OSTEOLOGY
Identify the bones which comprise the walls of the orbit: maxilla, zygomatic, ethmoid, lachrymal, frontal, and the greater and lesser wings of the sphenoid. Revise the openings of the orbit: superior orbital fissure, inferior orbital fissure, optic canal, nasolachrymal canal, anterior and posterior ethmoidal foramina, zygomatic foramina, infraorbital canal, supraorbital notch or foramen.

In the middle cranial fossa identify the superior orbital fissure, optic canal, pituitary fossa, and carotid canal. Trace the carotid canal through the temporal bone. Identify the foramen spinosum and follow the groove for the middle meningeal artery, which comes from the foramen and spreads out on the sides of the cranial cavity. Notice how deeply the anterior branch of the artery grooves the bone on the inside of the temple. What would be the result of a fracture of the bone in this region?
DURAL VENOUS SINUSES OF THE CRANIAL CAVITY

Study the preparations of the cranial cavity with the dura intact. Identify the dural sinuses, which are the venous drainage system of the brain: superior sagittal sinus, inferior sagittal sinus, straight sinus, transverse sinus, sigmoid sinus, inferior and superior petrosal sinuses, and the cavernous sinus.

Superior sagittal sinus
Inferior sagittal sinus
Straight sinus
Transverse sinus
Sigmoid sinus
Cavernous sinus
Superior petrosal sinus
Inferior petrosal sinus

What vessels can drain into the cavernous sinus

Apart from the internal jugular vein, what other paths can blood take to leave the cranial cavity? Can blood enter the cranial cavity through these alternative routes?

Compare the cranial cavity with dura, to a skull without the dura, you can see most of the sinuses as grooves in the bone on a skull. Identify the internal carotid artery as it enters the cranial cavity, compare this with the opening of the carotid canal on the skull, trace the course that the carotid artery takes before it emerges from the dura.
CRANIAL NERVES
Locate the cranial nerves as they pierce the dura:
The olfactory and optic nerves pierce the dura in front of the cavernous sinus.
The oculomotor, trochlear, ophthalmic division of the trigeminal, and the abducent nerves all pierce the dura behind the cavernous sinus on their way to the superior orbital fissure. These nerves run forwards in the walls of the cavernous sinus.
The facial and vestibulocochlear nerves go into the internal acoustic meatus.
The glossopharyngeal, vagus, spinal accessory and hypoglossal nerves pierce the dura in the floor of the posterior cranial fossa.

CAVEROUS SINUS
Examine some glass slides and diagrams of coronal sections through the pituitary gland and cavernous sinuses. Identify the carotid artery, and the oculomotor, trochlear, ophthalmic division of the trigeminal, and abducent nerves running through the cavernous sinuses. Draw a diagram a coronal section through the cavernous sinus and pituitary gland, including all the structures listed above.

Pituitary
Cavernous sinus
Internal carotid artery
Oculomotor nerve
Trochlea nerve
Ophthalmic nerve
Maxillary nerve
Abducent nerve
The oculomotor, trochlea, ophthalmic (frontal, lachrymal, nasociliary branches) and abducent nerves all pass through the superior orbital fissure.

The nasociliary, oculomotor and abducent nerves pass through the fibrous ring of origin for the extraocular muscles.

The lachrymal, frontal and trochlear nerves pass outside the cone of extraocular muscles.
EXTRA-OCULAR MUSCLES

Study a specimen with the roof of the orbit opened up. Notice how five of the six extra-ocular muscles form a cone, arising from a tendinous ring posteriorly. Consider how the obliquity of this cone affects the actions of the muscles.

Identify the *levator palpebrae superioris*, and the six extra-ocular muscles (medial rectus, lateral rectus, superior rectus, inferior rectus, superior oblique and inferior oblique) on models of the orbit. Notice that the rectus muscles insert in front of the equator of the eyeball, and that the oblique muscles insert behind the equator.

What action does each extra-ocular muscle have on the eyeball. Consider the action of each muscle about: a vertical axis (adduction - abduction), a transverse axis (elevation - depression), and an anteroposterior axis (medial and lateral rotation) Tabulate your results below.

<table>
<thead>
<tr>
<th></th>
<th>Transverse axis</th>
<th>Vertical axis</th>
<th>Anteroposterior axis</th>
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<tbody>
<tr>
<td></td>
<td>Elevate - depress</td>
<td>Adduct - abduct</td>
<td>Med &amp; Lat Rotate</td>
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<tr>
<td>Medial rectus</td>
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<td>Lateral rectus</td>
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<td>Superior rectus</td>
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<td>Inferior oblique</td>
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<td>Inferior rectus</td>
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<td>Superior oblique</td>
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Remember that because of the obliquity of the orbital axis, the superior and inferior rectus muscles have adduction/abduction, and medial/lateral rotation effects. Remember also that, in health, there are no appreciable rotations of the eyeball, so the rotary effects of these muscles must cancel opposite rotary effects.

Consider the superior rectus and inferior oblique. They both elevate the eye, but they have opposite actions about the anteroposterior and vertical axes. Therefore together they can elevate the eye and balance each others tendency to cause unwanted movements. If the eye is adducted which muscle will be the best elevator? What if the eye is abducted?

Inferior rectus and superior oblique form a similar couple, which coordinate depression of the eye.

**NERVES OF THE ORBIT**

Study the prosections where the roof of the orbit has been removed, and identify the branches of the ophthalmic division of the trigeminal nerve: lacrimal, frontal (supraorbital and supratrochlear) and the trochlear nerve going to superior oblique. Below these nerves is the levator palpebrae superioris, and the superior rectus muscles. The nasociliary branch of the ophthalmic nerve lies below superior rectus and sends branches through the ethmoidal foramina on the medial side of the orbit. Deeper in the orbit the medial and lateral rectus muscles can be seen on their respective sides. In some specimens the abducens nerve can be seen lying on the lateral rectus.

Deep in the middle of the orbit is the eyeball and the optic nerve, plus branches of the oculomotor nerve. The ciliary ganglion is sometimes visible on the lateral side of the optic nerve. It is a tiny brown structure with many small nerves radiating from it (short ciliary nerves). The ciliary ganglion is the parasympathetic cell station for the fibres of the oculomotor nerve which supply intraocular smooth muscle (ciliary muscle and sphincter pupillae).

The dilator pupillae muscle is innervated by sympathetic nerves, which travel with the nasociliary nerve (long ciliary nerves).

There is also some extraocular smooth muscle supplied by sympathetic nerves. This can be found in the levator palpebrae superioris muscle, and there is also supposed to be some smooth muscle stretching across behind the eyeball which acts to protrude the eye. These sympathetic innervated smooth muscles explain two of the symptoms of syndrome (damage to the cervical sympathetic trunk), ptosis (droopy eyelids) and enophthalmia (sunken eyes).

Use the diagram that shows nerves II, III, IV and VI to add the other nerves found in the orbit (Lacrimal, frontal, nasociliary).
THE EYE BALL (BULBUS OCULI)

Watch a video on the dissection of the ox eye. There are fresh cow eyes and dissection tools available in the lab if you want to dissect one yourself.

In particular you should understand that the eye ball has three layers

a) A tough white fibrous layer (sclera), represented in front by the transparent cornea

b) A vascular layer (choroid) which is pigmented so as to absorb light and make the eye dark inside. The choroid is represented in front by the iris, which controls the size of the pupil by circular (sphincter pupillae) and radial (dilator pupillae) smooth muscle.

c) A neural layer (retina) contains the receptors and nerve cells which do some early processing of visual information. The retina has its own blood supply quite separate from the vessels in the choroid, and these vessels can be seen through the pupil using an ophthalmoscope. Anteriorly this layer is represented by the lens.

The centre of the eye, behind the lens, is filled with a transparent jelly called the vitreous humour. In front of the lens and behind the cornea is a space which extends through the pupil, this space is filled with aqueous humour, aqueous humour is produced by the ciliary body at the periphery of the lens and flows slowly through the pupil to the irido-corneal angle where it is reabsorbed into the blood stream.
SURFACE ANATOMY AND LACRIMAL APPARATUS

Look into a partner's eye and identify the palpebrae, palpebral fissure, eye lashes (cilia). Lift an eyelid away from the eye and note the conjunctival sac; you may be able to see the openings of lachrymal ducts under the lateral side of the upper eyelid. Where the eyelids meet at the medial angle is the lachrymal caruncle, on the end of each eyelid above and below the caruncle is a lachrymal puncta (tiny hole) which collects tears and conducts them to a lachrymal sac deep to the caruncle. Tears drain from the lachrymal sac into the nasolachrymal duct and into the nasal cavity.

Feel in your upper eyelid for a cartilage plate (tarsal plate), this is what enables people to invert their eyelid.

Shine a light into a partner's eye and watch the pupil constrict, this is the light reflex. Explain the afferent and efferent limbs of the neural pathway for the light reflex (do not worry about what occurs inside the brain, although some of you should be able to describe the pathway in full).

If you touch the surface of the eye, it blinks; can you explain the nerves involved in this reflex pathway?

What is the function of tears? What kinds of things stimulate the flow of tears? What nerves control the secretion of tears? Can you describe their pathway to the lachrymal gland?
Practical anatomy checklist

Osteology
The orbit and middle cranial fossa

The cranial cavity
Dural venous sinuses
The cranial nerves and their relations to the dura and cavernous sinus

The Orbit
Extra ocular muscles
Nerves of the Orbit

The eyeball
Lachrymal apparatus