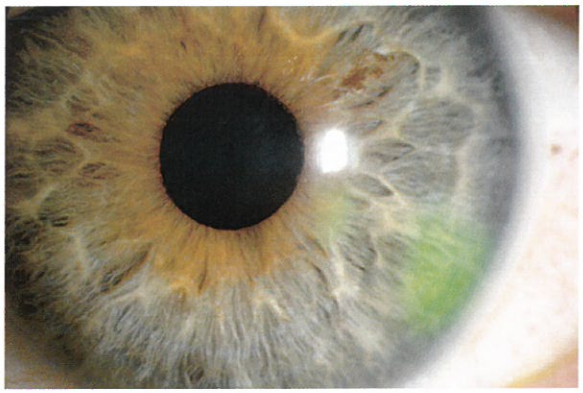

FIGURE 1.12 Fluorescein stain. A corneal abrasion is delineated by fluorescein stain, which marks any area denuded of epithelium. Irregularity of the corneal surface is indicated by the distorted light reflection.

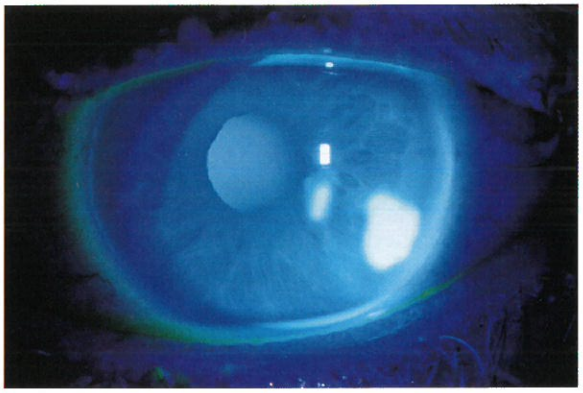

FIGURE 1.13 Fluorescein stain highlighted. The same eye as Figure 1.12 with the addition of cobalt-blue light, which dramatically defines the corneal epithelial defect.

hand and left eye to examine the patient's left eye. The patient's eyeglasses are removed, and, barring large astigmatic refractive errors, most examiners prefer to remove their own glasses as well. Contact lenses worn by either patient or examiner may be left in place.

Pupillary Dilation

Pharmacologic dilation of the patient's pupils greatly facilitates ophthalmoscopy. Recommended agents include tropicamide 1% and phenylephrine hydrochloride 2.5% (see Chapter 9). Dilation of the pupil should not be done under the following conditions:

1. If assessment of anterior chamber depth suggests a shallow chamber and a narrow angle, do not dilate because an attack of angle-closure glaucoma might be precipitated.
2. If a patient is undergoing neurologic observation and pupillary signs are being monitored (eg, a head-injured patient), do not dilate until the neurologist or neurosurgeon determines it is safe to do so.

See Chapter 9 for instructions on applying topical agents.

Method of Direct Ophthalmoscopy

To perform direct ophthalmoscopy, follow these steps:

1. Have the patient comfortably seated. Instruct the patient to look at a point on the wall straight ahead, trying not to move the eyes.
2. Set the focusing wheel at about +8. Set the aperture wheel to select the large, round, white light.
3. Begin to look at the right eye about 1 foot from the patient. Use your right eye with the ophthalmoscope in your right hand. When you look straight down the patient's line of sight at the pupil, you will see the red reflex (see the next section).
4. Place your free hand on the patient's forehead or shoulder to aid your proprioception and to keep yourself steady.
5. Slowly come close to the patient at an angle of about 15° temporal to the patient's line of sight. Try to keep the pupil in view. Turn the focusing wheel in the negative direction to bring the patient's retina into focus.
6. When a retinal vessel comes into view, follow it as it widens to the optic disc, which lies nasal to the center of the retina.
7. Examine the optic disc, retinal blood vessels, retinal background, and macula in that order (see the next section).
8. Repeat for the left eye.

Red Reflex

Light reflected off the fundus of the patient produces a red reflex when viewed through the ophthalmoscope at a distance of 1 foot. A normal red reflex (Figure 1.14) is evenly colored, is not interrupted by shadows, and is evidence that the cornea, anterior chamber, lens, and vitreous are clear and not a significant source for decreased vision. Opacities in the media—such as corneal scar, cataract, and vitreous hemorrhage—appear as black silhouettes and can be best appreciated when the pupil has been dilated.

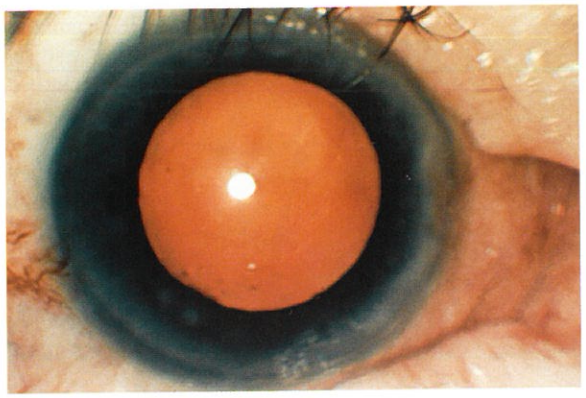

FIGURE 1.14 Red reflex. Reddish light reflected from the fundus can be visible even at a distance of 1 or 2 feet when the direction of illumination and the direction of observation approach each other—a condition that can be achieved with the ophthalmoscope.

Optic Disc

In most cases, when viewed through the ophthalmoscope, the normal optic disc (Figure 1.15) is slightly oval in the vertical meridian and has a pink color that is due to extremely small capillaries on the surface. Detail of these small vessels cannot be discerned, which differentiates them from pathologic vessels on the optic disc. The disc edge or margin should be identifiable (sharp). A central whitish depression in the surface of the disc is called the *physiologic cup*. The optic disc can be thought of as the yardstick of the ocular fundus. Lesions seen with the ophthalmoscope are measured in disc diameters (1 disc diameter equals approximately 1.5 mm).

A great deal of normal variation exists in the appearance of the optic disc. The size of the physiologic cup varies among individuals. (See Chapter 3 for a discussion of glaucomatous cupping.) The pigmented coats of the eye—the retinal pigment epithelium and the choroid—frequently fail to reach the margin of the optic disc, producing a hypopigmented crescent (Figure 1.16, left). Such crescents are especially common in myopic eyes on the temporal side of the optic disc. Conversely, an excess of pigment may be seen in some eyes, producing a heavily pigmented margin along the optic disc (see Figure 1.16, right). The retinal nerve fibers (ie, ganglion cell axons) ordinarily are nonmyelinated at the optic disc and in the retina, but occasionally myelination may extend on the surface of the optic disc and retina, producing a dense, white superficial opacification with feathery edges (Figure 1.17).

Retinal Circulation

The retinal circulation is composed of arteries and veins, visible with the ophthalmoscope (compare Figure 1.15 with Figure 1.18). The central retinal artery branches at or on the optic disc into divisions that supply the four quadrants

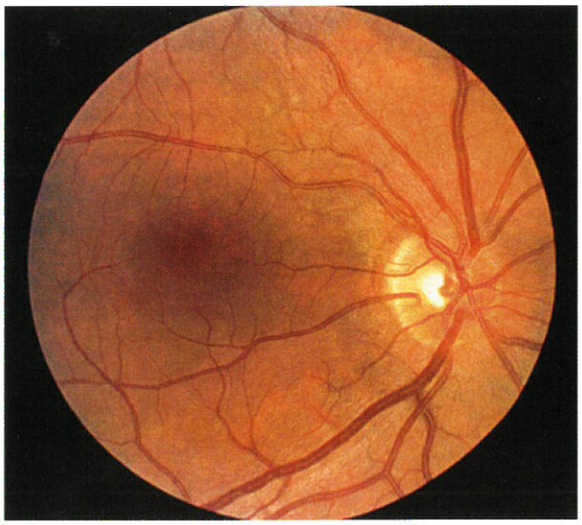

FIGURE 1.15 Normal posterior pole. A normal optic disc is shown, with a small central physiologic cup and healthy neural rim. Major branches of the central retinal artery emanate from the disc, whereas the major branches of the central retinal vein collect at the disc. Temporal to the disc is the macula, which appears darker; no blood vessels are present in the center.

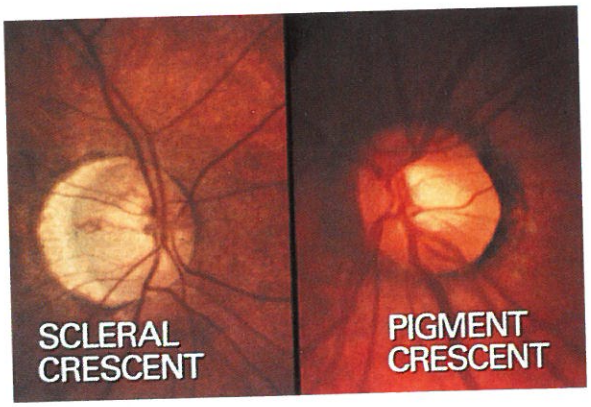

FIGURE 1.16 Scleral crescent and pigmented crescent. This figure shows normal variants of the optic disc. On the left, retinal and choroidal pigmentation does not reach the disc margin, leaving an exposed white scleral crescent. On the right, pigment accumulation is seen at the disc margin.

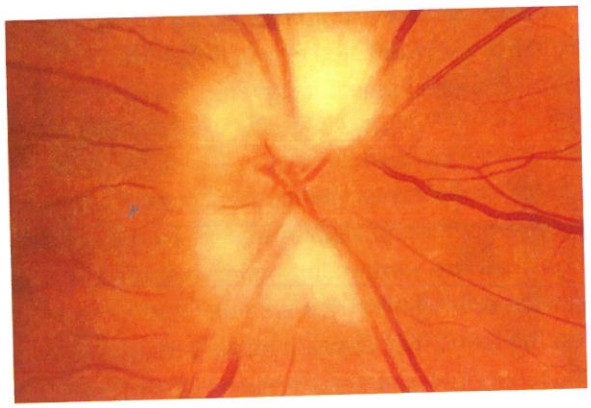

FIGURE 1.17 Myelinated nerve fibers. Usually, the axons of the retinal ganglion cells acquire myelin sheaths only behind the optic disc. Occasionally, as a variant, myelin is deposited along axons at the border of the disc or even away from the disc, elsewhere in the retina. These white, feathery patterns may be mistaken for papilledema.

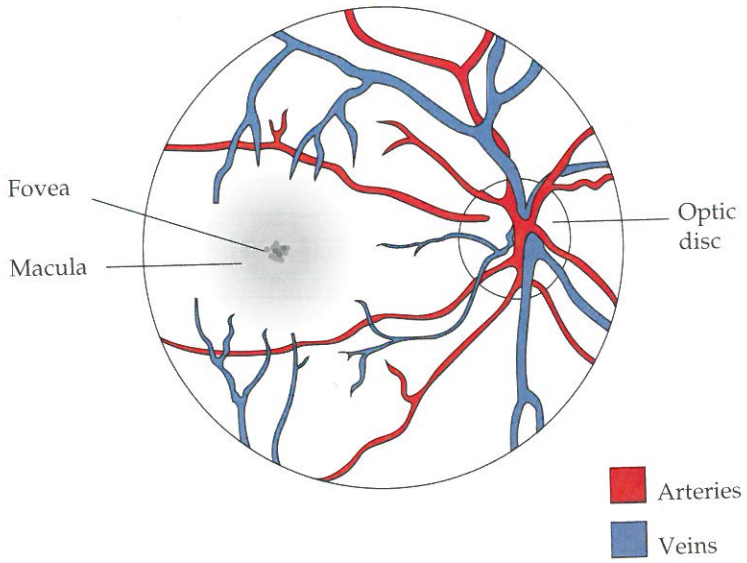

FIGURE 1.18 Fundus diagram.

of the inner retina; these divisions lie superficially in the nerve fiber layer. A similarly arranged system of retinal veins collects at the optic disc, where spontaneous pulsation (with collapse during systole) may be observed in 80% of normal eyes. The ratio of normal vein-to-artery diameter is 3:2. Arteries are usually lighter in color and typically have a more prominent light reflex than veins. The examiner should follow arteries from the disc and veins back to the disc in each quadrant, noting in particular the arteriovenous (A/V) crossing patterns.

Fundus Background

The normal fundus background is a uniform red-orange color due primarily to the pigmentation of the retinal pigment epithelium. The blood and pigment of the choroid also contribute to the appearance of the fundus background. For example, in heavily pigmented eyes, the fundus may have a darker color due to increased choroidal pigment content.

Fovea

The normal fovea, at the center of the macula (see Figures 1.15 and 1.18), is located directly temporal and slightly inferior to the optic disc and usually appears darker than the surrounding retina because the specialized retinal pigment epithelial cells of the fovea are taller and more heavily pigmented. In some eyes, the fovea may appear slightly yellow due to the xanthophyll pigment in the retina. The central depression of the fovea may act as a concave mirror during ophthalmoscopy and produce a light reflection known as the *foveolar reflex.*

SUMMARY OF STEPS IN EYE EXAMINATION

An accurate history must be obtained before beginning the physical examination.

1. Measure the visual acuity for each eye.
2. Perform a confrontation field test for each eye.
3. Inspect the lids and the surrounding tissues.
4. Inspect the conjunctiva and sclera.
5. Test the extraocular movements.
6. Test the pupils for direct and consensual responses.
7. Inspect the cornea and iris.
8. Assess the anterior chamber for depth and clarity.
9. Assess the lens for clarity through direct ophthalmoscopy.
10. Use the ophthalmoscope to study the fundus, including the disc, vessels, and macula.
11. Perform tonometry when acute angle-closure glaucoma is suspected, if a reliable tonometer is available.