CHAPTER 16 – SPECIAL SENSES: THE EYE

OBJECTIVES

On completion of this chapter, you will be able to:

• Describe the anatomical structures of the eye.
• Describe the external structures of the eye.
• Describe the internal structures of the eye.
• Analyze, build, spell, and pronounce medical words.
• Comprehend the drugs highlighted in this chapter.
• Describe diagnostic and laboratory tests related to the eye.
• Identify and define selected abbreviations.
• Describe each of the conditions presented in the Pathology Spotlights.
• Review the Pathology Checkpoint.
• Complete the Study and Review section and the Chart Note Analysis.

OUTLINE

I. Anatomy and Physiology Overview (The Structures of the Human Eye)

   The eye is composed of special anatomical structures that work together to facilitate sight. The coordinated actions of nerves that control the movement of the eyeball, the amount of light admitted by the pupil, the focusing of that light on the retina by the lens, and the transmission of the resulting sensory impulses by the lens, and the transmission of the resulting sensory impulses to the brain by the optic nerve allow the production of vision.

   A. External Structures of the Eye (see Table: Special Senses: The Eye, p. 530)

   1. Orbit – a coned-shaped cavity in the front of the skull that contains the eyeball. It is formed by the combination of several cranial bones and is lined with fatty tissue that cushions the eyeball. There are also several foramina (openings) through which blood vessels and nerves pass.

   2. Muscles of the Eye (Fig. 16–1, p. 531) – there are six eye muscles that control movement of the eye allowing it to follow a moving object and move precisely. Eye muscles also help maintain the shape of the eyeball. The muscles consist of:

      a. Rectus Muscles (four) – allows the eye to move up, down, right, and left.
      b. Oblique Muscles (two) – allows the eye to be turned in order to see upper left and upper right, lower left and lower right.

   3. Eyelids – their blinking motion keeps the eyeball’s surface lubricated and free from dust and debris. The eyelids, which are also known as superior and inferior palpebrae; are continuous with the skin, covers the eyeball, and protect it from

      • Intense light
Foreign particles
Impact

Parts of the eyelid include the:

a. **Canthus** – the angle at either corner of the eye.

b. **Palpebral Fissure** – the slit between the eyelids through which light reaches the inner eye.

c. **Eyelashes** – located on the edges of the eyelids, they protect the eyeball by preventing foreign particles from coming in contact with the eyeball.

d. **Meibomian Glands** – secrete sebum, oily substance that keeps the eyelids from sticking together. These glands are embedded into the **tarsal plate** of each eyelid and are also called **tarsal glands** and **palpebral glands**.

4. **Conjunctiva** – a mucous membrane lining of the underside of each eyelid and reflected onto the anterior portion of the eyeball. The membrane acts as a protective covering for the exposed surface of the eyeball.

5. **Lacrimal Apparatus** (Fig. 16–2, p. 532) – those structures that produce, store, and remove the tears that cleanse and lubricate the eye. The structures of the lacrimal apparatus are:

a. **Lacrimal Gland** – located at the outer corner of the eye, they secrete tears through 12 ducts onto the surface of the conjunctiva of the upper lid. The fluid washes across the anterior surface of the eye and is collected by the **lacrimal canaliculi**.

b. **Lacrimal Canaliculi** – two ducts at the inner corner of the eye that collect tears and drain them into the **lacrimal sac**.

c. **Lacrimal Sac** – the enlargement of the upper portion of the lacrimal duct. Tears secreted by the lacrimal glands are pulled into this sac and forced into the **nasolacrimal ducts** by the blinking action of the eyelids. The sac is dilated and pulls in fluid as the muscles associated with blinking close the lid. The sac constricts, forcing the fluid down the nasolacrimal duct, as the lid is opened.

d. **Nasolacrimal Duct** – the passageway draining lacrimal fluid into the nose. The lacrimal sac is the enlarged portion of this duct.

B. **Internal Structures of the Eye** (Fig. 16–3, p. 533)

1. **Eyeball** – the organ of vision; is globe shaped and divided into two cavities. The space in front of the lens, called the ocular cavity, is further divided by the iris into:

   • **Anterior Chamber** – filled with aqueous humor, a watery fluid.
• **Posterior Chamber** – filled with vitreous humor, a jellylike material, which maintains the eyeball’s spherical shape.

• **Three Layers** – forming the outer, middle, and inner surfaces of the eyeball.

  a. **Outer Layer** – composed of the sclera or white of the eye and the cornea or anterior transparent portion of the eye’s fibrous outer surface. The curved surface of the cornea is important in that it bends light rays and helps to focus them on the surface of the retina.

  b. **Middle Layer** – known as the uvea, lies just below the sclera. It consists of the:

     • **Iris** – the colored membrane attached to the ciliary body and suspended between the lens and cornea in the aqueous humor. It has a circular opening in its center – the pupil – and two muscles that contract or dilate to regulate the amount of light admitted by the pupil.

     • **Ciliary Body** – a thickened portion of the vascular membrane to which the iris is attached. Smooth muscle forming a part of the ciliary body governs the convexity of the lens. It secretes the aqueous humor, that nourish the cornea, the lens, and the surrounding tissues.

     • **Choroid** – a pigmented vascular membrane that prevents internal reflection of light.

  c. **Inner Layer** (Fig. 16–4, p. 534) – also known as the retina, is richly supplied with blood vessels and contains photoreceptive cells that translate light waves focused on its surface into nerve impulses. **Rods** and **cones** are the photosensitive cells of the retina.

     • **Cones** – approximately 6 million in number, cones are sensitive to bright light and color vision. Most cones are grouped into small areas called the macula lutea. In the center of each macula lutea is a small depression, the fovea centralis, containing only cone cells, which is the central focusing point within the eye.

     • **Rods** – approximately 120 million in number, rods are sensitive to dim light and used for night vision. They contain rhodopsin, a pigment necessary for night vision. The point at which nerve fibers from the retina converge to form the optic nerve is known as the optic disk. Nerve fibers of the optic nerve extend to the thalamus and on to the visual cortical areas of the brain. The absence of rods and cones in
the area of the optic disk creates a **blind spot** on the surface of the retina, located about 3 millimeters to the nasal side of the macula. It is the only part of the retina that is insensitive to light.

d. **Lens** – a colorless crystalline, biconvex in shape and enclosed in a transparent capsule, it is suspended by a ligament just behind the iris. Contraction and relaxation of the ciliary muscle control the tension of the suspensory ligaments to change the shape of the lens. The function of the lens is to sharpen the focus of light on the retina. This process, called **accommodation**, is reflective in nature and combines changes in the size of the pupil, curvature of the lens, and convergence of the optic axes to keep the image in the same place on both retinae. Accommodation occurs for both near and distant vision.

C. **How Sight Occurs** (Figs. 16–5 and 16–6, p. 535) – the following occurs when a person views external objects:

1. The light rays strike the eye and then pass through the cornea, pupil, aqueous humor, lens, and vitreous humor.
2. The rays then reach the retina and stimulate the rods and cones.
3. An upside-down image is relayed along nerve impulses to the optic nerve.
4. The images are transferred to the brain, which turns the images into a right-side-up image. This is the one that the person sees.

II. **Life Span Considerations**

A. **The Child** – the eyes begin to develop as an outgrowth of the forebrain in the 4-week-old embryo and are structurally complete at 24 weeks. At 28 weeks, eyebrows and eyelashes are present, and the eyelids open. The newborn can see, and **visual acuity** is approximately 20/400. Some characteristics present in the eyes of the newborn are:

1. **Appearance of the Eyes being Crossed** – eye muscles are not fully developed.
2. **Eyes Appear to be Blue or Gray** – permanent coloring becomes fixed between 6 and 12 months of age.
3. **Lack of Tears** – lacrimal gland ducts develop at between 1 to 3 months.
4. **Lack of Depth Perception** – depth perception develops around 9 months.

Visual acuity improves with age and by the age of 2 or 3 years, it is around 20/20. Children are farsighted until about 5 years of age.

B. **The Older Adult** – the following conditions may plague the older adult:

1. **Decreased Ability to Focus**
2. **Ciliary Muscles Weakness** – results in the decrease in pupil size which reduces the amount of light to the retina.
3. **Lens Becomes Stiff and Thicker**
4. **Lens Discoloration** – begins to yellow.
5. **Presbyopia** – farsighted along with the inability to focus.
6. **Sensitivity to Glare**
7. **Night Vision Impairment** – makes night driving difficult.
8. **Cataracts** – lens becomes opaque.
9. **Vascular Degeneration** – affects the retina, which contains nerves for receiving images rendering permanent loss of vision.
10. **Macular Degeneration** – the leading cause of new cases of blindness in the older adult. This disease affects the macula, the part of the eye that is responsible for sharp central vision.

III. **Building Your Medical Vocabulary**

A. **Medical Words and Definitions** – this section provides the foundation for learning medical terminology. Medical words can be made up of four types of word parts:

1. **Prefix (P)**
2. **Root (R)**
3. **Combining Forms (CF)**
4. **Suffixes (S)**

By connecting various word parts in an organized sequence, thousands of words can be built and learned. In the text, the word list is alphabetized so one can see the variety of meanings created when common prefixes and suffixes are repeatedly applied to certain word roots and/or combining forms. Words shown in **pink** are additional words related to the content of this chapter that have not been divided into word parts. Definitions identified with an **asterisk icon (*)** indicate terms that are covered in the Pathology Spotlights section of the chapter.

IV. **Drug Highlights**

A. **Drugs Used to Treat Glaucoma** – either increase the outflow of aqueous humor, decrease its production, or produce both of these actions.

1. **Prostaglandin Analogues** – work by increasing the drainage of intraocular fluid, thereby decreasing intraocular pressure.
2. **Adrenergic Drugs** – increase drainage of intraocular fluid.
3. **Alpha Antagonist** – works to both decrease production and increase drainage.
4. **Beta Blockers** – decrease the production of intraocular fluid.
5. **Carbonic Anhydrase Inhibitors** – decrease production of intraocular fluid.
6. **Cholinergic (Miotic)** – increases drainage of intraocular fluid.
7. **Cholinesterase** – increases drainage of intraocular fluid.
8. **Combination of Beta Blockers and Carbonic Anhydrase Inhibitors** – decreases production of intraocular fluid

B. **Mydriatics** – agents that are used to produce dilation of the pupil.
1. **Anticholinergics** – produce dilation of the pupil (mydriasis) and interferes with the ability of the eye to focus properly (cycloplegia). They are used to aid in refraction, during internal examination of the eye, in intraocular surgery, and in the treatment of anterior uveitis and secondary glaucoma.

2. **Sympathomimetics** – produce mydriasis without cycloplegia. Pupil dilation is obtained as the drug causes contraction of the dilator muscle of the iris. They also affect intraocular pressure by decreasing the production of aqueous humor while increasing its outflow from the eye.

C. **Antibiotics** – used to treat infectious disease and come in the form of an ointment, cream, or solution.

D. **Antifungal Agents** – used to treat fungal infections of the eye.

E. **Antiviral Agents** – used to treat keratitis caused by the herpes simplex virus. Some antiviral agents are used to treat viral infections of the eye and herpes simplex infections.

V. **Diagnostic and Lab Tests**
   A. **Color Vision Tests (Fig. 16–14, p. 547)** – use of polychromatic, multicolored, charts or an anomaloscope, a device for detecting color blindness, to assess the ability to recognize differences in color.
   B. **Exophthalmometry** – measurement of the forward protrusion of the eye via an exophthalometer; used to evaluate an increase or decrease in exophthalmos, an abnormal protrusion of the eyeball.
   C. **Gonioscopy** – examination of the anterior chambers of the eye via a gonioscope; used to determine ocular motility and rotation.
   D. **Keratometry** – measurement of the cornea via a keratometer.
   E. **Ocular Ultrasonography** – use of high-frequency sound waves using a small probe placed on the eye, to measure for intraocular lenses (IOL) and to detect orbital and periorbital lesions; also used to measure the length of the eye and the curvature of the cornea in preparation for surgery.
   F. **Ophthalmoscopy** – examination of the interior of the eye via an ophthalmoscope; used to identify changes in the blood vessels in the eye and to diagnose systemic diseases.
   G. **Tonometry (Fig. 16–13, p. 545)** – measurement of the intraocular pressure (IOP) of the eye via a tonometer; used to screen for and detect glaucoma.
   H. **Visual Acuity (Fig. 16–15, p. 548)** – measurement of the acuteness or sharpness of vision. A Snellen eye chart can be used, and the patient reads letters of various sizes from a distance of 20 feet. Normal vision is 20/20.

VI. **Abbreviations (p. 548)**

VII. **Pathology Spotlights**
A. **Cataract (Fig. 16–16, p. 550)** – a clouding of the lens of the eye that can cause vision problems. In early stages, a cataract may not cause problems, but over time, it may grow larger and cloud larger portions of the lens, making it harder to see. Because less light reaches the retina, the patient’s vision may become dull and bleary. Cataracts won’t spread from eye to eye, but may develop in both eyes. Etiology is unknown for cataract development, but some scientists think that several causes include smoking, diabetes, and excessive exposure to sunlight can contribute. Once cataracts are diagnosed they can be treated with eyeglasses, magnifying lenses, stronger light, or surgery. The most common surgery to remove cataracts is **phacoemulsification**. Cataract surgery is safe and about 90% effective. The symptoms of cataracts include:

- Cloudy or blurry vision
- Problems with light
- Colors that seem faded
- Poor night vision
- Double or multiple vision
- Frequent changes in vision prescriptions

There are four different types of cataracts:

1. **Age-Related Cataracts** – more than half of all Americans age 65 and older have a cataract.
2. **Congenital Cataracts** – some babies are born with cataracts or develop them in childhood, often in both eyes.
3. **Secondary Cataracts** – develop in those with certain other health problems.
4. **Traumatic Cataracts** – cataracts can develop after eye trauma or years later.

B. **Conjunctivitis** – commonly called **pinkeye**, is an inflammation of the conjunctiva. The condition is the most common and treatable eye infections in children and adults. Conjunctivitis can be caused by a:

- Virus
- Bacteria
- Irritating substances, including smoke, shampoo, dirt, and pool chlorine
- Allergens
- Sexually transmitted diseases (STDs)

The symptoms of conjunctivitis are:

- Redness – occurs in the white of the eye or inner eyelid.
- Increased amount of tears
- Thick yellow discharge – occurs with bacterial conjunctivitis; the discharge crusts over the eyelashes.
- Green or white discharge
- Itchy eyes – most common with allergic conjunctivitis.
- Burning eyes – especially with conjunctivitis caused by chemicals and irritants.
• Blurred vision
• Increased sensitivity to light

An ophthalmologist or family physician diagnose conjunctivitis by conducting an eye exam and perhaps taking a sample of fluid from the eyelid using a cotton swab. Treatment is based on the cause and can include antibiotic eye drops/ointments for bacterial conjunctivitis. Eye drops containing antihistamines, nonsteroidal anti-inflammatory agents, or corticosteroids can be used if allergies are the cause. If foreign matter has caused the inflammation, it is removed.

C. Glaucoma (Fig. 16–13, p. 545) – a group of eye diseases characterized by increased intraocular pressure (IOP). Glaucoma occurs when aqueous humor is blocked and drains too slowly from the anterior chamber. This causes a buildup of intraocular pressure that is too high for proper functioning of the optic nerve. When diagnosed early and managed properly, blindness can be prevented. There are three major categories of glaucoma (Fig. 16–17, p. 551):

• Closed-Angle (Acute) Glaucoma
• Open-Angle (Chronic) Glaucoma
• Congenital Glaucoma

The predisposing factors of developing glaucoma include:

• Age of 60 years or more
• African ancestry
• Family member with glaucoma or diabetes
• Previous eye injury
• Use of steroid medication
• Myopia
• Thyroid disease
• Diabetes
• Hypertension

Glaucoma can be treated with one of the following types of laser surgery or a procedure:

1. Laser Peripheral Iridotomy (LPI) – small hole made in iris to allow fall back from the fluid channel and help the fluid drain.

2. Argon Laser Trabeculoplasty (ALT) – laser beam opens the fluid channel of the eye, helping the drainage system to work better.

3. Selective Laser Trabeculoplasty (SLT) – laser surgery that uses a combination of frequencies allowing the laser to work at very low levels. It treats specific cells selectively and leaves untreated portions of the trabecular meshwork (the meshlike drainage canals surrounding the iris) intact.

4. Filtering Microsurgery – procedure used to make a tiny hole in the sclera (sclerostomy) allowing the fluid to flow out of the eye and thereby helping to lower eye pressure. It is used when
medications and/or laser surgery does not lower the intraocular pressure of the eye.

D. **Macular Degeneration** – an incurable eye disease that leads to blindness for those affected in the 55 age range and older. It is caused by the deterioration of the central portion of the retina, the inside back layer of the eye, that records the images a person sees and sends them via the optic nerve from the eye to the brain. The *macula* is the central portion of the retina and is responsible for the ability to read, drive a car, recognize faces or colors, and see objects in fine detail. There are two basic types of macular degeneration:

1. **Dry Macular Degeneration** – accounting for approximately 85 to 90% of all cases, it is the deterioration of the retina associated with the formation of small yellow deposits, known as *drusen*, under the macula. This effect leads to a thinning and drying of the macula. The amount of central vision loss is directly related to the amount of retinal thinning caused by the drusen. There is no known treatment for the dry type of macular degeneration. The signs and symptoms can include:
   - The need for increasing bright illumination when doing any types of close work.
   - Printed words seem increasingly blurry.
   - Colors that seem washed out and dull.
   - An increase in the haziness of overall vision.
   - Blind spots in the center of the visual field (VF) with a profound drop in central vision.

2. **Wet Macular Degeneration** – known as “wet” because it is the exudative type. Abnormal blood vessels known as *subretinal neovascularization* grow under the retina and macula. These new vessels may bleed and leak fluid causing the macula to bulge and lift up, thus distorting or destroying central vision. Vision loss can be rapid and severe if not treated immediately with laser surgery. The symptoms may appear rapidly and include:
   - Visual distortion, such as straight lines appearing wavy or crooked
   - Decreased central vision
   - Central blurry spot

E. **Stargardt’s Disease** – also called *juvenile macular degeneration*, an inherited disease that affects one in 10,000 people. It usually manifests itself between the ages of 7 and 12. It is believed to cause the eye’s central vision to deteriorate because the rod cells just outside the macula erode and this harms the *retinal pigment epithelium* (RPE). As RPE fails, the disease may spread to the macula’s cone cells, causing the characteristic loss of central vision. Vision loss is usually slow until 20/40 level then rapidly progressive to the 20/200 level in a matter of months. There is no cure or treatment effective for this type of degeneration.
VIII. Pathology Checkpoint

IX. Study and Review (pp. 554–559)

X. Practical Application: SOAP: Chart Note Analysis