OBJECTIVES: to understand the anatomy of the bony orbit and its contents, in particular, (1) the eyelids and lacrimal apparatus, (2) the extrinsic musculature of the eyeball, (3) the orbital vasculature, and (4) the cranial nerves within the orbit (i.e., CN II, CN III, CN IV, branches of CN V₁, and CN VI).

SUGGESTED READING: Moore & Dalley’s text: 899–916; Moore & Persaud’s Embryology text: 492–503
LAB READING: Dissector: 244–251

I. Osteology
A. Margin: frontal, maxilla, zygomatic
B. Superior wall: orbital plate of frontal, sphenoid bones
C. Medial wall: orbital lamina (lamina papyracea) of ethmoid bone, lacrimal, sphenoid, and frontal
D. Inferior wall: mostly maxilla, also zygomatic & palatine
E. Lateral wall: zygomatic bone and greater wing of sphenoid
F. Openings within the orbit
   1. Superior orbital fissure
      a. Largely within sphenoid bone (between greater & lesser wings)
      b. Opens posteriorly into middle cranial fossa
      c. Transmits: oculomotor n. (CN III), trochlear n. (CN IV), abducens n. (CN VI), branches of ophthalmic n. (CN V₁), superior ophthalmic v.
   2. Optic canal
      a. Within sphenoid bone
      b. Transmits optic n. (CN II), and ophthalmic a.
   3. Supraorbital foramen (or notch)
      a. Within frontal bone
      b. Transmits: supraorbital vessels and nerve
   4. Anterior & posterior ethmoidal foramina
      a. Within or near the suture between frontal and ethmoid bones
      b. Transmits: anterior and posterior ethmoidal vessels and nerves
   5. Nasolacrimal canal and groove
      a. Between lacrimal and maxilla
      b. Transmits: lacrimal sac and nasolacrimal duct
   6. Inferior orbital fissure
a. Between greater wing of sphenoid, maxilla, and zygomatic, and a very small part of the palatine
b. Opens into the pterygopalatine fossa and thereby into the infratemporal and temporal regions—(i.e., the superior orbital fissure opens internally into the brain (cranial cavity) whereas the inferior orbital fissure opens externally into the temporal region)
c. Transmits: maxillary n. (CN V\textsubscript{2}), infraorbital vessels, branches from the pterygopalatine ganglion

II. Orbital contents
   A. Eyelids and lacrimal apparatus
      1. Eyelids
         a. Palpebral fissure: the cleft between the eyelids
         b. Palpebral conjunctiva
            (1). Mucous membrane lining the internal portion of the eyelid
            (2). Continuous with the bulbar conjunctiva on the eyeball, thus partially enclosing the conjunctival sac
         c. Superior and inferior tarsi (= tarsal plates): rigid plates of dense connective tissue reinforcing each eyelid
         e. Orbicularis oculi muscle: the major sphincter of the palpebral fissure
         f. Levator palpebrae superioris: actively opens palpebral fissure (see below for more information); opening of fissure also caused passively by elastic recoil of tissues following relaxation of orbicularis oculi
         f. Medial and lateral palpebral ligaments
            (1). Attach eyelids and associated muscles to the bony orbit
            (2). Medial and lateral ligaments connected to each other via the tarsal plates

      2. Lacrimal apparatus
         a. Lacrimal gland
            (1). Moderate-sized gland located in the superolateral portion of the orbit and opening into the superior fornix of the conjunctival sac
            (2). Produces lacrimal fluid (= tears) which are carried medially across the corneal surface as the lids blink, moistening and cleansing the area
         b. Lacrimal punctum
            (1). Small opening on the internal surface of each eyelid at the medial canthus (= corner of eye)
            (2). Located at the tip of the lacrimal papilla
         c. Lacrimal canaliculus: small canal leading from the lacrimal punctum to the lacrimal sac
         d. Lacrimal sac
            (1). Collects tears from superior and inferior lacrimal canaliculi and conveys them to the nasolacrimal duct
            (2). A small slip of orbicularis oculi extends posterior to the lacrimal sac causing the sac to be emptied each time the orbicularis oculi contracts
         e. Nasolacrimal duct: conducts tears from lacrimal sac to nasal cavity; located within and between lacrimal and maxillary bones
         f. Summary of movement of lacrimal fluid: lacrimal gland $\Rightarrow$ conjunctival sac $\Rightarrow$ lacrimal punctum $\Rightarrow$ lacrimal canaliculus $\Rightarrow$ lacrimal sac $\Rightarrow$ nasolacrimal duct $\Rightarrow$ nasal cavity

   B. Extrinsic musculature
      1. Four rectus muscles (superior, inferior, lateralis, medialis)
         a. Origin: common annular (= ring) tendon (= tendinous ring, anulus tendineus): a tendinous cuff surrounding the optic canal and the juncture of the superior and
inferior ophthalmic fissures; two "heads" of lateral rectus produce a lateral hiatus in tendinous ring through which pass various nerves

b. Insertion: on the eyeball at the sclerocorneal junction according to their named position

2. Two oblique muscles (superior and inferior)
   a. Superior oblique
      (1). Origin: on the sphenoid bone superomedial to the tendinous ring
      (2). Course and insertion: passes superomedial to medial and superior rectus, its
tendon running through a fascial loop (the trochlea) attached to the superomedial edge of the orbit, after which it makes an acute angle to insert obliquely on the posterolateral surface of the eyeball
   
   b. Inferior oblique
      (1). Origin: maxillary floor of orbit
      (2). Course and insertion: passes posterolaterally to insert on the sclera inferior to inferior rectus

3. Actions of six extraocular muscles: complex due to the difference between the orbital axis and the optic axis
   a. Eyeball rotates around three axes: vertical, horizontal, and sagittal
   b. Rotation about the vertical axis: adduction/abduction
      (1). Medial and lateral rectus act only with respect to the vertical axis
         (a). Lateral rectus: abduction
         (b). Medial rectus: adduction
      (2). Superior and inferior rectus attach medial to the vertical axis and are thus adductors
      (3). Superior and inferior oblique attach posterolateral to the vertical axis and are hence abductors
   c. Rotation about the horizontal axis: elevation/depression
      (1). Superior and inferior rectus both attach anterior to the horizontal axis and thus have straightforward actions: elevation and depression, respectively
      (2). Superior oblique attaches posterior to the horizontal axis and thus draws the posterosuperior surface anteriorly—hence, depression
      (3). Inferior oblique attaches posterior to the horizontal axis and thus draws the posteroinferior surface anteriorly—hence, elevation
   d. Rotation about the sagittal axis: medial rotation (intorsion) vs. lateral rotation (extorsion)
      (1). Superior rectus and superior oblique pull the superior surface medially, hence
         producing intorsion
      (2). Inferior rectus and inferior oblique pull the inferior surface medially, hence producing extorsion
   e. Dysfunctional actions (usually due to damage to motor nerves) produces diplopia
      (double vision)

4. Levator palpebrae superioris
   a. A portion of superior rectus that delaminates embryologically from the superior rectus, attaching to the superior tarsus within the eyelid rather than to the eyeball
   b. Opens the palpebral fissure

5. Innervation (see below also)
   a. Oculomotor n. (CN III)
      (1). Superior division: Superior rectus, levator palpebrae superioris
      (2). Inferior division: medial rectus, inferior rectus, inferior oblique
b. Trochlear n. (CN IV): superior oblique

c. Abducens n. (CN VI): lateral rectus

C. Orbital vessels

1. Ophthalmic a.
   a. Branches off internal carotid just anterior to cavernous sinus; runs within the dural sheath of the optic n.
   b. Branches
      (1). Central artery of the retina: pierces optic n. within the dural sheath to enter the eyeball at the optic disc
      (2). Long and short posterior ciliary arteries: pierce sclera; supply the iris and ciliary body
      (3). Anterior ciliary arteries: branch variably off muscular branches to supply the anterior part of the eyeball
      (4). Lacrimal a.
         (a). Branches to lacrimal gland and eyelids
         (b). Recurrent meningeal a.: anastomoses with middle meningeal a. (hence, an anastomosis between external & internal carotid arteries)
         (c). Zygomatic a.: divides into zygomaticofacial and zygomaticotemporal arteries, passing through foramina of the same name within the zygomatic bone
      (5). Posterior and anterior ethmoidal arteries: run with nerves of the same name to enter the nasal cavity and paranasal air sinuses
      (6). Supraorbital a.: runs with supraorbital n. and emerges onto forehead, passing through the supraorbital foramen or notch
      (7). Supratrochlear a.: runs in the area of the trochlea, emerging on and supplying the forehead
      (8). Dorsal nasal a.: supplies external surface of nose; anastomoses with facial a.

2. Ophthalmic veins
   a. Receives blood from tributaries having the same names as the above arteries
   b. Superior ophthalmic v.: anastomoses with facial v. anteriorly; passes through superior orbital fissure to drain into the cavernous sinus
   c. Inferior ophthalmic v.: forms a venous plexus on the orbital floor; passes through inferior orbital fissure, ultimately to drain into the cavernous sinus

D. Cranial nerves of the orbit

1. Optic n. (CN II)
   a. Special somatic afferent conveying visual information from the retina
   b. Cell bodies are the ganglion cells located in the neuroepithelium of the retina (these are secondary sensory neurons and hence the optic "nerve" is actually a CNS tract)
   c. Axons of ganglion cells converge within the retina at the optic disc and then pass posteriorly as the optic n. through the orbit and optic canal (within the sphenoid bone) to enter the middle cranial fossa
   d. Optic chiasma: union of the two optic nerves, with about half the fibers (those from the nasal [medial] part of the retina) crossing the midline, the other half (those from the temporal [lateral] part of the retina) remaining ipsilateral
   e. Optic tracts: carry the fibers posteriorly to the lateral geniculate bodies of the thalamus; contain fibers from the temporal (lateral) half of the ipsilateral retina and fibers from the nasal (medial) half of the contralateral retina
f. Lesions in various portions of the optic pathways produce very characteristic visual field defects

2. Oculomotor n. (CN III)
   a. General somatic efferent (motor) to levator palpebrae superioris and all extraocular muscles except superior oblique and lateral rectus
      (1). Passes from nucleus in midbrain through the lateral wall of the cavernous sinus, then through the superior orbital fissure and common tendinous ring where it then divides into two branches
      (2). Two branches
         (a). Superior division: to levator palpebrae superioris and superior rectus
         (b). Inferior division
            (i). To other extraocular muscles
            (ii). Preganglionic parasympathetics to ciliary ganglion
   b. General visceral efferent (visceromotor)
      (1). Preganglionic parasympathetic axons (of neurons with cell bodies in accessory oculomotor [Edinger-Westphal] nucleus) run with oculomotor n.
      (2). Fibers synapse in ciliary ganglion
      (3). Postganglionic parasympathetics emerge from ciliary ganglion to run in short ciliary nerves innervating sphincter pupillae and ciliary muscle
   c. Conditions resulting from lesions of oculomotor n.
      (1). Diplopia (double vision)
      (2). Ptosis (drooping of eyelid): due to paralysis of levator palpebrae superioris
      (3). Pupillary dilation: due to paralysis of sphincter pupillae
      (4). Loss of accommodation: due to paralysis of ciliary muscle

3. Trochlear n. (CN IV)
   a. General somatic efferent (motor) to superior oblique
   b. Axons of cell bodies located in the midbrain emerge dorsally, passing through the lateral wall of the cavernous sinus and the superior orbital fissure (but not traversing the common tendinous ring) to reach the superior oblique

4. Abducens n. (CN VI)
   a. General somatic efferent (motor) to lateral rectus
   b. Axons of cell bodies located in the midbrain pass through the cavernous sinus, superior orbital fissure, and common tendinous ring to reach the lateral rectus

5. Orbital branches of ophthalmic division of trigeminal n. (CN V
   a. General somatic afferent (sensory) fibers only
   b. Passes into orbit from middle cranial fossa via superior orbital fissure
   c. Named branches correspond partially to arteries
   d. Three major branches of ophthalmic n.
      (1). Lacrimal n.
         (a). Innervates lacrimal gland, conjunctiva, and superior eyelid
         (b). Carries autonomic to lacrimal gland (see below)
      (2). Frontal n.
         (a). Passes superior to levator palpebrae superioris (not through common tendinous ring)
         (b). Branches: supraorbital n. & supratrochlear n.
      (3). Nasociliary n.
         (a). Passes through common tendinous ring
         (b). Branches
E. Orbital autonemics

1. Ciliary ganglion
   a. Peripheral parasympathetic ganglion
   b. Situated between optic nerve and lateral rectus muscle
   c. Preganglionic axons of neurons with cell bodies in the accessory oculomotor (= Edinger-Westphal) nucleus travel with the oculomotor n. (CN III) and synapse in the ciliary ganglion
   d. Postganglionic axons of neurons with cell bodies in the ciliary ganglion travel in the short ciliary nerves to innervate two muscles:
      (1). Sphincter pupillae
      (2). Ciliary muscle
   e. Fibers from the nasociliary n. pass through the ganglion without synapsing to convey sensory information from the eye
   f. Postganglionic sympathetic axons of neurons with cell bodies in the superior cervical ganglion travel along the arteries (as part of the internal carotid plexus), pass through the ganglion without synapsing, travel in the short ciliary nerves, and ultimately innervate the dilator pupillae and other smooth muscle

2. Autonomic innervation of lacrimal gland
   a. Parasympathetic
      (1). Preganglionic parasympathetic axons of neurons with cell bodies in the midbrain travel in the facial n., greater petrosal n, and nerve of pterygoid canal to synapse in the pterygopalatine ganglion
      (2). Postganglionic parasympathetic axons of neurons with cell bodies in the pterygopalatine ganglion travel along a communicating branch between the maxillary n. and lacrimal n. to reach the lacrimal gland in the lacrimal n.
   b. Sympathetic: postganglionic sympathetic axons of neurons with cell bodies in the superior cervical ganglion travel on the arteries as part of the carotid plexus to eventually run in the nerve of pterygoid canal, pass though the pterygopalatine ganglion without synapsing, and take the same subsequent route as the parasympathetics
   c. Function
      (1). Parasympathetic: stimulate secretion
      (2). Sympathetic: inhibit secretion

Self Test
1. List the orbital foramina and the structures that traverse them.
2. Describe the course taken by lacrimal fluid from its production to its elimination.
3. Understand how the extraocular muscles control eye movements. Which muscles abduct, adduct, elevate, depress, and rotate the eye? What are their innervations?
4. What functions would be impaired in a lesion of the oculomotor nerve?
Figure 41.2. The bony walls of the orbit (orbital cavity).

Figure 43-34. The tarsi and their ligaments. Right eye; anterior view.

Figure 41.3. Diagram of the orbital cavity (on sagittal section).
Figure 41.7. The actions of the 6 muscles of the right eyeball represented graphically. MR, medial rectus; SR, superior rectus; IR, inferior rectus; SO, superior oblique; IO, inferior oblique.

Table 30-1. Intracranial Musculature

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Primary Action</th>
<th>Secondary Actions</th>
<th>Innervation</th>
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<tr>
<td>Superior rectus</td>
<td>Anulus tendineus</td>
<td>Anterosuperior aspect</td>
<td>Elevation</td>
<td>Adduction and intorsion</td>
<td>Oculomotor</td>
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<tr>
<td>Inferior oblique</td>
<td>Lacrimal bone</td>
<td>Posterior lateral inferior quadrant</td>
<td>Elevation</td>
<td>Abduction and extorsion</td>
<td>Oculomotor</td>
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<tr>
<td>Inferior rectus</td>
<td>Anulus tendineus</td>
<td>Anteroinferior aspect</td>
<td>Depression</td>
<td>Adduction and extorsion</td>
<td>Oculomotor</td>
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<tr>
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<td>Sphenoid bone</td>
<td>Posterior lateral super quadrants</td>
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<td>Abduction and intorsion</td>
<td>Trochlear</td>
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<tr>
<td>Medial rectus</td>
<td>Anulus tendineus</td>
<td>Anteromedial aspect</td>
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<td>Oculomotor</td>
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<tr>
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<td>Anterolateral aspect</td>
<td>Abduction</td>
<td></td>
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</tr>
<tr>
<td>Levator palpebrae superioris</td>
<td>Sphenoid bone</td>
<td>Tarsal plate of upper eyelid</td>
<td>Raises upper eyelid</td>
<td></td>
<td>Oculomotor</td>
</tr>
</tbody>
</table>
Figure 29-6. The optic pathways. The locations of typical lesions and the resultant blindness are shown.

Figure 45-4. Branches of the ophthalmic nerve, superior aspect.

Figure 41-8. Diagram of the test movements for examining individual muscles that control eye movements.
Figure 45–6 The ciliary ganglion and its connections, lateral aspect.