CAROTID SHEATH

- From base of skull (Petrus & tympanic parts of temporal, blending with deep layer of parotid fascia)
- Adventitia of aortic arch
- It fuses with pretracheal fascia and the investing fascia under sternocleidomastoid
- The ansa cervicalis is in the carotid sheath over the internal jugular vein
- Escaping from the upper sheath are: glossopharyngeal (IX), superior laryngeal branch of vagus (X), spinal root of accessory (XI) and hypoglossal (XII) nerves
Cavernous Sinus
Coronal (Transverse) View
Right Side Looking Anteriorly

- Lies alongside body of sphenoid in middle cranial fossa
- Between periosteal (endosteal) and meningeal (fibrous) layers of dura
- Roof: Anterior & posterior clinoid processes with uncus of temporal lobe & internal carotid artery on it, III & IV into it
- Lateral wall: Dura, temporal lobe, III, IV, Va, Vb in wall
- Floor: Greater wing of sphenoid
- Medial wall: Dura over sphenoid, sella turcica, pituitary, sphenoid sinus
- Posterior wall: (narrow), dura of posterior fossa, superior and inferior petrosal sinuses, peduncle of brain
- Anterior wall: (narrow), medial end of superior orbital fissure, ophthalmic veins, orbit
- Contains: Internal carotid artery, VI & blood
- Draining into it: Superior/inferior ophthalmic veins, intercavernous sinuses, sphenoparietal sinuses, superficial middle cerebral vein
- Draining out of it: Superior/inferior petrosal sinuses, emissary veins to pterygoid plexus
EAR - CLINICAL PROBLEMS

OUTER EAR
- Wax
- Foreign body
- Otitis externa

INNER EAR
- Otitis media - Acute (± blocked auditory tube)
  - Chronic (cholesteatoma, glue ear)
- Perforation of eardrum
  - Infective
  - Traumatic
    - Direct injury
    - Barotrauma
- CSF leak with fractured skull

DEAFNESS - Conductive and Neural
- Post infection
- Traumatic dislocation of ossicles
- Otosclerosis
- Noise injury
- Genetic & senile
- Rubella in pregnancy
- Viruses & drugs
- Tumours of nerves (acoustic neuroma)

VERTIGO (Dizziness)
- Acute labyrinthitis
- Meniere’s disease (attacks with deafness & tinnitus)
NERVE SUPPLY

Blood supply:
- Posterior auricular
- Superficial temporal
- Deep auricular (maxillary)

Lymph nodes:
- Pre-auricular
- Mastoid
- Superficial cervical

External meatus and outer surface of drum are supplied by:
- Auriculotemporal
- Auricular br of vagus
- Facial (VII) (as small contribution from tympanic plexus)

Earp - RIGHT PINNA & EXTERNAL MEATUS

Helix

Concha

Tragus

Great auricular n (C2)

Lesser occipital

Auricular branch of vagus (X) (posterior inferior)

Looking down external meatus

Ear drum
**Ear Overview**

**External**
- Pinna
  - Amplification
  - Localization
  - Elastic cartilage
  - Vascular
- External meatus
  - 3 cm long
  - 2/3 bone
  - 1/3 cartilage
  - Curves forwards
- Hairs
- Glands
  - Sebaceous
  - Ceruminous
- Outer eardrum

**Middle**
- Ossicles
- Facial n
- Chorda tympani
- Inner eardrum
- Auditory tube
  - Opens on swallowing to equalise pressure
  - 3.5 cm long
  - 1/3 bone
  - 2/3 cartilage
- 30 degrees down
- 45 degrees ant/med
- Tubal tonsil at exit in nasopharynx
- Mucosa valvulike
- Sensory Ns - Vb & IX (referred pain)

**Internal**
- Labyrinth
  - Cachlea
  - Semicircular canals
The middle ear:

- Transfers and enhances vibrations of the tympanic membrane by means of the ossicles - malleus, incus and stapes. The signal is then passed via the foot plate of the stapes in the oval window to the labyrinth of the inner ear.
- Is a small air filled cavity in the petrous part of the temporal bone.
- Connects via an aditus posteriorly to the mastoid air sinus which contains air cells.
- Connects to the nasopharynx via the auditory tube for access of air & to keep the air pressure equilibrated by opening with each swallow.
- Contains two small muscles - tensor tympani (Vc) & stapedius (VII) which attach to malleus & stapes respectively, which dampen down movements of these ossicles to avoid over-vibration during low pitched sounds.
- Has the facial (VII) nerve passing through it from the internal acoustic meatus to the stylomastoid foramen. It is joined by nervus intermedius, carrying general sensory, taste & parasympathetic fibres, at the geniculate ganglion. Greater petrosal nerve leaves at this ganglion to pass eventually to the pterygopalatine ganglion. Facial nerve also gives a small motor branch to stapedius and then the chorda tympani leaves it just before it exits the middle ear. The chorda tympani passes back into the middle ear, crosses the pars flaccida of the tympanic membrane then exits forwards from the middle ear finally to join the lingual nerve.
- Has a tympanic branch of the glossopharyngeal nerve (IX) supplying sensation to it & it also supplies parasympathetic to the parotid gland via the lesser petrosal nerve & otic ganglion.
- Has mucous membrane covering all its contents.
- Has a sensory supply largely from glossopharyngeal (IX) with a small contribution from facial (VII).
- Has blood supply from a tympanic branch of maxillary & a stylomastoid branch of posterior auricular artery.
- May fill with fluid or pus when infected & transmission of sound via the ossicles is less efficient than sound passing directly through the bone. This is tested with a tuning fork.
MIDDLE EAR - OSSICLES

They increase the amplitude of the vibrations 15-20 times because of leverage and the eardrum to oval window ratio.

Synovial joints between them.
Middle Ear - Left Tympanic Membrane

- Chorda tympani over pars flaccida
- Incus
- Viewed from inside middle ear
- Umbo
- Pars tensa
- Tendon of tensor tympani

Viewed down an auroscope

Tympanic Membrane
- 3 layers
  - Inner - low columnar
  - Middle - fibrous
  - Outer - stratified squamous
- 1 cm diameter
- Pearly grey & shiny
- 55 degrees to horizontal
- Concave outwards
- Faces downwards, forwards & laterally
- Pulled inwards by tensor tympani
- Sensory supply
  - Inner - glossopharyngeal (IX)
  - Outer - auriculotemporal (Vc)
- Vibrates with incoming sound
- Needs equal air pressure on each side of it (see auditory tube)
MIDDLE EAR - AUDITORY (EUSTACHIAN) TUBE - TOPOGRAPHY

To middle ear

Bone

Cartilage

Tubal tonsil

To nasopharynx

NOTES

• Develops from 1st pharyngeal pouch
• 3-3.5cm long
• Blood supply from ascending pharyngeal & middle meningeal
• 30 degrees downwards, 45 degrees anteromedially
• Tubal tonsil at exit in nasopharynx
• 1/3 bone
• 2/3 cartilage
• Opens on swallowing to equalise pressure
• Mucosa is valvelike
• Sensation via pharyngeal branch of maxillary nerve (Vb) in lower part and glossopharyngeal (IX) in upper part (hence referred pain to middle ear from tonsils and oropharynx)
• Bony part in petrous temporal bone has columnar epithelium
• Cartilaginous part in squamotympanic fissure has ciliated columnar epithelium
• Muscles opening it are:
  • Salpingopharyngeus
  • Levator palati
  • Tensor palati
Effects of blocked auditory tube:
1. At first air is still absorbed - drum sucked in more
2. Giving poor ossicle/drum movement - deafness
3. Then viral/bacterial exudate gets infected
4. Middle ear +/- mastoid air cells fill with pus (otitis media)
5. Then pressure rises - drum bulges outwards +/- bursts
6. Infection may spread to - inner ear, venous sinuses, extradural, subdural, meninges, brain abscess
7. THEN EITHER:
   - Drains and heals
   - Becomes chronic. +/- glue ear or cholesteatoma
   - Persistent perforation of drum, +/- necrosis of ossicles
MIDDLE EAR
- RIGHT SIDE LOOKING POSTERIORLY

Right hand box is a view of the right middle ear looking posteriorly. The left hand box is the anterior wall of the right box. Hinges are to illustrate how it would close to become the anterior wall.

A = Aciculus to mastoid air sinus
B = Bony bulge of lateral semicircular canal
CT = Chorda tympani
E = External auditory meatus
G = Geniculate ganglion
I = Incus
LP = lesser petrosal n
M = Malleus
P = Promontory (last turn of cochlea)
RW = Round window
S = Stapes
ST = Stapedius
SMF = Stylomastoid foramen (VII emerging)
T = Bony tunnel for facial n
TBG = Tympanic branch of glossopharyngeal

Mucosa covers all contents & is supplied by IX & a little VII. The carotico-tympanic arteries (CTA) bring in blood supply & sympathetics for the tympanic plexus on the promontory.
INNER EAR
- BONY & MEMBRANOUS LABYRINTHS

Full size at birth
In petrous temporal bone
One continuous cavity
For hearing & balance
Vestibulocochlear nerve

Membranous labyrinth
lies within osseous labyrinth

Semicircular canals
(kinetic balance)

Endolymphatic sac & duct
Perilymphatic duct

External meatus
Auditory tube
Round window
Cochlear duct
(hearing ~23/4 turns)

Endolymph
Perilymph

Blood supply via
labyrinthine artery

U = Utricle
S = Saccule
(both for static balance)
INNER EAR - STRAIGHTENED OUT COCHLEA TO AID UNDERSTANDING

Stapes in oval window
Vestibular membrane
Apex of cochlea
Ossicles amplify vibrations 15-20 times
Scala vestibuli
Perilymph
Cochlear duct
Endolymph
Scala tympani
Round window closed with thin membrane
Hair cells lying on basilar membrane
Tectorial membrane lying on cilia of hair cells

HEARING MECHANISM

Sound waves → Pinna → External meatus →
Tympanic membrane → Ossicles → Stapes →
Vibrations in perilymph → Basilar membrane →
Hair cells (convert acoustic energy to action potentials) →
Tectorial membrane → Cochlear part of vestibulocochlear nerve (VIII) → Auditory cortex
EYE - BONES OF RIGHT ORBIT

- Anterior & posterior ethmoidal foramina
- Supra-orbital notch
- Greater wings of sphenoid
- Lesser
- Superior (to middle cranial fossa)
- Orbital fissures
- Inferior (to pterygo-palatine fossa)
- Zygoma
- Ethmoid
- Nasal bone
- Maxilla
- Posterior lacrimal crest on lacrimal bone
- Lacrimal fossa between these two
- Anterior lacrimal crest on frontal process of maxilla
- Groove
- Infra-orbital
- Foramen
- * Orbital process of palatine bone
- $ Optic canal
EYE - FASCIAL COVERINGS

View of right eye from front

Tenon's capsule

Zygomatic bone

Lateral check ligament attached to marginal tubercle (of Whitnall)

Suspensory ligament of Lockwood

Medial check ligament attached to posterior lacrimal crest

lacrimal bone

TENON'S CAPSULE
(Fascia bulbi)
- Fascial sheath of eye
- Bursa behind the eyeball
- Inner layer blends with sclera
- Outer layer pierced by tendons & it extends back along them

Note:
There is not normally any posterior displacement of the eyeball because of the following factors:
  - Medial/lateral check ligaments
  - Presence of orbital fat
  - Forward pull of 2 oblique muscles
EYE - OPTIC NERVE & ITS COVERINGS

OPTIC NERVE
- 3cm in orbit
- Blood supply
  - Intracranial portion - Anterior cerebral artery
  - Posterior 2cm in orbit - Ophthalmic artery
  - Anterior 1cm in orbit - Central artery of retina

COVERINGS
FIBROUS
- Sclera (nearly avascular)
- Canal of Schlemm (drains aqueous)
- Cornea (anteriorly is stroma between Bowman's membrane, posteriorly is Descemet's membrane)

VASCULAR
- Choroid (thin, pigmented, capillaries & 4-5 venules vorticosaes)
- Ciliary body and muscle
- Iris

NERVOUS
- Retina
EYE
CILIARY BODY AND ANTERIOR EYEBALL

Ciliary body (produces aqueous humour)
Ciliary muscle. Radial & circular. Allows lens to bulge under parasympathetic control. Elastic recoil

Sclera
Ora serrata
Choroid
ciliary processes
Suspensory ligament of lens
Cornea

Canal of Schlemm drains aqueous humour

Iris
Sphincter pupillae
Circular - parasympathetic
Dilator pupillae
Radial - sympathetic

• Attached to choroid
• Outside vitreous humour
• Stops at ora serrata
• Optic disc blind spot at entry of optic nerve (1.5mm)
• Macula lutea - 3mm lateral to disc. Has central pit (fovea) with cones only
• Rods for dim light and no colour
• Cones for colour. Very sensitive
• Fundus is what is seen with ophthalmoscope at back of eye
• Blood supply: central artery of retina. Central veins to superior ophthalmic veins

Right fundus
EYE - VIEW INTO RIGHT ORBIT TO SHOW EXTRINSIC EYE MUSCLES

- **Optic nerve**
- **Superior oblique (IV)**
- **Medial rectus (inferior division of III)**
- **Inferior rectus (inferior division of III)**
- **Superior rectus (superior division of III)**
- **Lateral rectus (VI)**
- **Ciliary ganglion (within cone of muscles on nerve to inferior oblique)**

For details of muscles see muscle section of Instant Anatomy

Eye movements produced by the action of single or combinations of extrinsic eye muscles of the right eye

- **Superior rectus & inferior oblique (up)**
- **Inferior oblique (up/out)**
- **Lateral rectus (out)**
- **Superior rectus (up/in)**
- **Medial rectus (in)**
- **Superior oblique (down/out)**
- **Inferior rectus (down/in)**
- **Inferior rectus & superior oblique (down)**
Because of the oblique angle of the orbit and the way that the muscles attach distal to the equator of the eye there is a tendency for some of the muscles to twist the eye in addition to its main action. This torsion, which can be internal (intorsion) or external (extorsion), is important as it counteracts the tilting movements of the head. The degree of twisting for any one muscle is determined by whether the eyeball is abducted or adducted.

**RIGHT EYE LOOKING FROM ABOVE**

**EYE IN ADDUCTION**

Superior rectus elevates & intorts
Inferior rectus depresses & extorts
Superior oblique turns eye down & out only
Inferior oblique turns eye up & out only

**EYE IN ABDUCTION**

Superior rectus elevates only
Inferior rectus depresses only
Superior oblique turns eye down & out & intorts
Inferior oblique turns eye up & out & extorts
**Eye - Exploded View of Left Eyelids**

- **Levator palpebrae superioris to tarsal plate (III/sympathetic) & to skin (III only)**
- **Orbicularis oculi (palpebral/orbital)**
- **Orbital septum & superior tarsal plate**
- **Conjunctiva**
- **Tarsal glands (Meibomian)**
- **Retracted eyelid skin**
- **Medial palpebral ligament to anterior lacrimal crest**
- **Angular vein & facial artery on orbicularis oculi**
- **Inferior tarsal plate**
- **Lateral palpebral ligament to marginal tubercle of zygomatic bone**

**Orbital septum:** Anterior lacrimal crest and margins of orbit

**Tarsal plates:** Fibrous thickening of orbital septum

**Meibomian glands:** In tarsal plates, modified sebaceous glands secreting oil

**Blood supply:** Of lids - palpebral branches of ophthalmic artery

**Nerves:**
- Upper skin/conjunctiva
  - Lacrimal, Supra-orbital, supra- & infratrochlear
- Lower skin/conjunctiva
  - Infra-orbital
• Serous gland
• In lacrimal fossa (lateral roof of orbit)
• 10-12 ducts draining into lateral/superior fornix of conjunctiva
• Tears swept medially by progressive lid closure
• Nerve supply - secretomotor. Superior salivary nucleus to facial nerve to greater petrosal nerve to pterygo-galatine ganglion to zygomatic branch of maxillary division of trigeminal (Vb) to zygomaticotemporal nerve to connecting branch in orbit to lacrimal nerve (Va) to gland
• Blinking achieved by palpebral part of obicularis oculi (no tear spill)
• Screwing up achieved by orbital part of obicularis oculi (tear spill and squeezes lacrimal sac)
• Lacrimal sac lies between anterior & posterior lacrimal crests with palpebral fibres of orbicularis oculi inserting into its walls to draw it open & suck in tears
• Lacus lacrimalis (lacrimal lake) lies above it.
• Nasolacrimal duct is 2cm long, drains into inferior meatus of lateral wall of nose & its mucosal folds are valvular to stop air
EYE - RIGHT OPHTHALMIC ARTERY

- Supratrochlear
- Dorsal nasal
- Supra-orbital
- Anterior ciliary
- Ethmoidal
- Anterior
- Posterior
- Muscular branches
- Zygomatico-facial/temporal
- Lacrimal
- Central artery of retina
- Posterior ciliary
- Optic nerve passing through optic canal & tendinous ring with ophthalmic artery
- Internal carotid

VIEWED FROM ABOVE
**LEVATOR PALPEBRAE SUPERIORIS**

**LATERAL**
- Palpebral branch of lacrimal n
- Lateral palpebral ligament
- Zygomatico-facial n

**MEDIAL**
- Supra-orbital n
- Supratrochlear n
- Medial palpebral ligament over lacrimal sac
- Infra-orbital n

**Infra-orbital n**

- Superior tarsal plate

**Orbicularis oculi**

- Corrugator

**Levator palpebrae superioris**

- Arises from posterior orbit above tendinous ring and inserts into eyelid skin and into superior tarsal plate.
- Nerve supply is via oculomotor (III)
- Somatic to both tarsal plate and skin.
- Sympathetic to tarsal plate only
Note:
- Medial orbital walls are parallel
- Lateral walls are at right angles
- Orbital fascia is the periostium of orbit which is continuous with dura over optic nerve
FACE
ARTERIAL SUPPLY & VENOUS DRAINAGE

- Lateral nasal (facial)
- Superficial temporal (ext. carotid)
- Zygomaticotemporal (superficial temporal)
- Lacrimal (ophthalmic)
- Infraorbital (maxillary)
- Transverse facial
- Facial (ext. carotid)
- External carotid
- Mental (inferior alveolar - maxillary)

* Zygomaticofacial (superficial temporal)

Supraorbital
Supratrochlear
(ophthalmic)

Angular
# Facial

Superficial temporal & maxillary

Retromandibular

Posterior auricular

External jugular

Internal jugular

IF = Inferior orbital fissure

Facial vein

Superior orbital fissure

Cavernous sinus

Pterygoid plexus

Pharyngeal & diploic veins

Deep facial vein via buccinator

2 maxillary veins deep to neck of mandible

Flow can reverse, pterygoid plexus has valves & can act as a suction pump (yawning).
Danger for infection between angular & deep facial veins
DEVELOPMENT OF FACE

NORMAL

Lateral nasal process

Maxillary process

Mandibular process

Frontonasal process grows down from forebrain capsule

2 globular processes give this median nasal process which becomes tip of nose

HARE LIP

Unilateral cleft (hare) lip

Hare lip 1:1000 births

Cleft palate 1:2500 births

Median cleft upper lip

Oblique facial cleft (failure of lateral nasal & maxillary processes to fuse)

Bilateral cleft (hare) lip
RIGHT FACIAL NERVE IN & BEFORE THE PAROTID

- Stylomastoid foramen
- Superficial temporal artery/vein deep to nerve
- Posterior auricular branch to occipital belly of occipitofrontalis & auricularis
- Posterior belly of digastric & stylohyoid
- Retromandibular vein
- One of its branches
- Branch of great auricular nerve
- Cervical branch of VII
- Parotid duct
- Posterior belly of digastric

Note: Only three structures lie anterior to the posterior belly of digastric:
- Cervical branch of VII
- Branch of the retromandibular vein
- Branch of great auricular nerve (cervical plexus)
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FACE: MOTOR AND SENSORY SUPPLY

SENSORY TRIGEMINAL (V)
- Supratrochlear
- Supra-orbital
- Auriculotemporal
- Zygomaticotemporal
- Lacrimal
- Zygomaticofacial
- Infra-orbital
- Buccal
- Great auricular
- Mental

MOTOR FACIAL (VII)
- Temporal
- Zygomatic
- Buccal
- Mandibular
- Cervical

Facial nerve branches:
- Ophthalmic (5 branches)
- Maxillary (3 branches)
- Mandibular (3 branches)

Infratrochlear
- External nasal (from anterior ethmoidal)

Mnemonic:
- Two
- Zulus
- Befriended
- My
- Cat

(note: proprioception is supplied by trigeminal)
**FACIAL NERVE LESIONS**

**SUPRANUCLEAR LESION**
Upper face has bilateral innervation
(bilateral cortical representation)

- Frontal lobe to corticobulbar fibres
- Part of hemiplegia
- Upper motor neurone lesion
- Lower face worse for voluntary movement but may be OK for emotion

**NUCLEAR/INFRA NUCLEAR LESION**
Ipsilateral

1. Lesion of nucleus/pontine fibres
   - Complete unilateral palsy. Loss of VII, VI, V, taste, opposite limbs long tracts

2. Temporal bone (fracture)
   - Complete unilateral palsy, loss of taste, decreased hearing or hyperacusis

3. Facial canal (middle ear infection) Bell's palsy

4. Other (MS, surgery, acoustic neuroma, herpes, diabetes, sarcoid)
   - Lower motor neurone lesion
FACE: MOTOR AND SENSORY SUPPLY

SENSORY TRIGEMINAL (V)
- Supratrochlear
- Supra-orbital
- Auriculotemporal
- Zygomaticotemporal
- Lacrimal
- Zygomaticofacial
- Infra-orbital
- Buccal
- Great auricular
- Mental

MOTOR FACIAL (VII)
- Temporal
- Zygomatic
- Buccal
- Mandibular
- Cervical
- Infrafacial
- External nasal (from anterior ethmoidal)

Facial nerve branches:
- Temporal: frontalis & procerus
- Zygomatic 1: eye & around orbit
- Zygomatic 2: mid face & smile
- Buccal: buccinator & upper lip
- Mandibular: lower lip & orbicularis oris
- Cervical: platysma

Mnemonic:
Two
Zulus
Befriended
My
Cat

(note: proprioception is supplied by trigeminal)
MUSCLES OF FACIAL EXPRESSION

A = Incisive slip of orbicularis oris
B = Mental slip of orbicularis oris
C = Orbital part of orbicularis oculi
   (complete sphincter, screws up eye, decreases volume of conjunctival sac & tears spill over)
D = Palpebral part of orbicularis oculi
   (Medial palpebral ligament to lateral palpebral raphe. Keeps volume of conjunctival sac constant, no tear spill, closes eye)
E = Levator labii superioris
F = Levator anguli oris
G = Levator labii superioris alaeque nasi
   (Dilator nares & depressor septi are not shown)

Note: The face has no deep fascia, variables amount of fat, good blood supply & drainage. Muscles are 2nd arch mesoderm, equivalent to the paniculus carnosus of animals, often attached to the dermis & are arranged into sphincters, dilators and expressors
<table>
<thead>
<tr>
<th>All Muscles of</th>
<th>Supplied By</th>
<th>Except</th>
<th>Which Is Supplied By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharynx</td>
<td>Pharyngeal plexus (IX, X &amp; sympathetic)</td>
<td>Stylopharyngeus</td>
<td>Glossopharyngeal (IX)</td>
</tr>
<tr>
<td>Palate</td>
<td>Pharyngeal plexus (IX, X &amp; sympathetic)</td>
<td>Tensor veli palatini</td>
<td>Nerve to medial pterygoid (Vc)</td>
</tr>
<tr>
<td>Tongue</td>
<td>Hypoglossal (XII)</td>
<td>Palatoglossus</td>
<td>Pharyngeal plexus (IX, X &amp; sympathetic)</td>
</tr>
<tr>
<td>Facial Expression &amp; Buccinator</td>
<td>Facial (VII)</td>
<td>Levator palpebrae superioris</td>
<td>Oculomotor (III)</td>
</tr>
<tr>
<td>Mastication</td>
<td>Mandibular division of Trigeminal (Vc)</td>
<td>Buccinator</td>
<td>Facial (VII)</td>
</tr>
<tr>
<td>Larynx</td>
<td>Recurrent laryngeal</td>
<td>Cricothyroid</td>
<td>External branch of superior laryngeal nerve (X)</td>
</tr>
</tbody>
</table>
CAROTID SHEATH

From base of skull (Petrus & tympanic parts of temporal, blending with deep layer of parotid fascia)

- It fuses with pretracheal fascia and the investing fascia under sternocleidomastoid
- The ansa cervicalis is in the carotid sheath over the internal jugular vein
- Escaping from the upper sheath are: glossopharyngeal (IX), superior laryngeal branch of vagus (X), spinal root of accessory (XI) and hypoglossal (XII) nerves

Adventitia of aortic arch
INVESTING LAYER OF DEEP FASCIA OF NECK

- External occipital protuberance
- Superior nuchal line
- Tympanic part of temporal bone
- Acoustic meatus
- Zygomatic process of temporal bone
- Stylohyoid ligament
- Mandible
- Chin
- Hyoid
- Jugular arch
- Sternohyoid
- Spine of C7
- Spine of scapula
- Clavicle
- Acromion
- Manubrium
- Ligamentum nuchae
- LO
- GA
- TC
- SC

* Anterior layer of parotid fascia is the superficial layer of the investing fascia that has split from the stylohyoid ligament.

X Posterior layer of parotid fascia is the deep layer of the investing fascia that has split from the stylohyoid ligament. It fuses with the parotid gland.
DEEP FASCIA OF NECK

Lateral view to show the 4 layers

Prevertebral fascia
Carotid sheath
Extensor muscles
Prevertebral muscles
Oesophagus

Axial (cross) section to show 4 layers

Prevertebral fascia
Investing fascia
Carotid sheath
Pretracheal fascia

Trapezius
Prevertebral muscles
Phrenic nerve
Sympathetic chain
External jugular vein
Sternocleidomastoid

o = Oesophagus
T = Trachea

Strap muscles
PREVERTEBRAL PART OF DEEP FASCIA OF NECK

From: base of skull

Extends

To: body of T3

It lies over the muscles as shown

Pierced by:
- Great auricular nerve
- Lesser occipital nerve
- Transverse cervical nerve
- Supraclavicular nerves
- Inferior root of ansa cervicalis

Lying on it:
- Sympathetic chain
- Lymph nodes
- Spinal root of accessory nerve

Deep to it:
- Cervical plexus
- Trunks of brachial plexus
- 3rd part of subclavian artery
- Phrenic nerve

It blends with the anterior longitudinal ligament. Its lower border laterally is the lower border of scalenus anterior.
TISSUE SPACES IN THE NECK

PREVERTEBRAL SPACE
Closed space behind prevertebral fascia which allows infection to track down into axilla via the axillary sheath which is, itself, part of the prevertebral fascia that is dragged off by the subclavian artery as it emerges from behind scalenus anterior

RETROPHARYNGEAL SPACE
Immediately anterior to prevertebral fascia. Below, it extends behind oesophagus to diaphragm via superior and then posterior mediastinum. Infection may spread from here, laterally, behind the carotid sheath into the posterior triangle

PARAPHARYNGEAL SPACE
Lateral continuation of retropharyngeal space

SUBMANDIBULAR SPACE
Extends above investing layer of deep cervical fascia, between hyoid and mandible to mucous membrane of floor of mouth. Contains mylohyoid muscle, sublingual gland above this muscle and submandibular gland hooking around its posterior border. Infection here gives cellulitis known as LUDWIG’S ANGINA
The mylohyoid muscle (not shown) overlaps the anterior edge of hyoglossus.

Hyoglossus is supplied by the hypoglossal nerve as are all the muscles of the tongue except palatoglossus (pharyngeal plexus).

Further anteriorly, under the mylohyoid, the lingual nerve passes lateral to the submandibular duct, then dips under it to appear on its medial side to enter the tongue.

The venae comitantes of the hypoglossal nerve pass posteriorly to join the facial vein.
HYOID BONE AND ATTACHMENTS

- Stylohyoid
- Hyoglossus
- Middle constrictor
- Omohyoid
- Sternohyoid
- Thyrohyoid
- Geniohyoid
- Mylohyoid

Ossification:
In cartilage
Primary centre in greater cornu (8-9 months gestation)
Secondary centres x2 in body (9 months gestation)
Secondary centres in each lesser cornu at puberty
INFRATEMPORAL FOSSA - BOUNDARIES

- Base of skull
- Between pharynx & ramus of mandible

LATERAL WALL
- Ramus of mandible
- Coronoid process

SUPERIOR CONSTRICTOR
- Pterygomandibular raphe
- Styloglossus
- Genioglossus
- Geniohyoid
- Digastric
- Mylohyoid
- Submandibular gland

MEDIAL WALL
- Tensor veli palatini
- Levator veli palatini
- Superior constrictor
- Lateral pterygoid plate
- Pterygomaxillary fissure
- Maxilla

POSTERIOR WALL
- Carotid sheath
- Superior constrictor

ANTERIOR WALL
- Posterior maxilla
- Inferior orbital fissure
INFRATEMPORAL FOSSA - CONTENTS

CONTENTS
- Pterygoid muscles
- Fat
- Insertion of temporalis
- Chorda Tympani
- Posterior superior alveolar branches of V3 (maxillary branch of trigeminal)

Deep temporal arteries & nerves

Auriculotemporal nerve
Superficial temporal artery
Maxillary artery
External carotid artery
Nerve to mylohyoid
Lingual nerve
Inferior alveolar nerve & artery

Maxillary nerve (V3)
Posterior superior alveolar nerves & arteries
Parotid duct
Buccinator
Buccal nerve

LP = lateral pterygoid
MP = medial pterygoid

SUPERFICIAL DISSECTION
INFRATEMPORAL FOSSA - DEEP DISSECTION

- Nerve to masseter
- Deep temporal nerves
- Infra-orbital nerve/nerve
- Posterior superior alveolar nerves & arteries
- Greater palatine artery
- Buccal nerve
- Inferior alveolar nerve & nerve to mylohyoid
- Lingual nerve

* Nerve to lateral pterygoid and just to its left is the otic ganglion
MANDIBULAR DIVISION OF TRIGEMINAL NERVE, EMERGING FROM FORAMEN OVALE DEEP IN INFRATEMPORAL FOSSA

- Lesser petrosal (via foramen ovale)
- Nervus spinosus (meningeal) via foramen ovale or spinosum
- Anterior/posterior deep temporal
- Masseteric
- Lateral pterygoid
- Buccal
- Lingual (joined by chorda tympani)
- Middle meningeal artery
- Nerve to mylohyoid
- Inferior alveolar

* Otic ganglion. Parasympathetics from lesser petrosal nerve synapse within it and post-ganglionic fibres are taken to the parotid gland by the auriculotemporal nerve
SPHENOMANDIBULAR LIGAMENT RELATIONS

Structures that pass between ligament and mandible

- Spine of sphenoid
- Chorda tympani
- Inferior alveolar nerve and vessels
- Mylohyoid nerve & vessels
- Auriculotemporal nerve
- Maxillary artery & vein
- Pass behind neck of mandible
- Pass behind ramus of mandible

Note that nerve to mylohyoid pierces the ligament
MAXILLARY ARTERY

In infratemporal fossa, either within or lateral to the superficial head of lateral pterygoid muscle. This muscle is shown below.
MUSCLES OF MASTICATION

- Temporalis
- Masseter
- Medial pterygoid
- Lateral pterygoid

All supplied by:
- Mandibular division of Trigeminal (Vc)
- All derived from 1st pharyngeal arch

LATERAL PTERYGOID
Arises: 2 heads
  - Upper: infratemporal surface of sphenoid
  - Lower: lateral surface of lateral pterygoid plate
Inserts: pterygoid fossa below head of mandible, disc, and capsule of temporomandibular joint
Action: protrudes jaw and opens mouth

MEDIAL PTERYGOID
Arises: 2 heads
  - Deep: medial side of lateral pterygoid plate and fossa between plates
  - Superficial: smaller. Tuberosity of maxilla and pyramidal process of palatine bone
Inserts: Medial ramus of mandible
Action: pulls mandible upwards, forwards and medially (closes mouth and chews)

See Muscle section of Instant Anatomy for details of temporalis and masseter
<table>
<thead>
<tr>
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- The vagus lies most medial in the foramen
- Glossopharyngeal nerve & inferior petrosal sinus exit from the anterior compartment of the foramen
- Vagus & accessory nerves exit from the middle compartment
- The sigmoid sinus exits from the posterior compartment, is soon joined by the inferior petrosal sinus to become the internal jugular vein
  - =$\ast$ = Tympanic branch of IX (Jacobson's nerve)
LARYNX - CORONAL SECTION
Viewed from behind so looking anteriorly

Blood supply: Superior & inferior laryngeal arteries

Mucosa: Pseudostratified ciliated columnar. Mucus glands in sinus
(cords & top of epiglottis - stratified squamous)

Nerve supply:
- Sensory above cords - Internal branch of superior laryngeal n
- Sensory below cords - Recurrent laryngeal n
- Motor to muscles - From nucleus ambiguus via cranial accessory
  - to: Cricothyroid: External branch of superior laryngeal n
  - to: All other laryngeal muscles, including upper oesophagus
    & cricopharyngeus - recurrent laryngeal nerve

Lymphatic drainage:
Above cords - upper deep cervical nodes
Below cords - lower deep cervical nodes
CRICOTHYROID has 3 special features that makes it different from other laryngeal muscles. These are:

- It is the only muscle that tightens the cords
- It is supplied the external branch of the superior laryngeal nerve and not the recurrent laryngeal
- It is the only intrinsic muscle of the larynx which on the outside of larynx

It is not initially obvious how this muscle tightens the cords but the illustration below helps with the understanding. If you can imagine a block of wood attached to the wall (A) with a strong piece of very slightly elastic string joining the block to the top of an angle-iron. The angle-iron can rotate on a nail in such a way that lifting the other end of it will tighten the string. The equivalent situation in the larynx (B) it that the cricothyroid muscle does the lifting of the angle-iron (cricoid) to tighten the cords. The thyroid cartilage is not fixed as is the block of wood in (A) so that both cartilages are tilted when the cords are tightened.

Note that the cords are attached to the back of the thyroid cartilage and the vocal processes of the arytenoids.
LARYNX - FUNCTION AND DEVELOPMENT

DURING SWALLOWING
- Closure of aditus by aryepiglotticus acting like a purse-string on the aryepiglottic folds
- Closure of rima glottidis/cords (lateral crico-arytenoids & transverse arytenoids)
- Epiglottis flips backwards/downwards with solid food
- Larynx/pharynx hauled up under the tongue (suprahoid muscles)

DURING PHONATION
- Cords held together for up to 3mm
- Vocalis helps to change the amount of cord that approximates
- Series of jets of air
- Resonance produced by structures above larynx (pharynx/sinuses)
- Whispering is very wasteful of air as it is a constant stream

DURING COUGHING AND STRAINING
- Explosion of compressed air via closed cords

DEVELOPMENT
From primitive pharynx, a laryngotraheal groove appears in midline, in floor, distal to pharyngeal pouches
LARYNX - INLET & EPIGLOTTIS

Inlet:

- Extends from tip of epiglottis to C6
- Open for respiration, partially closed for speaking, closed for coughing, straining and swallowing
- Hangs from hyoid bone via tongue/mandible (hyoglossus, mylohyoid, geniohyoid, digastrics, middle constrictor. Some effect on it by 3 of 4 strap muscles (omohyoid, sternohyoid & thyrohyoid)

Epiglottis

- Quadrangular membrane
- Rima glottidis
- Hya-epiglottic ligament
- Thyro-epiglottic ligament
- Vestibular fold/false cord (lowest edge of quadrangular membrane)
- Vocal fold (top edge of cricothyroid/cricovocal membrane)
- Aryepiglottic fold (free edge of quadrangular membrane)

Inlet (aditus) to larynx (made up of 2 aryepiglottic folds (leads to vestibule, the cavity just inside which faces backwards/upwards)

EPIGLOTTIS

- Elastic cartilage behind root of tongue
- Top & anterior surface is stratified squamous epithelium. Posterior is pseudostratified columnar
- Held by: hyo-epiglottic, thyro-epiglottic & aryepiglottic ligaments & median & lateral glosso-epiglottic folds

Cricoid cartilage

Thyroid cartilage
LARYNX - INTRINSIC MUSCLES

Posterior view

Oblique arytenoids (2) close cords by drawing together arytenoids. They extend into aryepiglottic fold as ary-epiglotticus to close the aditus

Transverse arytenoid (3) closes cords by drawing together arytenoids

Looking down at cords

Lateral crico-arytenoids (4) Adduct/close cords by rotating arytenoids medially

Thyro-arytenoids (5) & vocalis loosen cords by drawing together the thyroid cartilage & arytenoids

Posterior
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<tr>
<td>External branch of superior laryngeal nerve (X)</td>
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SEMON’S LAW
FOR DAMAGE OF NERVES TO LARYNX

Semons’s Law indicates the different effect between damage
and transection of the recurrent laryngeal nerve as applicable
to surgery in the region of this nerve (e.g. thyroidectomy or
parathyroidectomy).

### Transection of recurrent laryngeal nerve
- Complete paralysis
- Cords half abducted/adducted
- Cannot speak or cough

### Trauma but no transection
- Partial paralysis
- Adducted cords as posterior crico-arytenoid most vulnerable
- Cannot breathe

**BILATERAL** → **DISASTER**
**UNILATERAL** → **CAN PARTIALLY COMPENSATE**
**Emergency laryngotomy (cricothyroidotomy)**
Quick, relatively easy stab through cricothyroid membrane.
Insert any small round airway such as biro casing. Anaesthetic not essential. Saves lives.

**Formal tracheostomy.**
Not usually an emergency. Needs full anaesthetic. Ideal for temporary or permanent intubation. Hole cut in 2nd & 3rd tracheal rings, usually after dividing thyroid isthmus. Inferior thyroid veins can be a nuisance.
**VOCAL CORDS/CRICTHYROID MEMBRANE**

**TRUE VOCAL CORDS** are the free upper edges of the cricothyroid membrane (conus elasticus) where it is thickened to become the cricovocal ligament and covered with mucosa. The mucosa is pearly white and has no submucosa and thus cannot become oedematous.

- 40% of the vocal cord is arytenoid cartilage
- 60% is membrane

The cricothyroid membrane is attached around the inside of the ring of cricoid cartilage and has a free upper margin that is attached to the arytenoid cartilages posteriorly and to the back of the thyroid cartilage anteriorly.
SPHENOMANDIBULAR LIGAMENT RELATIONS

Structures that pass between ligament and mandible

- Spine of sphenoid
- Chorda tympani
- Auriculotemporal nerve
- Maxillary artery & vein
- Inferior alveolar nerve and vessels
- Mylohyoid nerve & vessels
- Pass behind neck of mandible
- Pass behind ramus of mandible

Note that nerve to mylohyoid pierces the ligament
INFERIOR ALVEOLAR NERVE: RELATIONS WITH MANDIBLE

BABY (Tooth buds)

ADULT (Teeth)

ELDERLY (Edentulous)
LIGAMENTS ASSOCIATED WITH MANDIBLE AND HYOID BONES

SPHENOMANDIBULAR LIGAMENT
Spine of sphenoid to lingula of mandible (1st arch remnant) Is axis of rotation for opening of mouth

PTYERGOMANDIBULAR RAPHE
Tendinous muscle fibres from pterygoid hamulus to posterior end of mylohyoid line. Medially lies buccal mucosa. Superior constrictor arises posteriorly & buccinator anteriorly from it. Buccinator also extends onto the pterygomaxillary ligament to reach the maxilla

STYLOMANDIBULAR LIGAMENT
Specialised band of deep cervical fascia. Styloid process to angle of mandible. Is the postero-inferior aspect of the parotid fascia

PTYERGOMAXILLARY LIGAMENT
Styloid process to lesser cornu of hyoid. 2nd arch remnant. Styloglossus from its upper end & middle constrictor from its lower end
Origin: Both jaws opposite 1st molar teeth & pterygomandibular raphe & pterygomaxillary ligament
Insertion: Modiolus
Action: Helps chewing, returns food to mouth from cheek pouches
Nerve supply: Facial (VII - buccal branches). Proprioceptive afferent fibres via buccal branch of Vc
INFRATEMPORAL FOSSA - BOUNDARIES

- Base of skull
- Between pharynx & ramus of mandible

**LATERAL WALL**
- Ramus of mandible
- Coronoid process

**ROOF**
- Infratemporal crest (greater wing of sphenoid)
- Squamous temporal

**MEDIAL WALL**
- Tensor veli palatini
- Levator veli palatini
- Superior constrictor
- Lateral pterygoid plate
- Pterygomaxillary fissure
- Maxilla

**POSTERIOR WALL**
- Carotid sheath

**ANTERIOR WALL**
- Posterior maxilla
- Inferior orbital fissure

**SUPERIOR CONSTRUCTOR**

**Sphenomandibular ligament**

**Lateral pterygoid**

**Parotid gland**

**Stylomandibular ligament**

**Medial pterygoid**

**Submandibular gland**

**Sublingual gland**

**Mylohyoid**

**Temporalsis**

**Genioglossus**

**Geniohyoid**

**Digastric**

**Maxilla**

**LVP TVP**
PAROTID REGION & MASSETER

- Definition: In front and below ear
- Features: Masseter
  Parotid gland

MASSETER

Origin: 3 heads from zygomatic arch
  1. Superficial - anterior 2/3
  2. Intermediate - middle 1/3
  3. Deep - Deep surface of posterior arch
Insertion: Ramus/angle of mandible
Action: Closes jaw
Nerve: Masseteric branch of mandibular division of trigeminal (Vc)
TEMPOROMANDIBULAR JOINT 1

- Synovial
- Condyloid
- Hemicylindrical
- Atypical (fibrocartilage on surfaces)
- Fibrocartilaginous disc
- Synovial membrane lines capsule
- Nerve supply: Auriculotemporal & nerve to masseter

**Articular tubercle**

**Between** mandible & mandibular fossa of squamous temporal bone

**Disc** attached anteriorly to head of mandible, thus moves forward with it. Also at lateral pterygoid plate and capsule

**Capsule** attached to neck of mandible at articular margin. Anterior - at articular tubercle. Posterior - at Squamotympanic fissure. Strong but lax at rest

**Lateral Temporomandibular Ligament** from zygomatic arch to posterior neck & ramus of mandible. Fuses with capsule, lax at rest, tightens with any movement

**Movement** in upper compartment is protraction (lateral pterygoids), retraction (posterior temporalis) & gliding side to side. In lower compartment is opening (lateral pterygoids & digastrics) & closing (masseters, medial pterygoids & temporalis)
Points A & B represent the 2 ends of the sphenomandibular ligament (spine of sphenoid to lingula of mandible). Distance between them must remain constant at all positions of the joint. Axis for opening must pass through lingula (B) on each side.

First few degrees of opening: Rotation only in lower cavity. Mostly gravity.

Majority of opening: Further rotation in lower joint cavity. Major degree of anterior displacement of head of mandible onto articular tubercle achieved by lateral pterygoid and occuring in upper joint cavity.

Last few degrees of opening: Further rotation in lower joint cavity only.
**Meninges**

- Outer endosteal (periosteal)
  - Inner meningeal (fibrous) into folds for TENSORIUM CEREBELLI & FALX CEREBRI
  - Outside both: middle meningeal vessels & site of extra-dural haemorrhage
  - Between layers: venous sinuses & Meckel's cave
  - Under both: subdural haemorrhage (venous & slow)

- Arachnoid
  - Lines inside of dura.
  - Forms villi to drain CSF into blood.
  - Several villi give an arachnoid granulation (Pacchionian body).
  - These indent bone & are mostly in the superior sagittal sinus

- Subarachnoid space
  - For circulation of CSF which suspends the brain. Larger areas are cisterns (CISTerna MAGNA, PONTINE, INTERPEDUNCULAR, CHIASMATIC). They are filled via the foramen of Magendie from the fourth ventricle. Subarachnoid haemorrhage into this space is arterial and sudden.

**Blood supply of dura**

- Middle meningeal artery, meningeal branches of vertebral, ophthalmic, anterior ethmoidal, internal carotid, accessory meningeal

**Nerve supply of dura in cranial fossae**

- Anterior: Anterior ethmoidal (V1)
- Middle: Nervus spinosus (V2), Middle meningeal nerve (Vb)
- Posterior: Meningeal branches of glossopharyngeal (IX) & Vagus (X)
- Foramen magnum: C1-3
- Supratentorial: Meningeal branches from Va
CAVERNOUS SINUS
CORONAL (TRANSVERSE) VIEW
RIGHT SIDE LOOKING ANTERIORLY

- Lies alongside body of sphenoid in middle cranial fossa
- Between periosteal (endosteal) and meningeal (fibrous) layers of dura
- Roof: Anterior & posterior clinoid processes with uncus of temporal lobe & internal carotid artery on it, III & IV into it
- Lateral wall: Dura, temporal lobe, III, IV, Va, Vb in wall
- Floor: Greater wing of sphenoid
- Medial wall: Dura over sphenoid, sella turcica, pituitary, sphenoid sinus
- Posterior wall: (narrow), dura of posterior fossa, superior and inferior petrosal sinuses, peduncle of brain
- Anterior wall: (narrow), medial end of superior orbital fissure, ophthalmic veins, orbit
- Contains: Internal carotid artery, VI & blood
- Draining into it: Superior/inferior ophthalmic veins, intercavernous sinuses, sphenoparietal sinuses, superficial middle cerebral vein
- Draining out of it: Superior/inferior petrosal sinuses, emissary veins to pterygoid plexus
**Meninges**

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  - Lines inside of dura.
  - Forms villi to drain CSF into blood.
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  - Outside both: middle meningeal vessels & site of extra-dural haemorrhage.
  - Between layers: venous sinuses & Meckel's cave.
  - Under both: subdural haemorrhage (venous & slow).

- **Subarachnoid Space**
  - Follows contour of brain everywhere. Forms denticulate ligament in spine and the filum terminale.
  - For circulation of CSF which suspends the brain. Larger areas are cisterns (Cisterna Magna, Pontine, Interpeduncular, Chiasmatic). They are filled via the foramen of Magendie from the fourth ventricle. Subarachnoid haemorrhage into this space is arterial and sudden.

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- Middle meningeal artery, meningeal branches of vertebral, ophthalmic, anterior ethmoidal, internal carotid, accessory meningeal.

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- Anterior: Anterior ethmoidal (Va)
- Middle: Nervus spinosus (Vc), Middle meningeal nerve (Vb)
- Posterior: Meningeal branches of glossopharyngeal (IX) & Vagus (X)
- Foramen magnum: C1-3
- Supratentorial: Meningeal branches from Va
STRUCTURES PIERCING THE DURA IN THE BASE OF THE SKULL

- Olfactory (I) bulb & nerve
- Optic nerve & ophthalmic artery
- Trigeminal ganglion & V\(_1\), V\(_2\), V\(_3\)
- Facial, nervus intermedius, vestibulocochlear (V\(_7\), V\(_8\))
- Glossopharyngeal Vagus Accessory (IX, X, XI)
- Cut edge of tentorium cerebelli
- Sigmoid sinus
- Hypoglossal (XII)
- Transverse sinus
- Tentorium cerebelli
- Middle meningeal artery
- Oculomotor (III)
- Trochlear (IV)
- Trigeminal (V)
- Spinal root of accessory
- Vertebral arteries
CORONAL SECTION OF SKULL, SCALP & MENINGES IN MIDLINE

To show layers of scalp, meninges and falx cerebri

Skin
Connective tissue
Aponoeurosis
Loose areolar tissue
Pericranium

Superior sagittal sinus
Lateral blood lake
Arachnoid granulations (a mass of villi) indenting the skull

Dura
Endostial (periosteal) Meningeal (fibrous)
Arachnoid
Pia
Falx cerebri
Inferior sagittal sinus

Brain

CEREBROSPINAL FLUID
- 130ml - 30ml in ventricles, 75ml in spinal system, 25ml in cranium
- Turn over - 500ml per day from choroid plexus to 4th ventricle to subarachnoid space to arachnoid villi
- Pressure - 130mm of water
- Function - Brain floats in it, some metabolic change, effectively reduces weight of brain from 1500g to 50g
RIGHT MIDDLE MENINGEAL ARTERY

ANTERIOR DIVISION
- Greater wing of sphenoid
- Ganglionic branch
- Squamous temporal
- Superior tympanic branch
- Pterion
- Foramen spinosum
- Auriculotemporal nerve
- Maxillary artery

POSTERIOR DIVISION
Where a vertical line from the mastoid process meets a horizontal line form the upper margin of the orbit. Fractured skull leads to extradural haemorrhage and contralateral deafness

ANTERIOR DIVISION
3cm above the midpoint of the zygomatic arch. Fractured skull leads to extradural haemorrhage with pressure on the motor area

Venous drainage of skull
- Diploic veins to sinuses within skull or to veins outside skull
- Meningeal veins to sphenoparietal sinus within skull or pterygoid plexus in infratemporal fossa

Note: the grooves on the inside of the skull are said to be due to veins and not the arteries. Middle meningeal artery does NOT supply the brain
MOUTH - GENERAL

From lips to palatoglossal fold (anterior pillar of fauces)

Vestibule is between teeth/gums and cheek. Emptied by buccinator

Roof is hard palate

Floor is tongue

Functions are eating, talking and extra airway

Sensations are taste, temperature, touch. Tongue/lips assess

Mucous membrane is stratified squamous. Nerve supply is Vb & Vc
(buccal, mental, infra-orbital). Contains salivary glands,
pierced by parotid duct (2nd upper molar tooth) and ducts
of glands
1. Tensor palati
2. Levator palati
3. Buccinator & superior constrictor from pterygomandibular raphe
4. Styloglossus
5. Stylopharyngeus
6. Rectus capitis lateralis
7. Stylohyoid
8. Inferior oblique
9. Middle constrictor
10. Thyropharyngeus
11. Transverse process of axis
12. Transverse process of atlas
13. Superior oblique
14. Hyoglossus
15. Genioglossus
16. Geniohyoid/mylohyoid
17. Cricothyroid
18. Thyrohyoid membrane

Stylohyoid ligament
Vertebral artery
Thyroid cartilage
Cricopharyngeus

MUSCLES OF TONGUE, MOUTH & NECK
HARD PALATE

- Mucoperiosteum (mucosa + periosteum)
- Sharpey’s fibres into pits on bone
- Blood supply: Greater palatine artery
- Venous drainage: Pterygoid plexus
- Lymph: Retropharyngeal and deep cervical nodes
- Nerve supply: Greater palatine and nasopalatine

See muscle section of Instant Anatomy for details of Tensor and Levator Veli Palatini
SOFT PALATE

Consists of:
- Aponeurosis
- Tensor veli palatini
- Levator veli palatini
- Palatoglossus
- Palatopharyngeus
- Muscles of uvula
- Mucosa
- Mucous & serous glands
- A few taste buds

Epithelium: Stratified squamous
Blood: Lesser palatine (maxillary)
         Ascending palatine (facial)
         Palatine branch of ascending
         pharyngeal (external carotid)
Veins: Pharyngeal & pterygoid plexus
Lymph: Retropharyngeal & antero-
       superior deep cervical
Nerve: Secretomotor - Vb via pterygo-
       palatine ganglion
       Sensation - Vb, lesser palatine
       + (IX)
       Taste - Greater petrosal then
       lesser palatine

Function: closes nasopharynx

Passavant’s ridge is a circular,
sphincter-like part of either
palatopharyngeus or superior
constrictor
**SUBLINGUAL GLAND**

- Mucous gland
- Between mylohyoid and genioglossus
- 15 ducts - 1/2 into submandibular duct  
  1/2 into sublingual fold
- Nerve supply - secretomotor via submandibular ganglion  
  general sensation via lingual (V3)
- Blood supply - Lingual artery & branches of submental artery
- Develops from a groove in floor of mouth that becomes a tunnel  
  Blind end proliferates (ectodermal) to give secreting acini
- (Note: all salivary glands develop from epithelial lining of mouth)
# TONGUE - SENSATION & TASTE

## SUMMARY OF NERVE SUPPLY TO TONGUE

<table>
<thead>
<tr>
<th>SOMATIC SENSATION</th>
<th>TASTE</th>
<th>SECRETOMOTOR</th>
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<tr>
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<td><strong>VALLECULAE</strong></td>
<td>Glossopharyngeal (IX)</td>
<td>Internal branch of superior laryngeal nerve (X)</td>
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Note: Sympathetic supply to tongue is from superior cervical ganglion via lingual artery.

For summary of TASTE please see page 83 in Instant Anatomy.
Development
- Budding of mouth ectoderm gives enamel
- Mesoderm is evoked to produce dentine & cementum
- Ameloblasts give enamel
- Mesoderm gives dental papillae which give odontoblasts which give dentine
- Dental papilla also gives pulp
TONGUE - DEVELOPMENT

FLOOR OF PHARYNX (PHARYNGEAL ARCHES)

Lateral lingual swellings

Tuberculum impar

Both mesoderm between 1st & 2nd arches

Copula (hypobranchial eminence)

Epiglottis from 4th arch

= 

Give anterior 2/3 of tongue

Epithelium & glands are from arch endoderm
Muscles are from occipital myotomes that migrate with the hypoglossal nerve

Posterior 1/3
From 2nd, 3rd & 4th arches (2nd is overgrown)

Epiglottis from 4th arch

NERVES

Anterior 2/3 Mandibular division of trigeminal (Vc), 1st arch nerve
Chorda tympani for taste. Only remnant of 2nd arch

Posterior 1/3 Glossopharyngeal (IX), 3rd arch nerve
Internal branch of superior laryngeal branch of vagus which is 4th arch nerve
TONGUE - MUSCLES

Hyoglossus
  Hypoglossal nerve (XII)
Genioglossus
  Hypoglossal nerve (XII)
Styloglossus
  Hypoglossal nerve (XII)
Palatoglossus
  Pharyngeal plexus (IX, X & sympathetic)
Intrinsic muscles
  Superior/inferior longitudinal, transverse & vertical
  Not attached to bone
  Hypoglossal nerve (XII)

Note: All muscles are supplied by hypoglossal nerve except palatoglossus

For details of these muscles see muscle section of Instant Anatomy
TONGUE - GENERAL TOPOGRAPHY

The tongue is a mass of skeletal muscle covered by mucous membrane. It is divided functionally and embryologically into an anterior 2/3 and a posterior 1/3 by the sulcus terminalis.

**Anterior 2/3**
- Oral
- Papillae (filiform, fungiform & vallate) for grip/taste
- Glands on tip and sides only
- Stratified, keratinising squamous epithelium

**Posterior 1/3**
- Smooth mucosa for swallowing
- No papillae
- Lingual tonsil
- Serous/mucous glands in oropharynx

**Papillae**
- Filiform for grip, keratin tips - pink after chewing, white then brown when dry
- Fungiform Taste buds
- Vallate with crypts for taste and serous glands

**Parts of the Tongue**
- Median & lateral glosso-epiglottic folds
- Epiglottis
- Tonsil
- Foramen caecum
- Sulcus terminalis
- Vallate papillae
- Folds/arches
- Palatopharyngeal
- Palatoglossal
- Valleculae
- Dorsum
- Tip
- Root
- Frenulum/deep lingual vein

**Inferior surface**
- 2 anterior lingual glands
TONGUE - LINGUAL ARTERY

- Dorsal lingual arteries
- Hypoglossal nerve (XII)
- External carotid artery
- Lingual artery
- Branch to sublingual gland
- Sublingual gland
- Deep lingual vein joins sublingual vein to join lingual, facial or internal jugular

LYMPH
- Tip to submental glands bilaterally
- Dorsum to submandibular mostly unilaterally
- Posterior to jugulo-omohyoid & deep cervical
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Note: Sympathetic supply to tongue is from superior cervical ganglion via lingual artery.

For summary of TASTE please see page 83 in Instant Anatomy.
NASAL CAVITY
BOUNDARIES & CORONAL VIEW

- Nasal cavity extends from nares to choanae (posterior septum)
- Floor: Hard palate
- Roof: Sphenoid and ethmoid
- Medial wall: Septum
- Lateral wall: medial orbit, ethmoidal air cells, maxillary sinus

MUCOSA
- Olfactory nerve
- Vestibular - skin & hair
- Respiratory - Pseudostratified ciliated columnar
LATERAL WALL OF LEFT NASAL CAVITY

Superior meatus
Under superior concha (cut away). Opening of posterior ethmoidal air cells

Sphenoid sinus
Openings of ethmoidal cells

Sphenopalatine foramen

Opening of auditory tube (Eustachian tube)

Frontal sinus

Sphen-ethmoidal recess with opening of sphenoid sinus

Inferior meatus
Under inferior concha (cut away). Opening of nasolacrimal duct

Middle meatus
Under middle concha (cut away). Opening of
1. Maxillary sinus
2. Middle ethmoidal sinus on bulla ethmoidalis
3. Infundibulum from frontal sinus into which anterior ethmoidal sinus usually drains (it may drain separately. The infundibulum is at the anterior end of the
4. Hiatus semilunaris
BLOOD SUPPLY OF LATERAL WALL OF NOSE

1. Branch of greater palatine
2. Perforating branches of greater palatine
3. Anterior superior alveolar from infra-orbital
**L/M PSN** = Lateral & medial posterior superior nasal, from nasopalatine, from Vb, from pterygopalatine ganglion
- **Anterior ethmoidal** from nasociliary, from Va
- **Lateral posterior inferior nasal**, from greater palatine, from Vb, from pterygopalatine ganglion
- **Nasopalatine** from Vb, from pterygopalatine ganglion
- **Anterior superior alveolar**, from infra-orbital, from Vb
- **Infra-orbital**, from Vb
**VENOUS DRAINAGE**

Anterior - to face  
Posterior - to pterygoid plexus. Also via ethmoidal veins to ophthalmic and inferior cerebral veins. 1% via foramen caecum to superior sagittal sinus.

**LYMPHATIC DRAINAGE**

Lateral wall and septum. Posterior: to retropharyngeal and to anterior/superior deep cervical. Anterior: to submandibular.

**LINING**

Respiratory epithelium - pseudostratified ciliated columnar with mucous cells and very vascular  
Olfactory epithelium - ciliated nerve cells. Yellowish, on roof & septum, under superior concha & in sphenoid recess.
EXTERNAL NOSE

- Breathing. Stops during swallowing
- Warming air
- Moistening air
- Filtering air
- Smell

Conchae & sinuses increase the surface area, the epithelium is vascular, there are cilia and mucus is secreted

EXTERNAL NOSE is cartilage and fibrofatty tissue

- Nerve supply: External nasal (terminal anterior ethmoidal) Va
  Supratrochlear (frontal) Va
  Infra trochlear (nasociliary) Va
  Infra-orbital (maxillary) Vb

- Blood supply: Dorsal nasal (ophthalmic)
  External nasal (anterior ethmoidal)
  Facial (lateral nasal & septal branches)
FACE: MOTOR AND SENSORY SUPPLY

SENSORY TRIGEMINAL (V)
- Supratrochlear
- Supra-orbital
- Auriculotemporal
- Zygomaticotemporal
- Lacrimal
- Zygomaticofacial
- Infra-orbital
- Buccal
- Great auricular
- Mental

MOTOR FACIAL (VII)
- Temporal
- Zygomatic
- Buccal
- Mandibular
- Cervical

Ophthalmic (5 branches)
- Maxillary (3 branches)
- Mandibular (3 branches)

Facial nerve branches:
- Temporal: frontalis & procerus
- Zygomatic 1: eye & around orbit
- Zygomatic 2: mid face & smile
- Buccal: buccinator & upper lip
- Mandibular: lower lip & orbicularis oris
- Cervical: platysma

Mnemonic:
Two Zulus Befriended My Cat

(note: proprioception is supplied by trigeminal)
ETHMOIDAL SINUSES

Diagrammatical representation of the ethmoid bone to show the left and right ethmoidal sinuses joined by the cribriform plate. The roof of the air cell containing sinuses on each side is the orbital plate of the frontal bone. Anterior to the ethmoid bone is the lacrimal bone & posterior is the sphenoid bone.

- Roof: Orbital plate of the frontal bone
- Crista galli
- Cribiform plate
- Air cells
- Superior/middle conchae
- Perpendicular plate (nasal septum)
- Anterior
- Middle
- Posterior
- Air cell drainage sites

Ethmoidal sinuses lie between the orbit & nose in the lateral (labyrinthise) part of the bone.
Septa lie between 3-18 lots of air cells.
Blood supply: Supra-orbital, anterior/posterior ethmoidal, sphenopalatine.
Lymph drainage: Submandibular and retropharyngeal.
Nerve: Supra-orbital (V1), Anterior ethmoidal (V1), lateral posterior superior nasal (V2), posterior ethmoidal (V1).
FRONTAL SINUSES

- Appear at 2 years
- Unequal in size
- Bony septum
- Lie between orbit and anterior cranial fossa
- Nerves: Supra-orbital & supratrochlear nerves
- Blood supply: Supra-orbital & supratrochlear arteries
- Lymph drainage: Submandibular
- Veins: Diploic & superior opthalmic

Drainage (diagrammatic)
- Ostium: lower medial aspect
- To middle meatus via frontonasal canal (anterior end of hiatus semilunaris)
- May drain via infundibulum from anterior ethmoidal sinus
PARanasal Sinus - General

- 4 pairs
- Lined by respiratory epithelium
- Communicate with nose via ostia
- Abundant sensory nerve supply at ostia
- Mucus is drained by cilia
- Function unknown but they lighten the skull, warm & moisten the air, resonate the voice

<table>
<thead>
<tr>
<th></th>
<th>Maxillary</th>
<th>Ethmoidal</th>
<th>Sphenoidal</th>
<th>Frontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Birth</td>
<td>Small</td>
<td>Absent</td>
<td>Enlarge</td>
<td>Enlarge</td>
</tr>
<tr>
<td>6-7 Years (2nd Dentition)</td>
<td>Enlarge</td>
<td></td>
<td>Enlarge</td>
<td></td>
</tr>
<tr>
<td>Post Puberty Bone Growth</td>
<td>Large</td>
<td></td>
<td>large</td>
<td></td>
</tr>
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</table>
MAXILLARY SINUS

- Pyramidal shape
- Anterior & posterior walls are maxilla
- Drains into posterior hiatus semilunaris of middle meatus
- Ostium is 3-4mm high on posterior end of nasal wall
- May be a second ostium
- Blood supply: Small arteries from facial, maxillary, infraorbital & greater palatine
- Lymph drainage: Submandibular glands
- Nerve supply: Anterior/middle/posterior superior alveolar with secretomotor from pterygopalatine ganglion
- Feature: The infra-orbital nerve lies in its ridge (junction of roof and anterior wall)
SPHENOIDAL SINUSES
Paired in body of sphenoid
Septum: Asymmetrical
If small: Then anterior to pituitary fossa
If large: Then beneath pituitary fossa, extending
          posteriorly to basi-occiput and laterally into
          greater wing
Ostium: In anterior wall opening into sphenoid-ethmoidal recess
Laterally: Cavernous sinuses, internal carotid artery and
          maxillary nerve
Posteriorly: Posterior cranial fossa and pons
Inferiorly: Roof of nasopharynx, nerve of pterygoid canal
            and palatovaginal canal (containing pharyngeal
            branch of Vb)
Walls: Indented by pterygoid & palatovaginal canals,
       internal carotid artery and maxillary nerve (Vb)
Nerve supply: Posterior ethmoidal (Va) & branches of
              pterygopalatine ganglion
Blood supply: Posterior ethmoidal & sphenopalatine branches of
              maxillary artery
Lymph drainage: Retropharyngeal
**PARATHYROID GLANDS**

**THYROID GLAND VIEWED FROM BEHIND**
- Superior gland
- Oesophagus
- Trachea
- Inferior gland
- Superior thyroid artery
- Inferior thyroid artery
- Pharynx

**NORMAL POSITIONS AND VARIATIONS**
- 4 (3-6) pinkish/brown glands
- Weighing 50mg & 6x3x2mm each
- Usually lie within pretracheal fascia
- Superior (develops from endoderm of dorsal diverticulum of 4th arch). Less variation in position
- Inferior (Is dragged down with thymus from 3rd pouch). More variation even into upper mediastinum
- Blood supply: Inferior thyroid arteries
- Nerves: Sympathetics on arteries for vasoconstriction
- Histology: Homogeneous
- Very vascular
- Small round cells
- No follicles
- Irregular columns

**Function:** Produces parathormone (PTH)
- Increases tubular reabsorption of calcium
- Decreases tubular reabsorption of phosphate/bicarbonate
- Mobilises calcium from bones to give hypercalcaemia and hypercalciuria
**PAROTID REGION & MASSETER**

- **Definition:** In front and below ear
- **Features:** Masseter
  Parotid gland

**MASSETER**

- **Origin:** 3 heads from zygomatic arch
  1. Superficial - anterior 2/3
  2. Intermediate - middle 1/3
  3. Deep - Deep surface of posterior arch
- **Insertion:** Ramus/angle of mandible
- **Action:** Closes jaw
- **Nerve:** Masseteric branch of mandibular division of trigeminal (Vc)

**Diagram Notes:**
- Masseteric nerve from Vc
- Masseteric artery from superficial temporal
- Temporalis
- Facial artery
- 3 heads of masseter
- Temporalis
- Buccinator
- Platysma
- Depressors
  - Labii inferior
  - Anguli oris
  - Mentalis
PAROTID GLAND 1

- Serous secretions
- Produces amylase, water, Ig factors (lubricates & oral hygiene)
- Lies between mastoid, styloid process, ramus of mandible
- Has an upper & lower pole, lateral, anterior & deep surfaces
- Surrounded by parotid fascia (investing layer of deep fascia)

**RELATIONS:**

- **Posterior**
  - Sternocleidomastoid
  - Mastoid process
- **Above**
  - External acoustic meatus
  - Temporomandibular joint
- **Anterior**
  - Angle of mandible
  - Medial pterygoid plate
  - Masseter
  - Stylomandibular ligament

**In gland:** Facial nerve, retromandibular vein, external carotid artery, lymph nodes, fibres of auriculotemporal nerve

**Deep to gland:** Mastoid process, sternomastoid, posterior belly of digastric, styloid process, stylohyoid ligament & muscle, styloglossus, stylopharyngeus, temporomandibular joint

**Lateral:** subcutaneous surface
PAROTID GLAND 2

- Blood supply: Branches of external carotid
- Venous drainage: To retromandibular
- Lymph drainage: Pre-auricular to deep cervical
- Nerve supply: Secretomotor via inferior salivary nucleus to glossopharyngeal nerve to its tympanic branch to lesser petrosal nerve to otic ganglion to auriculotemporal nerve. Sympathetics via superior cervical ganglion and external carotid artery. Sensation for gland - auriculotemporal (V3), for fascia - great auricular (C2)
- Duct: 5cm long, crosses masseter, pierces buccinator at 3rd molar and mucosa at 2nd molar. Stenson's duct
- Surface markings of duct:

Intertragic notch of ear
Philtrum

Relations in axial section

Anterior surface
Vagus
Stylomandibular ligament
Medial pterygoid
Mandible
Masseter
Facial nerve

Deep surface
Internal jugular vein
Internal carotid art.
Styloid process, stylohyoid, styloglossus, stylopharyngeus, stylohyoid and stylomandibular ligaments

Development
Lining of mouth
Ectoderm
Tunnel
Far end proliferates

Histology
Stratified cuboidal ducts
Tubulo-acinar glands with the occasional myoepitheliocyte
CLINICAL ASPECTS

- Mickulitz & Sjogren's syndromes
- Adenomas
  - Both sexes equal occurrence
  - Pleomorphic
  - Poorly circumscribed
  - Can become malignant
  - Usually superficial to VII
- Adenolymphoma - Warthin's tumour (more in males than females)
- Primary malignant - adenocystic, acinar cell
- Secondary malignant - from face
- Stones in duct
- Frey's syndrome - gustatory sweating. Regrowth of sympathetic fibres into damaged sympathetic of auriculotemporal nerve
PHARYNX - VESSELS & NERVES

ARTERIAL SUPPLY
- Greater palatine (maxillary)
- Artery to pterygoid canal (maxillary)
- Tonsillar (facial)
- Ascending palatine (facial)
- Lingual
- Superior laryngeal (superior thyroid)

VENOUS DRAINAGE
- Plexus on middle constrictor
draining to:
  - Pterygoid plexus
  - Internal jugular vein
  - Lower pharynx to inferior thyroid veins

NERVE SUPPLY
- Levator palati
- Salpingopharyngeus
- Palatopharyngeus
- Palatoglossus
- 3 constrictors
- Striated oesophagus
- All from PHARYNGEAL PLEXUS on posterior wall of pharynx. It is:
  - IX (glossopharyngeal) sensory only
  - X (pharyngeal branch of vagus)
    - Branchiomotor fibres from nucleus ambiguus via cranial accessory (XI)
    - Sympathetic - vasoconstrictor only
- Stylopharyngeus
- Glossopharyngeal (IX) only
- Stylopharyngeus
- Cricopharyngeus (+/- some oesophagus)
- Recurrent laryngeal (X)
- Sensation/taste
  - Nasopharynx: pharyngeal branch of maxillary (Vb) via pterygopalatine ganglion and palatovagal canal
  - Oropharynx/valleculae: IX and X
- Sensation only
  - Laryngopharynx: Internal branch of superior laryngeal (X) & recurrent laryngeal (X)

LYMPH
- Retropharyngeal to upper/lower deep cervical
PHARYNX - MUSCLES & STRUCTURES ENTERING IT

Between superior & middle constrictors are:
1. Glossopharyngeal nerve (IX)
2. Stylopharyngeus (IX)
3. Stylohyoid ligament
4. Lingual nerve (Vc)

Between middle & inferior constrictors are:
5. Thyrohyoid membrane pierced by:
   6. Internal laryngeal nerve
   7. Superior laryngeal vessels

Inferior constrictor
(Thyrohypharyngeus (8) is upper part that behaves like the other constrictors, closing on swallowing. Cricopharyngeus (9) is lower part - a sphincter that opens on swallowing. Between 2 parts is potential pharyngeal pouch (Dehiscence of Killian) (10)

Below inferior constrictor and passing upwards are:
11. Recurrent laryngeal nerve
12. Inferior laryngeal vessels

For details of these muscles see muscle section of Instant Anatomy
PHARYNX - DIVISIONS

- 5" (13cm) long fibromuscular tube
- Suspended from skull & anterior to prevertebral fascia
- Extends from nose to C6 (oesophagus)
- Like a mask applied to back of face
- Walls are mucous membrane, fibrous submucosa, muscle & thin buccopharyngeal fascia
- Muscles are:
  - 3 constrictors
  - Stylopharyngeus, palatopharyngeus, salpingopharyngeus
  - Note: levator palati is wholly intra-pharyngeal

CARTOON OF PHARYNX

Posterior nares
Oropharynx
Larynx
Oesophagus

2 entrances
2 exits

DIVISIONS OF PHARYNX

Posterior nares
Base of skull
Palato-glossal fold
Dorsal velum
Lower soft palate
Upper epiglottis
C6 (oesophagus)
See pharyngeal derivatives section in Instant Anatomy for more details
PHARYNX - CARTOON OF MUSCLES & PHARYNGOBASILAR FASCIA

CARTOON OF MUSCLES OF PHARYNX

Pharyngobasilar fascia
Superior constrictor
Middle constrictor
Inferior constrictor (thyro/crico-pharyngeus)
Oesophagus

LIKE 4 STACKED CUPS

PHARYNGOBASILAR FASCIA
(a rigid membrane with cartilage of auditory tube passing just above it. Shown in yellow)

Arises: Pharyngeal tubercle, back of foramen lacerum, petrous temporal anterior to carotid foramen, cartilage of auditory tube, medial pterygoid plate, pterygoid hamulus then across to opposite side
Lower border: Junction of hard and soft palates (Passavant's ridge)
Note: Levator palati arises within pharynx
# Rules of Nerve Supply for Muscle Groups

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Nasopharynx

- From Choanae to Lower Border of Soft Palate
- Back and sides: pharyngobasilar fascia
- Posterior: prevertebral space/fascia, body of C1 vertebra
- Anterior: choanae & back of soft palate
- Inferior: Soft palate & pharyngeal isthmus
- Superior: Pharyngeal tonsil (adenoid), sphenoid & occiput
- Epithelium: Ciliated columnar
- Features: Opening of auditory tube
  - Pharyngeal tonsil
  - Tubal tonsil
  - Pharyngeal recess (of Rosenmuller)
  - Salpingopharyngeus & levator palati
OROPHARYNX

- From: lower border of soft palate
- To: upper border of epiglottis
- Anterior: posterior aspect of tongue & palatoglossal arch
- Posterior: 3 constrictors & C2/C3 vertebrae
- Inferior: back of tongue, lingual tonsil & valleculae
- Lateral: palatoglossal/palatopharyngeal arches, constrictors & palatine (the) tonsil
- Lining: squamous epithelium
- Nerves: glossopharyngeal (IX) & internal laryngeal (X) in valleculae
- Features: Palatine tonsils (see separate illustration)
  - Lingual tonsils
  - Valleculae
PALATINE TONSIL

- Lymphoid tissue in tonsillar fossa
- Anterior/posterior: palatoglossal/palatopharyngeal arches
- Superior: soft palate
- Inferior: tongue
- Medial: mucosa & 20 tonsillar crypts, intratonsillar cleft (this is a large crypt from 2nd pharyngeal pouch)
- Bed: submucosa (capsule), superior constrictor, facial artery & its branches
- Lymph: to deep cervical & jugulodigastric
- Veins: plexus in capsule to pharyngeal venous plexus. Also external palatine (paratonsillar) from soft palate
- Nerves: tonsillar branch of glossopharyngeal (IX) - hence referred pain to the middle ear. Also lesser palatine (maxillary via pterygopalatine ganglion)
- Development: 2nd pharyngeal pouch endoderm gives mucosa & crypts
  Surrounding mesenchyme gives lymphoid tissue
- Surface marking: medial to lower masseter
WALDEYER’S RING

An interrupted circle of protective lymphoid tissue at the upper ends of the respiratory and alimentary tracts.

- Pharyngeal tonsil (adenoid)
- Upper midline in nasopharynx
- Tubal tonsil
- Around openings of auditory tube
- Palatine tonsil
- Either side of oropharynx
- Lingual tonsil
- Under mucosa of posterior third of tongue

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LARYNGOPHARYNX

- Extends from: tip of epiglottis - C3
- To: start of oesophagus - C6
- Anterior: larynx, aditus, epiglottis
- Posterior: 3 overlapping constrictors, dehiscence of Killian, cricopharyngeus, vertebrae C4, 5, 6
- Nerve supply: internal laryngeal branch of superior laryngeal nerve (X) & recurrent laryngeal nerve (X).
  Note that there is some overlapping of supply in the laryngopharynx unlike in the larynx
- Lining: squamous non-keratinising epithelium
- Features: aditus to larynx & piriform fossa

Piriform fossa
Medial: quadrangular membrane
Lateral: thyrohyoid membrane & lamina of thyroid cartilage

Hypopharynx
A clinical term for that part of the laryngopharynx below the aditus
Anterior: arytenoid cartilages
Posterior: dehiscence of Killian
POSTERIOR TRIANGLE OF NECK

- **Boundaries:** Posterior border of sternocleidomastoid, anterior border of trapezius, mid 1/3 clavicle
- **Shape:** Spiral
- **Roof:** Investing fascia, platysma, external jugular vein
- **Floor:** Prevertebral fascia covering muscles, subclavian artery, trunks of brachial plexus & cervical plexus
- **Contents:**
  - Arteries: Occipital, superficial cervical, suprascapular
  - Veins: Transverse cervical, suprascapular, external jugular
  - Nerves: Branches of cervical plexus, spinal root of accessory
  - Muscle: Omohyoid with its sling
  - Lymph nodes: Occipital (rubella/scalp infections) Supraclavicular (part of the deep chain)
PTERYGOPALATINE FOSSA 1

Right side of skull cut away to show trigeminal ganglion lying in Meckel's cave and the maxillary division entering the pterygopalatine fossa through foramen rotundum. The nerve of the pterygoid canal is seen entering the pterygopalatine ganglion and connecting to Vb so that sensory fibres can be distributed with the parasympathetic fibres from the ganglion and so that parasympathetics can pass on Vb to be distributed to sinuses and lacrimal gland.

The contents of the pterygopalatine fossa are:

- Terminal branches of the maxillary artery
- Maxillary nerve (Vb) to upper teeth, floor of orbit, face/skin
- Pterygopalatine ganglion for distribution of parasympathetics to nose and palate

![Diagram of pterygopalatine fossa with labeled structures]
PTERYGOPALATINE FOSSA 2

LOOKING INTO THE RIGHT SIDE

POSTERIOR

Greater wing of sphenoid
Pterygoid process of sphenoid
Medial pterygoid plate
Lateral pterygoid plate
Pyramidal process of palatine bone

ANTERIOR

Inferior orbital fissure
Sphenopalatine foramen into lateral nose
Posterior superior alveolar foramina in posterior maxilla
Pterygomaxillary fissure
Greater palatine canal

Lateral access into the fossa is via the pterygomaxillary fissure. Other entry and exit sites are shown on a separate illustration.
PTERYGOPALATINE FOSSA 3

Diagrammatic view of right fossa looking down on it from above to show entry and exit of nerves. The roof (removed) is greater wing of sphenoid.
THORACIC INLET

- Costocervical trunk
- Superior intercostal
- Deep cervical
- T1 anterior ramus
- C8 anterior ramus
- Lower trunk of brachial plexus
- Subclavian artery & vein
- Internal thoracic artery
- Vagus
- Brachiocephalic artery
- Thoracic duct

Inlet is 10cm wide
5cm anteroposterior

DOME OF PLEURA

Covered by suprapleural membrane (Gibson's fascia)
Held up by scalenus minimus (pleuralis) from transverse process of C7
Extends 4cm above middle of medial third of clavicle and first rib, BUT NOT above neck of first rib

Relations:
- Posterior: Sympathetic trunk, supreme intercostal vein, superior intercostal artery, T1 nerve root, 1st rib, thoracic duct on left
- Anterior: On right - brachiocephalic artery and vein
  On left - Subclavian artery and vein
- Superior: Costocervical trunk, thoracic duct on left

Mnemonic: Vagus nerves and phrenic nerves enter the chest between the arteries behind and the veins in front
PAROTID GLAND 1

- Auriculotemporal nerve
- Facial nerve
- Spinal root of accessory nerve (XI)
- Facial vein
- Buccinator
- Masseter
- Facial artery
- External jugular vein
- Sterno-mastoid
- Hypoglossal nerve (XII)
- Superficial temporal artery/vein

- Serous secretions
- Produces amylase, water, Ig factors (lubricates & oral hygiene)
- Lies between mastoid, styloid process, ramus of mandible
- Has an upper & lower pole, lateral, anterior & deep surfaces
- Surrounded by parotid fascia (investing layer of deep fascia)

RELATIONS:

Posterior
- Sternocleidomastoid
- Mastoid process

Above
- External acoustic meatus
- Temporomandibular joint

Anterior
- Angle of mandible
- Medial pterygoid plate
- Masseter
- Stylomandibular ligament

In gland: Facial nerve, retromandibular vein, external carotid artery, lymph nodes, fibres of auriculotemporal nerve

Deep to gland: Mastoid process, sternomastoid, posterior belly of digastric, styloid process, stylohyoid ligament & muscle, styloglossus, stylopharyngeus, temporomandibular joint

Lateral: subcutaneous surface
PAROTID GLAND 2

- Blood supply: Branches of external carotid
- Venous drainage: To retromandibular
- Lymph drainage: Pre-auricular to deep cervical
- Nerve supply: Secretomotor via inferior salivary nucleus to glossopharyngeal nerve to its tympanic branch to lesser petrosal nerve to otic ganglion to auriculotemporal nerve. Sympathetics via superior cervical ganglion and external carotid artery. Sensation for gland - auriculotemporal (V3), for fascia - great auricular (C2)
- Duct: 5cm long, crosses masseter, pierces buccinator at 3rd molar and mucosa at 2nd molar. Stenson's duct
- Surface markings of duct:

  - Intertragic notch of ear
  - Philtrum

Relations in axial section

- Anterior surface
- Vagus
- Internal jugular vein
- Internal carotid art.
- Posterior digastric
- Mastoid
- Sternoceleidomastoid
- Stylohyoid
- Styloglossus
- Stylopharyngeus
- Stylohyoid and stylomandibular ligaments

Development
- Lining of mouth
- Ectoderm
- Tunnel
- Far end proliferates

Histology
- Stratified cuboidal ducts
- Tubulo-acinar glands with the occasional myoepitheliocyte
CLINICAL ASPECTS

- Mickulitz & Sjögren's syndromes
- Adenomas
  - Both sexes equal occurrence
  - Pleomorphic
  - Poorly circumscribed
  - Can become malignant
  - Usually superficial to VII
- Adenolymphoma - Warthin's tumour (more in males than females)
- Primary malignant - adenocystic, acinar cell
- Secondary malignant - from face
- Stones in duct
- Frey's syndrome - gustatory sweating. Regrowth of parasympathetic fibres into damaged sympathetic of auriculotemporal nerve
SUBMANDIBULAR GLAND

- Mixed - mucous and serous
- Duct: (Wharton's) 5cm long. First between mylohyoid & hyoglossus, then between sublingual gland and geniohyoid. Opens in floor of mouth beside frenulum. Develops in ectoderm from a groove in the floor of mouth
- Produces 70% of the saliva
- Lymph nodes in it and on it. Drain to submandibular glands
- Histology: See parotid
**SUBLINGUAL GLAND**

- Mucous gland
- Between mylohyoid and genioglossus
- 15 ducts - 1/2 into submandibular duct
  1/2 into sublingual fold
- Nerve supply - secretomotor via submandibular ganglion
  general sensation via lingual (Vc)
- Blood supply - Lingual artery & branches of submental artery
- Develops from a groove in floor of mouth that becomes a tunnel
  Blind end proliferates (ectodermal) to give secreting acini
- (Note: all salivary glands develop from epithelial lining of mouth)
LATERAL VIEW OF SKULL TO SHOW BONES & OTHER FEATURES

- Bregma
- Lambda
- Superior/inferior temporal lines
- Pterion
- Nasion
- Nasal
- Inion (external occipital protuberance)
- Occipital
- Parietal
- Frontal
- Squamous temporal
- Lateral temporal
- Mastoid process
- Styloid process
- External acoustic meatus
- Maxilla
- Mandible
- Mental foramen
- Infra-orbital foramen
- Zygomatic

POSTERIOR VIEW OF SKULL TO SHOW BONES & OTHER FEATURES

- Sagittal suture
- Lambda
- Lambdoid suture
- Occipital
- Superior nuchal line
- Inferior nuchal line
- Mastoid process with groove for digastric
- Occipital condyle
- Back of mandible
- External occipital protuberance (inion)
- Parietal
- Wormian bone
STRUCTURES PIERCING THE DURA IN THE BASE OF THE SKULL

- Olfactory (I) bulb & nerve
- Optic nerve & ophthalmic artery
- Trigeminal ganglion & V1, V2, V3
- Facial, nerve intermedius, vestibulocochlear (VII, VIII)
- Glossopharyngeal Vagus Accessory (IX, X, XI)
- Cut edge of tentorium cerebelli
- Sigmoid sinus
- Hypoglossal (XII)
- Transverse sinus
- Tentorium cerebelli
- Oculomotor (III)
- Middle meningeal artery
- Trochlear (IV)
- Trigeminal (V)
- Spinal root of accessory
- Vertebral arteries
INTERNAL VIEW OF BASE OF SKULL TO SHOW SINUSES AND FORAMINA

- Frontal air sinuses
- Ethmoid air sinuses
- Sphenoidal air sinuses
- Optic canal
- Superior orbital fissure
- Foramen rotundum
- Foramen spinosum
- Foramen ovale
- Jugular foramen
- Internal acoustic meatus
- Hypoglossal canal
- Foramen magnum
- Foramen caecum
- Crista galli
- Cribiform plate
- Anterior
- Middle
- Posterior
- The vagus lies most medial in the foramen
- Glossopharyngeal nerve & inferior petrosal sinus exit from the anterior compartment of the foramen
- Vagus & accessory nerves exit from the middle compartment
- The sigmoid sinus exits from the posterior compartment, is soon joined by the inferior petrosal sinus to become the internal jugular vein

* = Tympanic branch of IX (Jacobson's nerve)
BLOOD SUPPLY OF SPINAL CORD

POSTERIOR SPINAL ARTERIES
- Arise at foramen magnum from posterior inferior cerebellar arteries (or vertebral)
- Lie anterior & posterior to posterior rootlets
- Run length of cord but poor anastomosis except at lower end of cord
- Supply own side of grey & white posterior columns

ANTERIOR SPINAL ARTERY
- Single artery that arises from each vertebral artery at foramen magnum to run length of cord
- Usually bigger than posterior spinal arteries but may be quite small.
- Supplies whole cord anterior to posterior grey columns, bilaterally

OTHER VESSELS
From vertebrals, deep & ascending cervicals, intercostals, lumbar & lateral sacrals. Note that all vessels anastomose under the pia mater in the periphery of the cord

RADICULAR (FEEDER) ARTERIES
- Enter via intervertebral foramina and reinforce anterior & posterior spinal arteries & supply dorsal root ganglia
- Variable number at variable levels but largest is Arteria Radicularis Magna, usually at T10 or 11 (artery of Adamkiewicz)
SPINAL CORD - GENERAL

- Cord begins at lower medulla of brain stem
- Cord finishes at lower border of L1 vertebra
- 45cm long

Diagram showing:
- Posterior lateral sulcus
- Posterior median sulcus
- Posterior white columns
- Medial - fasciculus gracilis
- Lateral - fasciculus cuneatus
- Posterior grey column
- Spinal accessory (C1-5)
- Anterior grey column
- Lateral white column
- Anterior white column
- Anterior median sulcus
- Sympathetic/parasympathetic from lateral horn
- Somatic motor
Basivertebral veins emerge from foramina in posterior vertebral bodies & drain into the internal vertebral plexus (anterior/posterior) which drains via the intervertebral segmental veins (with the nerve roots) into the external vertebral plexuses which, in turn connect above & below the diaphragm to the inferior & superior vena cavae via vertebral, azygos, lumbar & lateral sacral veins.

These veins are VALVELESS and thus cancer cells from thyroid, breast, kidney & prostate can easily enter the bones.

The posterior longitudinal ligament attaches to the discs only and not to the vertebral bodies so that there is free drainage of the basivertebral veins.

The dural sac finishes at S2 but the PIA MATER in the form of the filum terminale continues below S2 and attaches to the back of the coccyx.

The DENTICULATE (dentate) ligament is pia mater that connects the cord to the dura mater laterally between the exits sites for the nerves. It pierces the arachnoid mater. Note that the spinal roots of the accessory nerve (C1-5) emerge dorsal to the denticulate ligament, whereas the sensory roots emerge dorsal and the motor roots ventral to it.

**SPINAL SUB-ARACHNOID SPACE**
- Volume 75ml
- Tapped during spinal puncture or anaesthetic below L2
RIGHT STYLOID PROCESS
MUSCLE AND LIGAMENT ATTACHMENTS
LATERAL VIEW

Styloglossus
From lower anterior
1/3 into tongue
Hypoglossal nerve (XII)

Stylohyoid ligament
From tip to lesser cornu

Stylohyoid (Retracted)
From upper posterolateral
1/3
Facial Nerve (VII)

Stylopharyngeus
From upper postero-
medial 1/3 to posterior
thyroid lamina
Glossopharyngeal nerve (IX)

Digastric
From mastoid
to mandible
Anterior Vc
Posterior VII

Hyoid bone
LIGAMENTS ASSOCIATED WITH MANDIBLE AND HYOID BONES

**Sphenomandibular Ligament**
Spine of sphenoid to lingula of mandible (1st arch remnant) Is axis of rotation for opening of mouth

**Stylomandibular Ligament**
Specialised band of deep cervical fascia. Styloid process to angle of mandible. Is the posteroinferior aspect of the parotid fascia

**Ptérygomandibular Raphe**
Tendinous muscle fibres from ptérygoid hamulus to posterior end of mylohyoid line. Medially lies buccal mucosa. Superior constrictor arises posteriorly & buccinator anteriorly from it. Buccinator also extends onto the ptérygomaxillary ligament to reach the maxilla

**Stylohyoid Ligament**
Styloid process to lesser cornu of hyoid. 2nd arch remnant. Styloglossus from its upper end & middle constrictor from its lower end
RELATIONS TO SCALENUS ANTERIOR

ANTERIOR
- Phrenic nerve (Under prevertebral fascia)
- Ascending cervical artery
- Transverse cervical/suprascapular arteries
- Carotid sheath
- Vagus
- Thoracic duct
- Lower belly of omohyoid
- Deep cervical nerves

POSTERIOR
- 2nd part subclavian artery
- Anterior rami C3-T1
- Costocervical trunk
- Superior intercostal & deep cervical arteries
- Scaleneus Medius

MEDIAL
- Iongus coli
- Carotid tubercle
- Pyramidal space
- Carotid sheath
- Stellate ganglion
- Vertebral artery
- Middle cervical ganglion
- Inferior thyroid artery
- 1st part subclavian artery
- Ansa subclavia
- Thyrocervical trunk
- Vertebral vein

LATERAL
- Trunks of brachial plexus
- 3rd part subclavian artery
LAYERS OF SCALP

- **EYEBROWS** (anteriorly)
- **EARS/ZYGOMATIC ARCHES** (laterally)
- **SUPERIOR NUCHAL LINE** (posteriorly)

**Skin**
- Thick, many sebaceous glands, muscles inserted into it

**Connective tissue**
- Very vascular
  - **Central:** Epicranial aponeurosis (Galea aponeurotica)
  - **Anterior/posterior:** Occipitalis onto superior nuchal line (posterior auricular branch of VII)

**Aponeurosis**
- Frontalis into skin of eyebrow & orbicularis oculi, meeting in midline (Temporal/zygomatic branches of VII)

**Loose areolar tissue**

**Pericranium**
- Periosteum, loosely attached to bone, haematoma possible under it but limited to each bone
CORONAL SECTION OF SKULL, SCALP & MENINGES IN MIDLINE

To show layers of scalp, meninges and falx cerebri

- **Skin**
- **Connective tissue**
- **Aponeurosis**
- **Loose areolar tissue**
- **Pericranium**

- **Dura**
  - Endosteal (periosteal)
  - Meningeal (fibrous)

- **Arachnoid**
- **Pia**
- **Falx cerebri**
- **Inferior sagittal sinus**

- **Superior sagittal sinus**
- **Lateral blood lake**
- **Arachnoid granulations** (a mass of villi) indenting the skull

CEREBROSPINAL FLUID
- 130ml - 30ml in ventricles, 75ml in spinal system, 25ml in cranium
- Turn over - 500ml per day from choroid plexus to 4th ventricle to subarachnoid space to arachnoid villi
- Pressure - 130mm of water
- Function - Brain floats in it, some metabolic change, effectively reduces weight of brain from 1500g to 50g
SUBMANDIBULAR GLAND

- Mixed - mucous and serous
- Duct: (Wharton’s) 5cm long. First between mylohyoid & hyoglossus, then between sublingual gland and geniohyoid. Opens in floor of mouth beside frenulum. Develops in ectoderm from a groove in the floor of mouth
- Produces 70% of the saliva
- Lymph nodes in it and on it. Drain to submandibular glands
- Histology: See parotid
SWALLOWING

1. FOOD BOLUS MOVED BY TONGUE TO OROPHARYNX
   - Mylohyoid (Vc) lifts tongue • Tongue (XII) • Styloglossus
   - Muscles of mastication (Vc) • Buccinator (VII)
2. NASOPHARYNX CLOSES
   - Superior constrictor (PP- pharyngeal plexus) • Passavant's ridge (PP) • Tensor palati (Vc) • Levator palati (PP)
3. AUDITORY TUBE OPENS
   - Levator palati (PP) • Tensor palati (Vc) • Salpingopharyngeus (PP)
4. PHARYNX & LARYNX MOVE UP TO HYOID
   - Happens before bolus arrives • Stylopharyngeus (IX)
   - Salpingopharyngeus (PP) • Palatopharyngeus (PP)
   - Inferior constrictor (PP)
5. OROPHARYNX KEPT CLOSED
   - Palatoglossus (PP) • Intrinsic muscles of tongue (XII)
   - Styloglossus (XII)
6. LARYNX CLOSES
   - Aryepiglotticus (X-RLN) • Cords close (X-RLN) • Epiglottis flaps
7. HYOID ELEVATES BRINGING PHARYNX/LARYNX UP MORE
   - Stylohyoid (VII)
8. HYOPHARYNX OPENS
   - Cricopharyngeus/upper oesophagus relax (X-RLN)
9. HYOID, LARYNX & PHARYNX MOVE DOWN TOGETHER
   - Elastic recoil
10. LARYNX & PHARYNX MOVE DOWN FROM HYOID
    - Elastic recoil
11. PERISTALSIS
    - Striated muscle then smooth muscle of oesophagus (3-5cm/sec)
      (X-RLN)

ORDER OF EVENTS IN SUMMARY

LARYNX & PHARYNX MOVE UP TO HYOID ➔ LARYNX, PHARYNX & HYOID MOVE UP ➔ LARYNX, PHARYNX & HYOID MOVE DOWN ➔ LARYNX & PHARYNX MOVE DOWN FROM HYOID
TEMPORAL FOSSA

The space beneath temporalis muscle
Above: Superior (A) & inferior (B) temporal lines
Roof: Temporalis fascia
Posterior: Supramastoid crest (C)
Floor: Skull - pterion (D)
Anterior: Zygoma (E), zygomatic process of frontal bone (F) &
zygomatic process of maxilla (G)
Below: Zygomatic arch & zygomatic process of temporal bone (H)
Contains: Temporalis, deep temporal arteries (maxillary), deep
temporal nerves (Vc)
Superficial temporal artery (I) from external carotid
Auriculotemporal nerve (J) from Vc
Temporalis: See muscle section of Instant Anatomy
Other structures shown: Parietal bone (K), temporal bone (L),
greater wing of sphenoid (M), Temporal branch of VII (N)
zygomatic branch of VII (O)
THORACIC INLET

- Costocervical trunk
- Superior intercostal
- Deep cervical
- Phrenic nerve
- 1st rib
- Internal thoracic artery
- Vagus
- Brachiocephalic artery
- Thoracic duct
- T1 anterior ramus
- C8 anterior ramus
- Lower trunk of brachial plexus
- Subclavian artery & vein
- Inlet is 10cm wide
  5cm anteroposterior

DOME OF PLEURA

Covered by supracleural membrane (Sibson's fascia)
Held up by scalenus minimis (pleuralis) from transverse process of C7
Extends 4cm above middle of medial third of clavicle and first rib, BUT NOT above neck of first rib

Relations:
- Posterior: Sympathetic trunk, supreme intercostal vein, superior intercostal artery, T1 nerve root, 1st rib, thoracic duct on left
- Anterior: On right - brachiocephalic artery and vein
  On left - Subclavian artery and vein
- Superior: Costocervical trunk, thoracic duct on left

Mnemonic: Vagus nerves and phrenic nerves enter the chest between the arteries behind and the veins in front
THYROID - DEVELOPMENT

FORAMEN CAECUM

Site of origin of thyroglossal duct between floor of branchial arches 1 and 2

THYROGLOSSAL DUCT

Endodermal downgrowth of thyroid epithelium from it. Developing tissue invades hypobranchial mesenchyme which gives capsule and septa

RETROSTERNAL THYROID

If developing process goes too far

Sites of thyroglossal cysts (move up with protrusion of tongue), remnant thyroid tissue (lingual thyroid), fistulae, sinuses & pyramidal lobe

Note: The ultimobranchial bodies (5th pouch) give "C" cells
THYROID GLAND - GENERAL & BLOOD SUPPLY

Bilobed, lobulated & 5cm long, extending to tracheal ring 6
Shield shaped & lies on carotid sheath
Limited extension upwards by sternothyroid
Can pass below into mediastinum

Note relationship of branching of arteries to pretracheal fascia

Superior thyroid artery from external carotid

Behind sympathetic chain

Inferior thyroid artery from thyrocervical trunk (other branches are ascending cervical, transverse cervical & suprascapular)

Upper pole

Lateral lobe

Lower pole

Isthmus

Thyroidea ima (3% from aorta)

Note intimate relationship of branches of the inferior thyroid artery to the recurrent laryngeal nerve
THYROID GLAND - SURGICAL ASPECTS

NORMAL  PARTIAL THYROIDECTOMY  SUBTOTAL THYROIDECTOMY

HYPERTHYROIDISM
- 80% Graves' disease (auto-immune)
- 10% Multinodular goitre
- 5% Toxic adenoma

INDICATIONS FOR SURGERY (subtotal or nodule excision)
- Failed medical treatment
- Poor drug compliance
- Large goitre/nodule
- Compression – trachea, oesophagus, superior vena cava
- Retrosternal extension

RISKS OF SURGERY
- To parathyroids
- To recurrent laryngeal/superior laryngeal nerves (1%)

Note that right recurrent laryngeal nerve can enter larynx directly from vagus and not pass around subclavian artery
THYROID GLAND - AXIAL SECTION AT C7

Relations of thyroid gland

Posterior: Prevertebral fascia, carotid sheath, parathyroids, trachea
Medial: Recurrent laryngeal nerve, trachea, larynx, oesophagus
Anterior: Pretracheal fascia, sternohyoid, sternothyroid venous arch
TISSUE SPACES IN THE NECK

PREVERTEBRAL SPACE
Closed space behind prevertebral fascia which allows infection to track down into axilla via the axillary sheath which is, itself, part of the prevertebral fascia that is dragged off by the subclavian artery as it emerges from behind scalenus anterior.

RETROPHARYNGEAL SPACE
Immediately anterior to prevertebral fascia. Below, it extends behind oesophagus to diaphragm via superior and then posterior mediastinum. Infection may spread from here, laterally, behind the carotid sheath into the posterior triangle.

PARAPHARYNGEAL SPACE
Lateral continuation of retropharyngeal space.

SUBMANDIBULAR SPACE
Extends above investing layer of deep cervical fascia, between hyoid and mandible to mucous membrane of floor of mouth. Contains mylohyoid muscle, sublingual gland above this muscle and submandibular gland hooking around its posterior border. Infection here gives cellulitis known as LUDWIG'S ANGINA.
- Elastic structure
- 10cm long but extends to 15cm on inspiration
- C shaped cartilages - trachealis muscle closes C
- Mucosa ciliated pseudostratified columnar
- Blood: Inferior thyroid artery & veins & bronchial arteries.
- Lymph: Posterior/inferior deep cervical
- Nerves: Vagus & recurrent laryngeal for pain and secretomotor
  Sympathetic to blood vessels and smooth muscle (T1-4)
- Relations: (see cross section at C7)
  - Posterior - oesophagus, recurrent laryngeal nerves
  - Sides - carotid sheath, lateral lobes of thyroid to 6th ring
  - Anterior - Inferior thyroid veins, anterior jugular arch,
    thyroidea ima artery, levator glandulae thyroidea,
    thymus if large, manubrium, sternohyoid,
    sternothyroid, left brachiocephalic vein
BLOOD SUPPLY OF SPINAL CORD

POSTERIOR SPINAL ARTERIES
- Arise at foramen magnum from posterior inferior cerebellar arteries (or vertebral)
- Lie anterior & posterior to posterior rootlets
- Run length of cord but poor anastomosis except at lower end of cord
- Supply own side of grey & white posterior columns

ANTERIOR SPINAL ARTERY
- Single artery that arises from each vertebral artery at foramen magnum to run length of cord
- Usually bigger than posterior spinal arteries but may be quite small.
- Supplies whole cord anterior to posterior grey columns, bilaterally

OTHER VESSELS
From vertebrais, deep & ascending cervicals, intercostals, lumbars & lateral sacrals. Note that all vessels anastomose under the pia mater in the periphery of the cord

RADICULAR (FEEDER) ARTERIES
- Enter via intervertebral foramina and reinforce anterior & posterior spinal arteries & supply dorsal root ganglia
- Variable number at variable levels but largest is Arteria Radicularis Magna, usually at T10 or 11 (artery of Adamkiewicz)
**INTERVERTEBRAL DISCS & COSTAL ELEMENTS**

Intervertebral joint is secondary cartilaginous (symphysis)-

- **Bone**
  - **Hyaline Cartilage**
  - **Fibro-Cartilage**
  - **Hyaline Cartilage**
  - **Bone**

- **Anterior longitudinal ligament**
- **Posterior longitudinal ligament**
- **Nucleus pulposus**
- **Hyaline cartilage**
- **Annulus fibrosus**

- 15% of disc
- Gelatinous, occasional cells
- 90% water normally
- 70% in old age
- Increasing collagen with age
- Decreasing elasticity with age
- Notochord remnant
- Towards back in lumbar region
- Herniation damages nerve one below the level of prolapse

- Alternate angled lamellae
- Strong attachment to anterior & posterior longitudinal ligaments
- Fibrocartilage

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**COSTAL ELEMENTS OF VERTEBRAE AT VARIOUS LEVELS**

- **Cervical**
  - **Centrum**
  - **Neural Arch & Its Process**
  - **Transverse Element**
  - **Costal Element**

- **Thoracic**
  - **Centrum**

- **Lumbar**
  - **Centrum**

- **Sacral**
  - **Centrum**
VERTEBRAL COLUMN - FEATURES & CURVATURES

VERTEBRAE
7 cervical (atlas, axis & C7 are atypical)
12 thoracic
5 lumbar
5 sacral (fused)
4 coccygeal (3-5)

FUNCTIONS
Weight bearing
Movement of trunk
Support for limbs
Protection of spinal cord
Production of blood
Metabolic reserves (Calcium, etc)

WEIGHT BEARING
Aided by secondary lordosis
  40% bony wedge
  60% disc wedge
Caused/held by
  Extensor spinal muscles
Aided by intervertebral discs
  Dampeners, resilient, compressible

Primary curvature
Neck & lumbar secondary curvatures
Movements at facet & intervertebral joints are individually small but accumulatively considerable.
ATLANTO-AXIAL & ATLANTO-OCcipital joints

- Anterior atlanto-occipital membrane
- Apical ligament
- Tectorial membrane
- Superior band of cruciform
- Transverse ligament of atlas
- Inferior band of cruciform
- Posterior longitudinal ligament
- Dura

- Sagittal section of upper cervical spine
- Tectorial membrane
- Alar ligaments
- Capsule of antlanto-occipital joint
- Foramen transversarium
- Superior inferior transverse bands of cruciform ligament
- Tectorial membrane (cut)
- Posterior atlanto-occipital membrane
- Looking into upper spinal canal from behind
- Posterior view
- Vertebral artery
- C1
- C2
VERTEBRAL COLUMN - JOINTS & LIGAMENTS

JOINTS

ARTICULAR FACET (zygapophyseal)
Plane, synovial, nerve supply by nerves above and below

NEUROCENTRAL (uncovertebral) JOINTS OF LUSCHKA
Cervical & T1 only, small on lateral side of body, between uncinate process and side of body. Probably degenerative

ATLANTO-OCCIPITAL
Synovial, weak anterior/posterior atlanto-occipital membrane. Nodding movement

ATLANTO-AXIAL
Synovial, head pivoting. Ligaments are apical, alar, cruciform. Posterior longitudinal ligament becomes membrana tectoria

LIGAMENTS

- Interarticular Between facet joints
- Interspinous Weak, fused with supraspinous
- Supraspinous White, strong, fibrous, into ligament nuchae above

Above becomes membrana tectoria (C2 to occiput)

2 other ligaments are: LIGAMENTUM FLAVUM between laminae like tiles on a roof - under surface of one above to outer surface of one below. Also INTERTRANSVERSE - between transverse processes - weak

Below finishes in sacral canal
SUBOCCIPITAL TRIANGLE

SUBOCCIPITAL NERVE
- Posterior ramus of C1
- No skin distribution
- Rectus capitis posterior major/minor
- Superior/inferior obliques
- Semispinalis capitis

GREATER OCCIPITAL NERVE
- Posterior ramus of C2
- Semispinalis capitis
- Splenius capitis
- Inferior oblique via connection to C1
- Skin of posterior scalp

SUBOCCIPITAL TRIANGLE
Boundaries: Superior oblique, inferior oblique & rectus capitis posterior major
Floor: Posterior atlanto-occipital membrane, posterior arch of atlas
Contains: Vertebral artery & suboccipital nerve
In roof: Greater occipital nerve & occipital artery

See muscle section of Instant Anatomy for details of muscles
• C3–6
  Bifid spinous process
  Large triangular foramen
  Short wide pedicle
  Small body
  Foramen transversum
    Artery, vein, sympathetic from C6 to C1

• C6: Has carotid tubercle of Chassaignac (enlarged anterior tubercle over which passes the common carotid artery

• C7: Vertebra prominens has vestigial anterior tubercle, long, non-bifid spinous process, small foramen transversum containing vein only (no artery). Note that C7 nerve is above C7 vertebra and C8 nerve is below it
ATLAS - C1

- Groove for vertebral artery & C1 nerve
- Posterior tubercle (virtually no spinous process)
- Posterior arch
- Greater occipital nerve (posterior ramus C2)
- Suboccipital nerve (posterior ramus of C1)
- Transverse process
- C1 anterior ramus (between facet & artery)
- Superior facet (kidney shaped)
- Anterior arch & tubercle (attachment of longitudinal ligament)
- Foramen transversum
- Anterior view
- Superior
- Transverse process
- Inferior
- Vertebral artery
- C1 anterior ramus (between facet & artery)
AXIS - C2

- Viewed from above
- Spinal process (thick, broad, bifid)
- Pedicle
- Lamina
- Greater occipital (C2 posterior ramus)
- Inferior facet
- Foramen transversum
- Superior facet (large, flat)
- Alar ligaments
- Apical ligament
- Dens (superiorly)
- Posterior view
- Anterior facet for arch of atlas
- Groove for transverse ligament & bursa
- Body
- Transverse process (posterior tubercle)
- Foramen transversum
- Inferior facet
LUMBAR VERTEBRAE

TYPICAL VERTEbra (L2)

- Lamina
- Mamillary
- Processes
- Accessory
- Transverse process
- Short, thick pedicle

Costal element (Becomes a lumbar rib if not fused)

- Viewed from above
- Superior facet
- Superior vertebral notch

Dorsal root between processes

- Viewed from behind
- Mamillary
- Processes
- Accessory

- Viewed from side
- Superior facet
- Inferior vertebral notch

L5 viewed from above

- Wide, short pedicles
- Forward facing facets
- Thick short transverse process
A TYPICAL VERTEBRA

Each vertebra has:
A BODY: anteriorly
A VERTEBRAL ARCH: posteriorly

Each arch has:
2 pedicles, 2 laminae, a spinous process,
a transverse process & a vertebral foramen

OSSIFICATION

Primary centres (♦) appear at 8-10 weeks intra-uterine. There are 3: 1 in the centrum & 1 in the base of each transverse process. From the latter, ossification spreads to pedicle, lamina, spinal process, body & facets.

Secondary centres (★★) appear at puberty. 5: spinous process, transverse processes, each annular epiphyseal rings

Fusion
Arches by 2 years
Arch/centrum by 7yrs
Secondary centres by 25yrs
THORACIC VERTEBRAE

- Superior articular facet
- Transverse process (facet for rib)
- Body (heart shaped)
- Demi-facet on neural arch bone
- Costal element is rib plus articular facets

Viewed from above:

Viewed from behind:
- Broad lamina
- Superior facet
- Inferior facet
- Posterior surface of body

On each side of body:
- T1: 1 1/2 rib facets
- T2-10: 2 hemifacets
- T11,12: 1 full facet

Viewed from side:
- Wedge shaped body
- Demi-facet
- Inferior facet
- Spinous process
- Transverse process (facet for rib)
VERTEBRAL VENOUS PLEXUSES

Anterior

External venous plexus. Anterior. Drain via vertebral bodies VALVELESS

Drain into:
- Cervical veins
- Azygos veins
- Ascending lumbar lateral sacral

Posterior

External venous plexus. Posterior to ligamentum flavum VALVELESS

Internal vertebral veins. One set of anterior & two sets of posterior. Around dura & posterior longitudinal ligament. VALVELESS. Communicate above with occipital & basilar sinuses, segmentally receive veins from spinal cord & basivertebral veins

Internal vertebral venous plexus

Posterior, external vertebral venous plexus

Intervertebral veins which are valveless & connect with portal & systemic systems. Allow retrograde spread of cancer cells

Lumbar vein & ascending lumbar vein

Basivertebral veins

Anterior, external vertebral venous plexus
**SPINAL CORD - VEINS & SOME LIGAMENTS**

Basivertebral veins emerge from foramina in posterior vertebral bodies & drain into the internal vertebral plexus (anterior/posterior) which drains via the intervertebral segmental veins (with the nerve roots) into the external vertebral plexuses which, in turn connect above & below the diaphragm to the inferior & superior vena cava via vertebral, azygos, lumbar & lateral sacral veins. These veins are **VALVELESS** and thus cancer cells from thyroid, breast, kidney & prostate can easily enter the bones.

The **posterior longitudinal ligament** attaches to the discs only and not to the vertebral bodies so that there is free drainage of the basivertebral veins.

The dural sac finishes at S2 but the PIA MATER in the form of the filum terminale continues below S2 and attaches to the back of the coccyx.

The **DENTICULATE (dentate) ligament** is pia mater that connects the cord to the dura mater laterally between the exits sites for the nerves. It pierces the arachnoid mater. Note that the spinal roots of the accessory nerve (C1-5) emerge dorsal to the denticulate ligament, whereas the sensory roots emerge dorsal and the motor roots ventral to it.

**SPINAL SUB-ARACHNOID SPACE**

- Volume 75ml
- Tapped during spinal puncture or anaesthetic below L2
# SUMMARY OF CRANIAL NERVES

<table>
<thead>
<tr>
<th>Roman Numeral</th>
<th>Nerve Name</th>
<th>Function Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Olfactory</td>
<td>Smell</td>
</tr>
<tr>
<td>II</td>
<td>Optic</td>
<td>Sight</td>
</tr>
<tr>
<td>III</td>
<td>Oculomotor</td>
<td>Eye movements</td>
</tr>
<tr>
<td>IV</td>
<td>Trochlear</td>
<td>Eye movements</td>
</tr>
<tr>
<td>V</td>
<td>Trigeminal</td>
<td>Sensory (motor for mastication)</td>
</tr>
<tr>
<td>VI</td>
<td>Abducens</td>
<td>Eye movements</td>
</tr>
<tr>
<td>VII</td>
<td>Facial</td>
<td>Motor (facial expression)</td>
</tr>
<tr>
<td>VIII</td>
<td>Vestibulocochlear</td>
<td>Hearing/Balance</td>
</tr>
<tr>
<td>IX</td>
<td>Glossopharyngeal</td>
<td>Sensory to tongue &amp; pharynx (single muscle motor)</td>
</tr>
<tr>
<td>X</td>
<td>Vagus</td>
<td>Parasympathetic</td>
</tr>
<tr>
<td>XI</td>
<td>Accessory</td>
<td>Cranial root joins vagus spinal root motor to trapezius &amp; sternocleidomastoid</td>
</tr>
<tr>
<td>XII</td>
<td>Hypoglossal</td>
<td>Motor to tongue</td>
</tr>
</tbody>
</table>

- **Special senses**
- **Motor-somatic or branchial**
- **General sensory**
- **Parasympathetic**

This is a very simplified outline of the cranial nerves. Several of them carry sympathetic and parasympathetic fibres.
### Cranial Nerves with Motor Supply to Muscles of Branchial Origin

<table>
<thead>
<tr>
<th>CRANIAL NERVE</th>
<th>MOTOR SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BRANCHIOMOTOR (MUSCLES OF BRANCHIAL ORIGIN)</strong></td>
<td></td>
</tr>
</tbody>
</table>
| V             | Nucleus: Motor of trigeminal  
               | M of mastication, mylohyoid, ant digastric,  
               | tensors palati & tympani |
| VII           | Nucleus: Facial  
               | M of facial expression, buccinator, post  
               | digastric, stylohyoid, stapedius |
| IX            | Nucleus: Ambiguus  
               | Stylopharyngeus |
| X             | Nucleus: Ambiguus  
               | M of pharynx, upper oesophagus, palate,  
               | larynx (from cranial XI) |
| XI            | Nucleus: Ambiguus  
               | M of palate & pharynx via vagus |

Cranial nerves V, VII, IX, X are the nerves to the branchial (pharyngeal) arches 1, 2, 3, 4/6 respectively. In addition the cranial part of XI dumps its fibres on the vagus to be distributed with it.

1st arch. Nerve: mandibular division of trigeminal  
2nd arch. Nerve: Facial  
3rd arch. Nerve: glossopharyngeal  
4th & 6th arches. Nerve: vagus
**CRANIAL NERVES THAT CARRY PARASYMPATHETIC FIBRES**

<table>
<thead>
<tr>
<th>Cranial Nerve</th>
<th>Parasympathetic (General Visceral Motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>Nucleus: Edinger-Westphal</td>
</tr>
<tr>
<td></td>
<td>Ciliary ganglion</td>
</tr>
<tr>
<td></td>
<td>Ciliary body &amp; muscle, Sphincter pupillae</td>
</tr>
<tr>
<td>VII</td>
<td>Nucleus: Superior salivary</td>
</tr>
<tr>
<td></td>
<td>Pterygopalatine &amp; submandibular ganglia</td>
</tr>
<tr>
<td></td>
<td>Lacrimal, submandibular, sublingual &amp; palatine glands</td>
</tr>
<tr>
<td>IX</td>
<td>Nucleus: Inferior salivary</td>
</tr>
<tr>
<td></td>
<td>Otic ganglion</td>
</tr>
<tr>
<td></td>
<td>Parotid, glands in post 1/3 tongue &amp; oropharynx</td>
</tr>
<tr>
<td>X</td>
<td>Nucleus: Dorsal motor of vagus</td>
</tr>
<tr>
<td></td>
<td>Cardiac &amp; visceral muscle in thorax &amp; abdomen</td>
</tr>
</tbody>
</table>

Cranial nerves III, VII, IX and X all carry parasympathetic fibres from the various central parasympathetic nuclei and they take these fibres to their respective parasympathetic ganglion where they synapse and then are distributed via a branch of the trigeminal to the end organ.
### CRANIAL NERVES THAT SUPPLY SOMATIC FIBRES TO SKELETAL MUSCLES

<table>
<thead>
<tr>
<th></th>
<th>SOMATIC MOTOR TO SKELETAL MUSCLE</th>
</tr>
</thead>
</table>
| III | Nucleus: Oculomotor  
Recti (Sup, med, inf), inf oblique, levator palpebrae superiors |
| IV  | Nucleus: Trochlear  
Sup oblique |
| VI  | Nucleus: Abducent  
Lat rectus |
| XI  | Nucleus: Lat roots C1-5  
Sternocleidomastoid & trapezius |
| XII | Nucleus: Hypoglossal  
M of tongue (not palatoglossus) |

Cranial nerves III, IV, VI, XI and XII carry somatic nerve fibres to head and neck muscles that have NOT originated from the branchial arches.
### CRANIAL NERVES THAT CARRY SOMATIC SENSORY FIBRES

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Somatic Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Nucleus: Sensory of V</td>
</tr>
<tr>
<td></td>
<td>Mesencephalic: proprioception</td>
</tr>
<tr>
<td></td>
<td>Main: touch</td>
</tr>
<tr>
<td></td>
<td>Spinal: pain &amp; temperature</td>
</tr>
<tr>
<td></td>
<td>For V (face, orbit, tongue)</td>
</tr>
<tr>
<td>VII</td>
<td>Nucleus: Sensory of V</td>
</tr>
<tr>
<td></td>
<td>Some skin of ext auditory meatus &amp; tympanic membrane</td>
</tr>
<tr>
<td>IX</td>
<td>Nucleus: Sensory of V</td>
</tr>
<tr>
<td></td>
<td>Posterior 1/3 tongue, palate, pharynx, tonsil, middle ear</td>
</tr>
<tr>
<td>X</td>
<td>Nucleus: Sensory of V</td>
</tr>
<tr>
<td></td>
<td>Skin of posterior/inferior auricle, external auditory meatus; pharynx; larynx</td>
</tr>
<tr>
<td>NB</td>
<td>Cell bodies outside central nervous system except mesencephalic nucleus</td>
</tr>
</tbody>
</table>

The trigeminal nerve is the main sensory nerve for the head. Note that whichever nerve carries the sensation, the fibres all eventually reach the sensory nucleus of the trigeminal nerve. Remember that the Facial Nerve (VII) is essentially a motor nerve even though it does have a small sensory component.
# Cranial Nerves Carrying General and Special Sensory Fibres

<table>
<thead>
<tr>
<th></th>
<th>General Visceral Sensory</th>
<th>Special Visceral Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>VII</td>
<td></td>
<td>Nucleus: Solitarius Chorda tympani Taste: ant 2/3 tongue</td>
</tr>
<tr>
<td>IX</td>
<td></td>
<td>Nucleus: Solitarius Taste: post 1/3 tongue, vallate papillae, oropharynx: baro &amp; chemoreceptors</td>
</tr>
<tr>
<td>X</td>
<td>Nucleus: Solitarius or dorsal sensory of Vagus. From heart, lungs &amp; abdominal viscera</td>
<td>Nucleus: Solitarius Taste: vallecula &amp; epiglottis: baro &amp; chemoreceptors</td>
</tr>
<tr>
<td>NB</td>
<td>From heart, lungs &amp; gut</td>
<td>Taste: baro &amp; chemoreceptors</td>
</tr>
</tbody>
</table>

Note that in the case of the vagus the sensation travels with this parasympathetic nerve but the fibres are really general visceral sensory and not parasympathetic. Special visceral sensory comprises taste and baroreception.
<table>
<thead>
<tr>
<th>CRANIAL NERVES FOR SPECIAL SENSES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>II</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>VIII</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
The purpose of this figure is to show how some cranial nerves pass directly to their end organ (1, 2, 5c, 8, 9, 10, 11, 12) whilst others pass through well defined cavities such as the cavernous sinus (3, 4, 5a, 5b, 6) or the pterygopalatine fossa (5b). For purposes of remembering the likely exit from the skull of cranial nerves, they can be grouped into those that pass to the nose (1), to the orbit (2, 3, 4, 5a, 6), to the front of the face (5b) and through the base of the skull (5c, 7, 9, 10, 11, 12).
Ganglia

Somatic sensory cell bodies
- Posterior (dorsal) root
- Trigeminal
- Geniculate
- Glossopharyngeal
- Vagal

Sympathetics either synapse or pass through to synapse later
- Sympathetic chain
- Sympathetic peripheral
  - eg Coeliac
  - Sup mesenteric
  - Renal

Parasympathetic synapse
- Somatic sensory & sympathetic pass through
  - Ciliary
  - Pterygopalatine
  - Submandibular
  - Otic

Each nerve has a cell body. For the sensory system this cell body is in the dorsal root ganglion or the equivalent for the sensory cranial nerves. There are no synapses in such ganglia.

In the sympathetic ganglia there are two alternatives. For those nerves that synapse there are cell bodies belonging to the post-ganglionic fibres. Others pass through without synapsing (gut & adrenal).

In the parasympathetic ganglia in the head and neck there is always a synapse with a post-ganglionic cell body.
- OPTIC N: Blind R eye
- CHIASMA: Bitemporal hemianopia
- TRACT: L homonymous hemianopia
- LAT GENICULATE BODY IN THALAMUS
- PRETECTAL NUCLEUS: "Pupillary light reflex"
- SUP COLICULUS: "Near reflex"
  - Accommodation
  - Pupillary constriction
  - Convergence
**III, IV, VI EYE MUSCLES**

**SOMATIC MOTOR**
- **III Oculomotor**
  - Sup Rectus
  - Inf Rectus
  - Med Rectus
  - Inf Oblique

**Parasympathetic via Ciliary Ganglion**
- From: Edinger Westphal nucleus
- To: ciliary muscle & sphincter pupillae
- For: accommodation & pupillary constriction

**Sympathetic from Cavernous Sinus**
- From: internal carotid artery
- To: levator palpebrae superioris

**IV Trochlear**
- Sup Oblique
- Emerges dorsally

**VI Abducens**
- Lat Rectus

**Cavernous Sinus**
- Superior Orbital Fissure
- Tendinous Ring
TRIGEMINAL: OPHTHALMIC

**SENSORY**
- Scalp
- Upper face
- Sinuses
- Eye

**PARASYMPATHETIC VIA CILIARY GANGLION**
- Ciliary muscle (accommodation)
- Sphincter pupillae
- Lacrimal gland (via pterygopalatine ganglion)

**SYMPATHETIC VIA CAVERNOUS SINUS**
- Dilator pupillae

**DELIVERS**
- 10 short ciliary n's
- 2-3 long ciliary n's

**KEY BRANCHES**
- Supra-orbital
- Supratrochlear
- Lacrimal
- Infratrochlear
- External nasal
- Nasociliary

**5 SENSORY TO FACE**
- frontal
- Lacrimal
- Infratrochlear
- Nasociliary
- External nasal
Vb
TRIGEMINAL: MAXILLARY

SENSORY
- Middle face
- Palate
- Sinuses
- Nasopharynx/nose

DELIVERS
PARASYMPATHETIC
VIA PTERYGOPALATINE GANGLION
- Lacrimal gland
- Mucous glands of sinuses, nose, palate, nasopharynx

CARRIES
TASTE
- Hard & soft palate

KEY BRANCHES
3 SENSORY TO FACE
- Zygomatico-temporal
- Zygomatico-facial
- Infra-orbital

OTHER
- Nasopalatine to nasal cavity
- Greater palatine to palate
- Lesser palatine to palate
- Pharyngeal to nasopharynx
- Alveolar to upper teeth
TRIGEMINAL: MANDIBULAR (1st arch)

SENSORY
- Lower face
- Hairy temple
- Ant 2/3 tongue

BRANCHIOMOTOR
- Muscles of mastication
- Tensors tympani & palati

DELIVERS
PARASYMPATHETIC VIA SUBMANDIBULAR & OTIC GANGLIA
- Parotid gland
- Submandibular/sublingual glands
- Mucous glands floor of mouth, gums & sides of tongue

CARRIES
- Ant 2/3 tongue

TASTE

KEY BRANCHES
- 3 SENSORY TO FACE
- OTHER
  - Lingual
  - Muscular
* Nerve to lateral pterygoid and just to its left is the otic ganglion
PTERYGOPALATINE FOSSA 1

Right side of skull cut away to show trigeminal ganglion lying in Meckel’s cave and the maxillary division entering the pterygopalatine fossa through foramen rotundum. The nerve of the pterygoid canal is seen entering the pterygopalatine ganglion and connecting to Vb so that sensory fibres can be distributed with the parasympathetic fibres from the ganglion and so that parasympathetics can pass on Vb to be distributed to sinuses and lacrimal gland.

The contents of the pterygopalatine fossa are:
- Terminal branches of the maxillary artery
- Maxillary nerve (Vb) to upper teeth, floor of orbit, face/skin
- Pterygopalatine ganglion for distribution of parasympathetics to nose and palate

- Va in superior orbital fissure
- Trigeminal ganglion
- Foramen rotundum
- Foramen ovale
- Inferior orbital fissure
- Zygomatic
- Infra-orbital
- Nasapalatine
- Greater palatine
- Lesser palatine

Maxillary artery giving branches to the 5 nerves that emerge from the pterygopalatine ganglion & also a branch with the infra-orbital nerve (infra-orbital artery)

* Nerve of the pterygoid canal (Vidian’s nerve)
MANDIBULAR DIVISION OF TRIGEMINAL NERVE, EMERGING FROM FORAMEN OVALE DEEP IN INFRATEMPORAL FOSSA

- Lesser petrosal (via foramen ovale)
- Nervus spinosus (meningeal) via foramen ovale or spinosum
- Chorda tympani (via petrotympanic fissure)
- Medial pterygoid
- Tensors tympani & palati
- Auriculotemporal & parotid branch
- Middle meningeal artery
- Nerve to mylohyoid
- Inferior alveolar
- Anterior/posterior deep temporal
- Masseteric
- Lateral pterygoid
- Buccal
- Lingual (joined by chorda tympani)

* Otic ganglion. Parasympathetics from lesser petrosal nerve synapse within it and post-ganglionic fibres are taken to the parotid gland by the auriculotemporal nerve
MANDIBULAR DIVISION OF TRIGEMINAL NERVE, EMERGING FROM FORAMEN OVALE DEEP IN INFRATEMPORAL FOSSA

- Lesser petrosal (via foramen ovale)
- Nervus spinosus (meningeal) via foramen ovale or spinosum
- Chorda tympani (via petrotympanic fissure)
- Anterior/posterior deep temporal
- Medial pterygoid
- Tensors tympani & palati
- Lateral pterygoid
- Masseteric
- Auriculotemporal & parotid branch
- Middle meningeal artery
- Buccal
- Lingual (joined by chorda tympani)
- Nerve to mylohyoid
- Inferior alveolar

* Otic ganglion. Parasympathetics from lesser petrosal nerve synapse within it and post-ganglionic fibres are taken to the parotid gland by the auriculotemporal nerve.
TRIGEMINAL NERVE (V) 
EXTRA NOTES

- Nerve of the first pharyngeal arch
- 3 nuclei in brain stem (see below)
- Somatic but carries parasympathetic and sympathetic
- Mostly sensory but small motor branch in mandibular division
- Motor is branchiomotor (special visceral motor)
- All cell bodies are in the trigeminal ganglion EXCEPT
  for proprioception and these are in the mesencephalic
  nucleus in the brain stem

**MESENCEPHALIC NUCLEUS**
- Proprioception from muscles of mastication, face, orbit,
  tongue & temporomandibular joint

**MAIN SENSORY NUCLEUS**
- Touch & fine sensation

**SPINAL NUCLEUS**
- Pain & temperature

**GANGLION**
- In Meckel's cave
- Motor root inferior
- Blood supply from internal carotid in cavernous sinus &
  accessory meningeal via foramen ovale
- Nerve supply from nervus spinosus (Vc)

Diagram: In CSF in Meckel's cave. In dural layers of cavernous sinus.
Superior orbital fissure.
Motor root.
Foramen ovale.
Foramen rotundum.
Posterior
Anterior
**BRANCHIOMOTOR**
- Muscles of facial expression
- Stapedius
- Post belly digastric, stylohyoid, occipitofrontalis

**SENSORY (via nervus intermedius)**
- Small contribution to external acoustic meatus

**PARASYMPATHETIC (via nervus intermedius)**
- Greater petrosal to pterygopalatine ganglion then to hay fever glands via Vb
- Chorda tympani to submandibular ganglion then to submandibular & sublingual glands via Vc

**TASTE (via nervus intermedius)**
- Palate via greater petrosal
- Ant 2/3 tongue via chorda tympani

**KEY BRANCHES**
- Stylomastoid foramen
- Post auricular branch to occipitofrontalis
- Post belly digastric & stylohyoid

**OTHER**
- Greater petrosal
- Chorda tympani
- Small sensory br
- N to stapedius

**VIIL FACIAL**
(2nd arch)

**6 motor to muscles of facial expression**

**T**
- Z1
- Z2
- B
- M
- C
RIGHT FACIAL NERVE
IN & BEFORE THE PAROTID

- Stylomastoid foramen
- Superficial temporal artery/vein deep to nerve
- Posterior auricular branch to occipital belly of occipitofrontalis & auricularis
- Posterior belly of digastric & stylohyoid
- Retromandibular vein
- One of its branches
- Branch of great auricular nerve
- Posterior belly of digastric

Note: Only three structures lie anterior to the posterior belly of digastric:
- Cervical branch of VII
- Branch of the retromandibular vein
- Branch of great auricular nerve (cervical plexus)
FACE: MOTOR AND SENSORY SUPPLY

SENSORY TRIGEMINAL (V)
- Supratrochlear
- Supra-orbital
- Auriculotemporal
- Zygomaticotemporal
- Lacrimal
- Zygomaticofacial
- Intra-orbital
- Buccal
- Great auricular
- Mental

MOTOR FACIAL (VII)
- Temporal
- Zygomatic
- Buccal
- Mandibular
- Cervical

Facial nerve branches:
- Temporal: frontalis & procerus
- Zygomatic 1: eye & around orbit
- Zygomatic 2: mid face & smile
- Buccal: buccinator & upper lip
- Mandibular: lower lip & orbicularis oris
- Cervical: platysma

Mnemonic:
Two
Zulus
Befriended
My
Cat

(note: proprioception is supplied by trigeminal)
**FACIAL NERVE LESIONS**

**SUPRANUCLEAR LESION**
Upper face has bilateral innervation (bilateral cortical representation)
- Frontal lobe to corticobulbar fibres
- Part of hemiplegia
- Upper motor neurone lesion
- Lower face worse for voluntary movement but may be OK for emotion

**NUCLEAR/INFRAHINAL LESION**
Ipsilateral
1. **Lesion of nucleus/pontine fibres**
   - Complete unilateral palsy. Loss of VII, VI, V, taste, opposite limbs long tracts
2. **Temporal bone (fracture)**
   - Complete unilateral palsy, loss of taste, decreased hearing or hyperacusis
3. **Facial canal (middle ear infection) Bell’s palsy**
4. **Other** (MS, surgery, acoustic neuroma, herpes, diabetes, sarcoid)

Lower motor neurone lesion
COCHLEAR DIVISION - HEARING

- From organ of Corti in cochlea
- Hair cells to cell bodies in spiral ganglion (in modiolus)
- To 2 cochlear nuclei (ventral & dorsal)

VESTIBULAR DIVISION - BALANCE

- From semicircular canals, utricle & saccule
- Cell bodies in vestibular ganglion in outer part of internal acoustic meatus
- To 4 vestibular nuclei (medial, lateral, superior & inferior)
IX GLOSSOPHARYNGEAL (3RD ARCH)

SENSORY
- Oropharynx
- Post 1/3 tongue
- Tonsil
- Middle ear

SPECIAL VISCERAL SENSORY
- Carotid body/sinus

BRANCHIOMOTOR
- Stylopharyngeus

PARASYMPATHETIC
- Lesser petrosal n to otic ganglion to parotid gland via Vc

TASTE
- Post 1/3 tongue & oropharynx

KEY BRANCHES
- Tonsil
- Pharynx & tongue
- Taste
- Baro- & chemoreceptors
- The vagus lies most medial in the foramen
- Glossopharyngeal nerve & inferior petrosal sinus exit from the anterior compartment of the foramen
- Vagus & accessory nerves exit from the middle compartment
- The sigmoid sinus exits from the posterior compartment, is soon joined by the inferior petrosal sinus to become the internal jugular vein

* = Tympanic branch of IX (Jacobson’s nerve)
**PARASYMPATHETIC**
- Cardiac branches
- Thorax & abdomen

**VISCERAL SENSORY**
- Thorax & abdomen

**TASTE**
- Valleculae

**BARO/CHEMO-RECEPTORS**

**BRANCHIOMOTOR**
(from cranial accessory)
- Muscles of pharynx, larynx, palate & upper oesophagus

**SENSORY**
- Larynx, laryngopharynx, valleculae
- Small areas of skin: ext auditory meatus, eardrum & behind ear

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Diagram: Connections and branches of the vagus nerve, including sensory and motor components, with annotations for specific anatomical regions and functions.
XI ACCESSORY (TO VAGUS)

- Cranial root of accessory
- Jugular foramen
- Spinal root of accessory (C1-5)
- Spinal root to sternomastoid & trapezius

BRANCHIOMOTOR

SOMATIC MOTOR
POSTERIOR TRIANGLE OF NECK

- **Boundaries:** Posterior border of sternocleidomastoid, anterior border of trapezius, mid 1/3 clavicle
- **Shape:** Spiral
- **Roof:** Investing fascia, platysma, external jugular vein
- **Floor:** Prevertebral fascia covering muscles, subclavian artery, trunks of brachial plexus & cervical plexus
- **Contents:**
  - Arteries: Occipital, superficial cervical, suprascapular
  - Veins: Transverse cervical, suprascapular, external jugular
  - Nerves: Branches of cervical plexus, spinal root of accessory
  - Muscle: Omohyoid with its sling
  - Lymph nodes: Occipital (rubella/scalp infections)
    Supraclavicular (part of the deep chain)
SPINAL ROOT OF ACCESSORY NERVE

SURFACE MARKINGS

Mastoid process
Transverse process of C1 (atlas)
Spinal root of accessory (C1-5)

Method one
1. Find transverse process of atlas just anterior mastoid process
2. Draw a line to anterior border of trapezius, 5 cm above the clavicle
3. This is the line of the nerve through sternocleidomastoid and posterior triangle

Method two
1. Draw a line from a third of the way down the posterior border of sternocleidomastoid to a third of the up the anterior border of trapezius
2. This is the line of the nerve through sternocleidomastoid and posterior triangle

For details of sternocleidomastoid, see muscle section of Instant Anatomy
SOMATIC MOTOR

HYPOGLOSSAL

- Occipital artery
- Hypoglossal canal
- Int/ext carotid arteries
- Lingual artery
- Facial vein
- Hyoglossus
- Tongue muscles
- Superior root of ansa cervicalis
- Thyrohyoid
- Geniohyoid
- C1
- 10-15 rootlets
LINGUAL NERVE: RELATION TO MUSCLES

Lingual nerve
Tensor veli palatini
Lateral pterygoid
Medial pterygoid
Mylohyoid
Hyoglossus

The lingual nerve passes between:
1. Tensor veli palatini and lateral pterygoid
2. Medial pterygoid and mandible
3. Mandible and mucosa of mouth
4. Mylohyoid and hyoglossus
CRANIAL NERVES EMERGING FROM
BASE OF THE BRAIN

- Optic nerve
- Oculomotor
- Facial
- Vestibulocochlear
- Glossopharyngeal
- Hypoglossal
- Ventral root of 1st cervical nerve
- Spinal root of accessory
- Olfactory bulb
- Olfactory tract
- Trochlear
- Trigeminal
- Abducent
- Vagus
- Accessory
CRANIAL NERVE NUCLEI IN BRAIN STEM

- Edinger-Westphal
- III Oculomotor
- IV Trochlear
- V Trigeminal motor
- VI Abducent
- VII Facial
- Superior salivary
- Inferior salivary
- Nucleus ambiguus (branchiomotor)
- X Dorsal motor of vagus
- Hypoglossal

V - Trigeminal

Mesencephalic (proprioception)

Chief (touch)

Spinal (pain & temperature)

Vestibular & cochlear

Nucleus solitarius

SOMATIC | MOTOR

Somatic
Taste/baroreceptors
Special sense

Somatic
Parasympathetic
Branchiomotor
STRUCTURES PIERCING THE DURA IN THE BASE OF THE SKULL

- Olfactory (I) bulb & nerve
- Optic nerve & ophthalmic artery
- Trigeminal ganglion & Vа, Vb, Vc
- Facial, nervus intermedius, vestibulocochlear (VII, VIII)
- Glossopharyngeal Vagus Accessory (IX, X, XI)
- Cut edge of tentorium cerebelli
- Sigmoid sinus
- Hypoglossal (XII)
- Transverse sinus
- Tentorium cerebelli
- Oculomotor (III)
- Middle meningeal artery
- Trigeminal (V)
- Spinal root of accessory
- Vertebal arteries
SUMMARY OF CRANIAL NERVES THAT CARRY PARASYMPATHETIC

III (OCULOMOTOR) → EYE
- PUPIL CONSTRUCTION
- ACCOMMODATION

VII (FACIAL) → LACRIMAL GLAND
- MUCOSAL GLANDS OF NOSE/PALATE
- SUBMANDIBULAR
- SUBLINGUAL GLANDS

IX (GLOSSOPHARYNGEAL) → PAROTID GLAND

X (VAGUS) → HEART
- GUTS TO 2/3 ALONG TRANSVERSE COLON

(S 2, 3, 4 PELVIC OUTFLOW FOR PELVIC ORGANS & GUT BELOW VAGAL DISTRIBUTION)
CERVICAL PLEXUS

Posterior rami | Anterior rami

Greater occipital (C2 +/- C3)

Suboccipital (no skin)

Spinal root of accessory (C1-5)

Geniohyoid
Thyrohyoid

Hypoglossal

Superior/inferior roots of ansa cervicalis (C1-3)

Lesser occipital

Great auricular

Transverse cervical

Supraclavicular

Phrenic (C3,4,5) +/- Accessory phrenic from nerve to subclavius (C5,6)

Greater occipital (C2)

3rd occipital (C3)

Dorsal rami (C3,4,5)

Lesser occipital (C2)

Great auricular (C2,3)

Transverse cervical (C2,3)

Supraclavicular (C3,4)

Don’t confuse
Greater auricular with:
Posterior auricular branch of facial (VII) - motor to occipitalis
Auriculotemporal branch of mandibular (V3) sensory to hairy temple.
ANSA CERVICALIS

Hypoglossal nerve (XII)

Tongue muscles

Geniohyoid

Thyrohyoid

Lower root

Upper root

C1

C2

C3

Inferior belly of omohyoid

Superior belly of omohyoid

Sternohyoid

Sternothyroid

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INFERIOR ALVEOLAR NERVE: RELATIONS WITH MANDIBLE

BABY
(Tooth buds)

ADULT
(Teeth)

ELDERLY
(Edentulous)
SUMMARY AND KEY POINTS OF SYMPATHETICS

EMERGENCY
Fight, Flight, Fright

HOMEOSTATIC
- Selectively constricts blood vessels (vasomotor)
  (e.g. redirects blood from gut to heart and muscles)
- Temperature regulation
- Stimulate sweat glands (sudomotor)
- Erects hairs in skin (pilomotor)

SPECIFIC
- Stimulates suprarenal gland
- Speeds the heart & increases blood pressure
- Bronchial dilatation to maximise air intake
- Inhibits the gut, dries secretions & closes sphincters
- Stimulates ejaculation
- Special in head & neck
- Dilates the pupil

KEY POINTS
- Only output is between T1 and L2 cord levels. They pass up & down the sympathetic chain to reach parts of the body beyond these levels. The chain extends the whole length of the body.
- True sympathetic nerves are all motor. General visceral sensory nerves run with them. They detect distension, hunger, pain etc.
- They arise from cell bodies in the lateral horn of the spinal cord & emerge with the somatic motor nerves from the ventral horn. They leave the somatic nerve to reach the sympathetic ganglia via a white (myelinated) ramus communicans.
- Within each ganglion some sympathetic nerves always synapse and their secondary neurones (unmyelinated) then pass back onto the same somatic nerve via a grey ramus communicans to supply sudomotor, pilomotor and vasomotor activity to the distribution of that somatic nerve.
- Visceral fibres leave the ganglia (either the one they entered or others above or below) as visceral branches. RULE: Visceral branches always synapse in the ganglion from which they leave unless they supply gut (bowel, liver spleen, etc) or adrenal gland. If they have not synapsed in the ganglion then they will do so in peripheral ganglia nearer the organ that they supply. From each cervical ganglia a visceral branch goes to the heart (6 branches altogether).
- From the cervical ganglia there are grey rami communicantes to the somatic cervical nerves (C1-8). But each cervical ganglia also has an vascular branch to distribute sympathetics to the neck & into the head on arteries. These vascular branches reach the eye for pupil dilatation for vision in dark surroundings & emergency situations. They also supply the eyelids for opening the eyes widely.
- Sympathetic supply to the gonads controls vascular tone only.
CONNECTIONS OF SYMPATHETIC CHAIN IN NECK

VASCULAR BRANCHES - Purple
SOMATIC BRANCHES - Orange
VISCERAL BRANCHES - Red

To int. carotid
v/c of branches
Dilator pupillae
Levator palpe buccal

To ext. carotid
Somatic to skin
Visceral to glands

To inf. thyroidea
Visceral to lower larynx, trachea, hypopharynx, oesophagus

Cervical sympathetic ganglia
(All branches are postganglionic)
SYMPATHETIC CHAIN & GANGLIA IN NECK

- **Internal carotid artery**
- **External carotid artery**
- **Inferior thyroid artery**
- **Cardiac branches from each ganglion**
- **Vertebral artery**
- **Ansa subclavia around subclavian artery**

**SUPERIOR CERVICAL GANGLION**
- Anterior to lateral mass C1 & C2
- 3cm long
- 4 somatic branches (C1-4)
- Branches to internal & external carotid arteries

**MIDDLE CERVICAL GANGLION**
- At C6, medial to carotid tubercle
- Anterior to vertebral artery
- 2 somatic branches (C5,6)
- Branches to inferior thyroid & subclavian arteries

**INFERIOR CERVICAL GANGLION**
- At C7, behind vertebral artery
- 1cm x 0.5cm on neck of 1st rib
- 2 somatic branches (C7,8)
- Branches to vertebral artery
RELATIONS TO SCALenus ANTERIOR

ANTERIOR
- Phrenic nerve (Under prevertebral fascia)
- Ascending cervical artery
- Transverse cervical-suprascapular arteries
- Carotid sheath
- Vagus
- Thoracic duct
- Lower belly of omohyoid
- Deep cervical nodes

MEDIAL
- Iongus colli
- Carotid tubercle
- Pyramidal space
- Carotid sheath
- Stellate ganglion
- Vertebral artery
- Middle cervical ganglion
- Inferior thyroid artery
- 1st part subclavian artery
- Ansa subclavia
- Thyrocervical trunk
- Vertebral vein

POSTERIOR
- 2nd part subclavian artery
- Anterior rami C3-T1
- Costocervical trunk
- Superior intercostal & deep cervical arteries
- Scaleneus Medius

LATERAL
- Trunks of brachial plexus
- 3rd part subclavian artery
CONNECTIONS OF SYMPATHETIC CHAIN TO SPINAL CORD

Somatic n

Peripheral ganglion

Sympathetic chain

GRC = (Grey ramus communicans)
WRC = (white ramus communicans)

- = Preganglionic sympathetic
--- = Postganglionic sympathetic
The autonomic system is essential for survival. Without vascular tone we would faint every time we stood up. There would be no intestinal activity to digest and absorb food and no increase in heart rate with exercise. Without sexual activity there would be no continuation of the species!

Deliberate destruction of the nerves is sometimes necessary. For instance in excessive sweating the sympathetic chain can be cut selectively or the parasympathetics (vagus nerves) can be cut to decrease acid production in the stomach. Referred pain, for example from the appendix or gonads, is explicable in terms of general visceral sensory fibres in the autonomic system.
This typical parasympathetic ganglion could be either the CILIARY, OTIC, SUBMANDIBULAR OR PTERYGOPALATINE. Irrespective which one it is, there is always a parasympathetic nerve from either III, VII, or IX synapsing within it. Passing through it, and carrying the parasympathetic on to its end organ, is always a branch of the trigeminal.

Here we see a branch of Vc but it could have been a branch of Va or Vb.

Also through each ganglion passes a branch of the sympathetic from the superior cervical ganglion via an appropriate artery (internal carotid for the ciliary and pterygopalatine ganglia and external carotid for the submandibular and otic ganglia)
Maxillary

Lacrimal gland

PPG

Greater petrosal

Nose, palate
nasopharynx
sinuses

Submandibular ganglion

Submandibular, sublingual glands

Sympathetic off int & ext respectively

Chorda tympani

Superior Salivary Nucleus via nervus intermedius VII

Via z-temporal & lacrimal

lingual

lingual
Inferior Salivary Nucleus via IX

Lesser petrosal

Tympanic branch of IX

Auriculotemporal

Sympathetic off ext carotid

OTIC GANGLION

Parotid gland
<table>
<thead>
<tr>
<th><strong>CENTRAL NUCLEUS</strong></th>
<th>Edinger–Weschhal (mid brain)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EMERGING WITH CRANIAL NERVE</strong></td>
<td>III (oculomotor)</td>
</tr>
<tr>
<td><strong>NERVE CARRYING PREGANGLIONIC FIBRES</strong></td>
<td>III. Nerve to inferior oblique</td>
</tr>
<tr>
<td><strong>PATHWAY &amp; FORAMEN</strong></td>
<td>Cavernous sinus and superior orbital fissure</td>
</tr>
<tr>
<td><strong>SITE OF GANGLION</strong></td>
<td>Between optic nerve and lateral rectus in apex of orbit</td>
</tr>
<tr>
<td><strong>NAME OF GANGLION</strong></td>
<td>Ciliary</td>
</tr>
<tr>
<td><strong>NERVE CARRYING POSTGANGLIONIC FIBRES</strong></td>
<td>Vα: nasociliary and short ciliary</td>
</tr>
<tr>
<td><strong>ORGAN(S) SUPPLIED</strong></td>
<td>Ciliary muscle for accommodation. Circular iris muscle for pupil constriction</td>
</tr>
<tr>
<td><strong>SOURCE OF SYMPATHETIC THROUGH GANGLION</strong></td>
<td>Ophthalmic artery (internal carotid)</td>
</tr>
</tbody>
</table>
| **PTERYGOPALATINE GANGLION:**
| **DETAILED PATHWAYS TO AND FROM IT** |
| **CENTRAL NUCLEUS** | Superior salivary (pons) |
| **EMERGING WITH CRANIAL NERVE** | VII (facial) |
| **NERVE CARRYING PREGANGLIONIC FIBRES** | Nervus intermedius then VII then greater petrosal then nerve of pterygoid canal |
| **PATHWAY & FORAMEN** | Internal acoustic meatus then middle ear then middle cranial fossa then pterygoid canal then pterygopalatine fossa |
| **SITE OF GANGLION** | Pterygopalatine fossa |
| **NAME OF GANGLION** | Pterygopalatine |
| **NERVE CARRYING POSTGANGLIONIC FIBRES** | Vb: 1. Maxillary branches
2. Infra-orbital then zygomatic then zygomaticotemporal then lacrimal (Va) |
| **ORGAN(S) SUPPLIED** | 1. Mucosal glands of nose, nasopharynx, sinuses, soft palate
2. Lacrimal gland |
| **SOURCE OF SYMPATHETIC THROUGH GANGLION** | Deep petrosal nerve off internal carotid just before it enters the cavernous sinus.
It joins the greater petrosal nerve to become, together, the nerve of the pterygoid canal |
<table>
<thead>
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<th><strong>SUBMANDIBULAR GANGLION: DETAILED PATHWAYS TO AND FROM IT</strong></th>
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<td>SOURCE OF SYMPATHETIC THROUGH GANGLION</td>
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SUMMARY AND KEY POINTS OF PARASYMPATHETICS

**NON - EMERGENCY** (at rest and quiet activity)
- Stimulates glands (salivary, mucus) to secrete
- Slows the heart & minimises blood pressure
- Bronchial constriction to lessen dead space
- Stimulates gut peristalsis & opens sphincters
- Contracts the bladder & uterus
- Causes erection of penis and clitoris
- Special in Head & neck
- Constricts the pupil
- Accommodates the eye (lens) for near vision

**KEY POINTS**
- Parasympathetic output in the body is only from cranial nerves III (oculomotor), VII (facial), IX (glossopharyngeal) and X (vagus) & sacral segments 2, 3, 4.
- In the head & neck it constricts the pupil, accommodates the eye & makes the salivary & lacrimal glands secrete. The vagus supplies the whole trunk down to the left side of the transverse colon. Below that the supply is from S2, 3, 4 output.
- Each vagus nerve has two branches in the neck destined for the heart. There are separate vagal branches to the heart & respiratory system as the vagi pass through the chest & there are branches throughout the abdomen as defined above after they pass through the oesophageal opening of the diaphragm.
- The parasympathetics from the 2, 3, 4 sacral segments arise from cell bodies in the lateral horn of the spinal cord but emerge with the somatic motor nerves via the ventral horn. They join the pelvic plexus as the pelvic splanchnic nerves.
- True parasympathetic nerves are all motor. Sensory nerves within the parasympathetic system are general visceral sensory nerves that simply run with the parasympathetics and are not strictly part of the system.
- The vagus nerves & the output from S2, 3, 4 are all preganglionic fibres which all synapse in small peripheral ganglia on or near the organs of distribution. In the head there are four special parasympathetic ganglia for synapsing.
- There is no parasympathetic supply to limbs or gonads.
GREATER PETROSAL NERVE

TEAR AND HAY FEVER

Nucleus:
Secretomotor - Superior salivary
Taste - Tractus solitarius

Greater petrosal nerve emerges from geniculate ganglion & passes forwards & medially at 45 degrees through petrous temporal bone. Emerges in middle cranial fossa. Runs in a groove under the dura & under the trigeminal ganglion to reach foramen lacerum, on or near the internal carotid artery.

Here it is joned by the deep petrosal nerve (sympathetic) off the artery & superior cervical ganglion. Greater petrosal + deep petrosal = nerve of pterygoid canal.

Pterygoid canal opens into the pterygopalatine fossa. The nerve enters the pterygopalatine ganglion. Parasympathetics synapse, sympathetics & taste pass through unchanged. All nerves distributed with branches of Vb to nose, sinuses, hard/soft palate, nasopharynx, lacrimal gland.

Nerve of pterygoid canal enters its canal via a hole in the anterior wall of the upper end of the foramen lacerum.

Nervus intermedius. Into internal auditory meatus with VII & VIII. Joins VII just before geniculate ganglion.

At geniculate ganglion. Parasympathetic passes through, incoming taste have cell bodies here.
LESSER PETROSAL NERVE

TO PAROTID GLAND

Nucleus: Inferior salivary. Tympanic branch (also known as Jacobson’s nerve) of IX (glossopharyngeal nerve) leaves it just below the IX ganglion

Enters middle ear via the petrous temporal bone onto promontry where it mixes with sympathetic & parasympathetic from VII

Leaves middle ear high up on anteromedial wall as lesser petrosal nerve to enter middle cranial fossa via the petrous temporal bone

It runs under the dura to reach foramen ovale where it exits the skull to reach the otic ganglion which hangs off the nerve to tensor tympani

The postganglionic fibres join the auriculotemporal nerve (Vc) which carries them to the parotid gland

The parasympathetic in the lesser petrosal nerve synapses in the otic ganglion. Sympathetics which joined the nerve from the middle meningeal artery, pass right through

Note on Frey’s Syndrome
During parotid surgery the parasympathetic secretomotor fibres in the auriculotemporal nerve can be damaged. When they regenerate they sometimes grow up the sheaths of the sympathetic nerves that supply the sweat glands on the hairy temple. As sweat glands have cholinergic receptors these parasympathetic fibres are able to stimulate the sweat glands inappropriately and this gives “gustatory sweating”
CHORDA TYMPANI

SECRETOMOTOR FOR SUBMANDIBULAR
AND SUBLINGUAL GLANDS
TASTE FROM ANTERIOR 2/3 TONGUE

Nucleus - Superior salivary
Taste - Tractus solitarius

Nervus intermedius. Into
internal auditory meatus
with VII & VIII. Joins
VII just before geniculate
ganglion

Chorda tympani leaves the
facial nerve (VII) 6mm above
the stylomastoid foramen,
below the floor of the middle
ear. It passes back into the
middle ear via its posterior
wall

At geniculate ganglion. Para-
sympathetic passes
through, incoming taste
have cell bodies here

It passes across the handle
of the malleus and the pars
flaccida of the tympanic
membrane, under the mucosa

It leaves the middle ear via
the anterior canaliculus in the
anterior wall, through the
petrous temporal bone &
exits via the petrotympanic
fissure

It leaves the lingual nerve
to reach the submandibular
ganglion where parasym-
pathetic fibres synapse before
supplying the submandibular & siblingual
salivary glands. Returning taste
from the anterior 2/3 of tongue
keep with the lingual nerve.
Sympathetic fibres pass
through the ganglion from the
facial artery

In the infratemporal fossa it
passes medial to, & grooves the
spine of the sphenoid. It then
passes antero-inferior, deep
to lateral pterygoid to join the
lingual nerve 2cm below skull
SUMMARY OF CRANIAL NERVES THAT CARRY PARASYMPATHETIC

III (OCULOMOTOR) → EYE
- PUPIL CONSTRICITION
- ACCOMMODATION

VII (FACIAL) →
- LACRIMAL GLAND
- MUCOSAL GLANDS OF NOSE/PALATE
- SUBMANDIBULAR SUBLINGUAL GLANDS

IX (GLOSSOPHARYNGEAL) → PAROTID GLAND

X (VAGUS) →
- HEART
- GUTS TO 2/3 ALONG TRANSVERSE COLON

(S2,3,4 PELVIC OUTFLOW FOR PELVIC ORGANS & GUT BELOW VAGAL DISTRIBUTION)
DERMATOMES & NAMED SKIN NERVES

See under head and neck nerves, somatic, cervical plexus and also under the individual branches of the trigeminal nerve in the cranial nerve section of nerves. See also in nerve section of Instant Anatomy.
TEMPOROMANDIBULAR JOINT

- Synovial
- Condylar
- Hemicylindrical
- Atypical (fibrocartilage on surfaces)
- Fibrocartilaginous disc
- Synovial membrane lines capsule
- Nerve supply: Auriculotemporal & nerve to masseter

**Articular tubercle**

**Disc**

**Lateral pterygoid**

**Lateral temporomandibular ligament**

**Capsule**

**Stylomandibular ligament**

**Sphenomandibular ligament**

**Between mandible & mandibular fossa of squamous temporal bone**

**Disc** attached anteriorly to head of mandible, thus moves forward with it. Also at lateral pterygoid plate and capsule.

**Capsule** attached to neck of mandible at articular margin. Anterior - at articular tubercle. Posterior - at squamotympanic fissure. Strong but lax at rest.

**Lateral temporomandibular ligament** from zygomatic arch to posterior neck & ramus of mandible. Fuses with capsule, lax at rest, tightens with any movement.

**Movement** in upper compartment is protraction (lateral pterygoids), retraction (posterior temporalis) & gliding side to side. In lower compartment is opening (lateral pterygoids & digastrics) & closing (masseters, medial pterygoids & temporalis).
Points A & B represent the 2 ends of the sphenomandibular ligament (spine of sphenoid to lingula of mandible). Distance between them must remain constant at all positions of the joint. Axis for opening must pass through lingula (B) on each side.

First few degrees of opening: Rotation only in lower cavity. Mostly gravity.

Majority of opening: Further rotation in lower joint cavity. Major degree of anterior displacement of head of mandible onto articular tubercle achieved by lateral pterygoid and occurring in upper joint cavity.

Last few degrees of opening: Further rotation in lower joint cavity only.
MUSCLES OF FACIAL EXPRESSION

A = Incisive slip of orbicularis oris
B = Mental slip of orbicularis oris
C = Orbital part of orbicularis oculi
   (complete sphincter, screws up eye, decreases volume of conjunctival sac & tears spill over)
D = Palpebral part of orbicularis oculi
   (Medial palpebral ligament to lateral palpebral raphe. Keeps volume of conjunctival sac constant, no tear spill, closes eye)
E = Levator labii superioris
F = Levator anguli oris
G = Levator labii superioris alaeque nasi
   (Dilator nares & depressor septi are not shown)

Note: The face has no deep fascia, variables amount of fat, good blood supply & drainage. Muscles are 2nd arch mesoderm, equivalent to the panniculus carnosus of animals, often attached to the dermis & are arranged into sphincters, dilators and expressors
**LARYNX - INTRINSIC MUSCLES**

**Posterior view**

- **Oblique arytenoids (2)** close cords by drawing together arytenoids. They extend into aryepiglottic fold as aryepiglotticus to close the aditus.

- **Transverse arytenoid (3)** closes cords by drawing together arytenoids.

**Looking down at cords**

- **Lateral crico-arytenoids (4)** adduct/close cords by rotating arytenoids medially.

- **Thyro-arytenoids (5)** & vocalis loosen cords by drawing together the thyroid cartilage & arytenoids.
MUSCLES OF MASTICATION

- Temporalis
- Masseter
- Medial pterygoid
- Lateral pterygoid

All supplied by:
- Mandibular division of Trigeminal (Vc)
- All derived from 1st pharyngeal arch

LATERAL PTERYGOID

Arises: 2 heads
- Upper: infratemporal surface of sphenoid
- Lower: lateral surface of lateral pterygoid plate
Inserts: pterygoid fossa below head of mandible, disc, and capsule of temporomandibular joint
Action: protrudes jaw and opens mouth

MEDIAL PTERYGOID

Arises: 2 heads
- Deep: medial side of lateral pterygoid plate and fossa between plates
- Superficial: smaller. Tuberosity of maxilla and pyramidal process of palatine bone
Inserts: Medial ramus of mandible
Action: pulls mandible upwards, forwards and medially (closes mouth and chews)

See Muscle section of Instant Anatomy for details of temporalis and masseter
NECK MUSCLES 1

OMOHYOID
Transverse suprascapular ligament via clavicle to hyoid
Nerve: Ansa cervicalis (C1-3)

STYLOHYOID
Base/back of styloid process to hyoid
Nerve: Facial nerve (VII)

STERNOHYOID
Superior/lateral/posterior manubrium to hyoid
Nerve: Ansa cervicalis (C1-3)

THYROHYOID
Oblique line on thyroid cartilage to hyoid
Nerve: C1 fibres on hypoglossal

MYLOHYOID
Mylohyoid line on inner mandible. 3/4 into midline raphe, rest into hyoid
Nerve: Nerve to mylohyoid (Vc)

Fuller details in muscle section of Instant Anatomy
NECK MUSCLES 2

GENIOHYOID
Inferior mental (genial) spine on mandible to hyoid
Nerve: C1 fibres on hypoglossal

DIGASTRIC
Digastric notch on mastoid, via sling on hyoid to digastric fossa on back of anterior mandible
Nerve: Anterior belly - nerve to mylohyoid (Vc)
          Posterior belly - facial nerve (VII)

STERNOHYOID
Posterior manubrium to oblique line on thyroid cartilage
Nerve: Ansa cervicalis (C1-3)

PLATYSMA
(Panniculus carnosus) Deep fascia under breasts to inferior border of mandible
Nerve: Cervical branch of facial (VII)

Fuller details in muscle section of Instant Anatomy
SOFT PALATE

- Consists of:
  - Aponeurosis
  - Tensor veli palatini
  - Levator veli palatini
  - Palatoglossus
  - Palatopharyngeus
  - Muscles of uvula
  - Mucosa
  - Mucous & serous glands
  - A few taste buds

- Epithelium: Stratified squamous
- Blood: Lesser palatine (maxillary)
  - Ascending palatine (facial)
  - Palatine branch of ascending pharyngeal (external carotid)
- Veins: Pharyngeal & pterygoid plexus
- Lymph: Retropharyngeal & antero-superior deep cervical
- Nerve: Secretomotor - Vb via pterygopalatine ganglion
  - Sensation - Vb, lesser palatine + (IX)
  - Taste - Greater petrosal then lesser palatine
- Function: closes nasopharynx

Passavant’s ridge is a circular, sphincter-like part of either palatopharyngeus or superior constrictor.
PHARYNX - MUSCLES & STRUCTURES ENTERING IT

Superior constrictor

Between superior & middle constrictors are:
1. Glossopharyngeal nerve (IX)
2. Stylopharyngeus (IX)
3. Stylohyoid ligament
4. Lingual nerve (Vc)

Middle constrictor

Between middle & inferior constrictors are:
5. Thyrohyoid membrane pierced by:
   6. Internal laryngeal nerve
   7. Superior laryngeal vessels

Inferior constrictor

(Thyropharyngeus (8) is upper part that behaves like the other constrictors, closing on swallowing. Cricopharyngeus (9) is lower part - a sphincter that opens on swallowing. Between 2 parts is potential pharyngeal pouch (Dehiscence of Killian) (10)

Below inferior constrictor and passing upwards are:
11. Recurrent laryngeal nerve
12. Inferior laryngeal vessels

For details of these muscles see muscle section of Instant Anatomy
PREVERTEBRAL MUSCLES

Rectus capitis lateralis
(lateral mass of atlas to jugular process of occipital bone)

Rectus capitis anterior
(lateral mass of atlas to front of foramen magnum)

Longus capitis
(TP C3-6, anterior tubercles to basi-occiput)

Splenius

Levator scapulae
(TP C1-4 to upper medial scapula)

Longus colli
(bodies T3, 2, 1 & C7, 6, 5 to bodies C4, 3, 2, 1 & TP C3-6 anterior tubercles)

Scalenus posterior
(TP C4-6, posterior tubercles to 2nd rib)

Serratus anterior

Scalenus medius
(TP C2-7, posterior tubercles, to 1st rib between neck & subclavian groove)

Scalenus anterior
(TP C3-6, anterior tubercles, to 1st rib-scalene tubercle)

TP = Transverse process
# Rules of Nerve Supply for Muscle Groups

<table>
<thead>
<tr>
<th>All Muscles of</th>
<th>Supplied By</th>
<th>Except</th>
<th>Which Is Supplied By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharynx</td>
<td>Pharyngeal plexus (IX, X &amp; sympathetic)</td>
<td>Stylopharyngeus</td>
<td>Glossopharyngeal (IX)</td>
</tr>
<tr>
<td>Palate</td>
<td>Pharyngeal plexus (IX, X &amp; sympathetic)</td>
<td>Tensor veli palatini</td>
<td>Nerve to medial pterygoid (Vc)</td>
</tr>
<tr>
<td>Tongue</td>
<td>Hypoglossal (XII)</td>
<td>Palatoglossus</td>
<td>Pharyngeal plexus (IX, X &amp; sympathetic)</td>
</tr>
<tr>
<td>Facial Expression &amp; Buccinator</td>
<td>Facial (VII)</td>
<td>Levator palpebrae superioris</td>
<td>Oculomotor (III)</td>
</tr>
<tr>
<td>Mastication</td>
<td>Mandibular division of Trigeminal (Vc)</td>
<td>Buccinator</td>
<td>Facial (VII)</td>
</tr>
<tr>
<td>Larynx</td>
<td>Recurrent laryngeal</td>
<td>Cricothyroid</td>
<td>External branch of superior laryngeal nerve (X)</td>
</tr>
</tbody>
</table>
**LEVATOR PALPEBRAE SUPERIORIS**

- **LATERAL**
  - Palpebral branch of lacrimal n
  - Lateral palpebral ligament
  - Zygomatico-facial n

- **MEDIAL**
  - Supra-oral n
  - Supratrochlear n
  - Medial palpbral ligament over lacrimal sac
  - Infra-orbital n

- * Superior tarsal plate

**Orbicularis oculi**

- Corrugator

**Levator palpebrae superioris**

- Arises from posterior orbit above tendinous ring and inserts into eyelid skin and into superior tarsal plate.
- Nerve supply is via oculomotor (III)
- Somatic to both tarsal plate and skin.
- Sympathetic to tarsal plate only.
BUCCINATOR

Viewed from inside
- Pterygomandibular raphe
- Inferior alveolar nerve
- Nerve to mylohyoid
- Buccinator
- Lingual nerve
- Parotid duct
- Superficial constrictor
- Medial pterygoid

Viewed from outside
- Mylohyoid
- Pterygomaxillary ligament
- Inferior alveolar nerve
- Pterygomandibular raphe
- Buccinator
- Lingual nerve
- Parotid duct

Origin: Both jaws opposite 1st molar teeth & pterygomandibular raphe & pterygomaxillary ligament
Insertion: Modiolus
Action: Helps chewing, returns food to mouth from cheek pouches
Nerve supply: Facial (VII - buccal branches). Proprioceptive afferent fibres via buccal branch of Vc
- The mylohyoid muscle (not shown) overlaps the anterior edge of hyoglossus
- Hyoglossus is supplied by the hypoglossal nerve as are all the muscles of the tongue except palatoglossus (pharyngeal plexus)
- Further anteriorly, under the mylohyoid, the lingual nerve passes lateral to the submandibular duct, then dips under it to appear on its medial side to enter the tongue
- The venae comitantes of the hypoglossal nerve pass posteriorly to join the facial vein
**ANTERIOR**
- Phrenic nerve (Under prevertebral fascia)
- Ascending cervical artery
- Transverse cervical/suprascapular arteries
- Carotid sheath
- Vagus
- Thoracic duct
- Lower belly of omohyoid
- Deep cervical nodes

**POSTERIOR**
- 2nd part subclavian artery
- Anterior rami C3-T1
- Costocervical trunk
- Superior intercostal & deep cervical arteries
- Scaleneus Medius

**MEDIAL**
- Longus colli
- Carotid tubercle
- Pyramidal space
- Carotid sheath
- Stellate ganglion
- Vertebral artery
- Middle cervical ganglion
- Inferior thyroid artery
- 1st part subclavian artery
- Ansa subclavia
- Thyrocervical trunk
- Vertebral vein

**LATERAL**
- Trunks of brachial plexus
- 3rd part subclavian artery
TONGUE - MUSCLES

Hyoglossus
   Hypoglossal nerve (XII)
Genioglossus
   Hypoglossal nerve (XII)
Styloglossus
   Hypoglossal nerve (XII)
Palatoglossus
   Pharyngeal plexus (IX, X & sympathetic)
Intrinsic muscles
   Superior/inferior longitudinal, transverse & vertical
   Not attached to bone
   Hypoglossal nerve (XII)

Note: All muscles are supplied by hypoglossal nerve except palatoglossus

For details of these muscles see muscle section of Instant Anatomy
RIGHT INTERNAL & EXTERNAL JUGULAR VEINS

Surface Markings
- Internal jugular: Earlobe to sterno-clavicular joint
- External jugular: Earlobe to mid clavicle
- Anterior jugular: Begins below chin & runs down under platysma

SB = Superior bulb
IB = Inferior bulb
O = Deep fascia
VERTEBRAL LEVELS OF STRUCTURES

C1  • Spinal root of accessory nerve crosses transverse process of atlas
     • Open mouth and dens

C2  • Superior cervical ganglion

C3  • Body of hyoid bone

C4  • Upper border of thyroid cartilage
     • Bifurcation of common carotid arteries

C6  • Cricoid cartilage
     • Larynx becomes trachea
     • Pharynx becomes oesophagus
     • Middle cervical ganglion
     • Vertebral artery enters foramen transversum of C6
     • Carotid tubercle of Chassaingac
     • Inferior thyroid artery crosses to thyroid gland and passes behind sympathetic chain

C7  • First clearly palpable spinous process (Vertebra prominens - C7)
     • Stellate/inferior cervical ganglion
BREAST STRUCTURE AND CHANGES IN PREGNANCY

- Deep fascia
- Lymph nodes
- Fat
- Lobes of glands
- Ducts (non pregnant)
- Alveoli of ducts (early pregnancy)
- Enlarged alveoli (mid pregnancy)
- Nipple
- Areola
- Dilated alveoli (lactation)
- Regression (after weaning)

MATURE HISTOLOGY
Tubulo-alveolar glands (apocrine) leading to ducts with cuboidal epithelium - stratified squamous at openings with myo-epithelial cells, interspersed by fat
Lies on
- Pectoralis major
- Serratus anterior
- External oblique
  (tail may curl round posterior to pectoralis minor)

A modified sweat gland

Position
- On ribs 2-6 in mid-clavicular line
- Nipple in 4th intercostal space

Lymphatics
- Run deep to capsule in sub mammary space to:
  - Axilla (anterior, apical & central nodes)
  - Infraclavicular nodes
  - Internal thoracic nodes (parasternal)

Capsule
- Posterior to breast
- Thickened Scarpa's fascia

In disease lymphatics may go to:
- Other side
- Deep cervical
- Into peritoneum
- Inguinal

Support
Suspensory ligaments of Astley Cooper from deep fascia to dermis

Blood supply
- Internal thoracic (1st part subclavian)
- Lateral thoracic (2nd part axillary)
- Thoraco-acromial (2nd part axillary)
- Intercostal (internal thoracic)

Structure
15-20 lobes
Each with 1 lactiferous duct leading to:
RIB ARTICULATION

Inner aspect of a typical rib

Superior demifacet (vertebral body above)

Transverse crest (intervertebral disc)

Inferior demifacet (vertebral body below, ie same number as rib)

Primary cartilaginous costochondral joint

Transversus thoracis

Anterior angle (on outside) for:
- External oblique abdominis 5-12
- Serratus anterior 1-8
- Latissimus dorsi 5-12

Ossification:
- Posterior angle 8 weeks intra-uterine
- Head/tubercle 15 years. Fuse 25 years

RIB MOVEMENTS

Upper ribs (pump handle)
- Rotation

Lower ribs (bucket handle)
- Gliding

1st rib: Short, broad, most curved, single facet on head
2nd rib: Poorly marked costal groove, rough area for serratus anterior & scalenus posterior
3-10 ribs: Typical. 7th longest
11/12 ribs: Floating, single facet, no tubercle, tapered end. 12th no groove
1-7 ribs articulate with sternum
8-10 ribs with each other

Muscles attached to outer ribs:
- Serratus anterior 1-8
- External oblique abdominis 5-12
- Pectoralis minor 3,4,5
- Latissimus dorsi 9-12

Muscles attached to costal cartilages:
- Pectoralis major 1-7 (often 2-6)
CHEST WALL MUSCLES

External intercostals
From sharp edge of rib above - downwards/forwards to rounded edge of rib below, from superior costotransverse ligament posteriorly to costochondral junction anteriorly. Then anterior intercostal membrane beyond this

Internal intercostals
From costal groove above - downwards/backwards to upper border of rib below, from sternal edge to angle of rib. The posterior intercostal membrane beyond this

Transversus thoracis
At back: Subcostals. In lower chest. Wider below
At side: Innermost intercostals. Extend for more than one space
At front: Transversus thoracis (previously Sterno-costalis) from lower sternum to costal cartilages 2-6
UNDER SURFACE OF DIAPHRAGM

Origin:
Vertebral - Right crus (L1,2,3), left crus (L1,2), 5 arcuate ligaments
Sternal - Xiphoid Costal - Rib & costal cartilages 7-12

Insertion:
Central tendon (trefoil -1 ant, 2 post, fused with pericardium)

Action:
Inspiration - 70% at rest (5cm of movement)
Less % on exertion (10cm movement)
Straining - Outlet of chest is fixed to raise intra-abdominal pressure

Nerve supply:
Phrenic nerves - C3,4,5. 1/3 sensory, 2/3 motor. Diaphragm has no other motor supply

Blood:
Outer - lower 5 intercostals & subcostal arteries
Inner - Inferior phrenic (aorta), musculophrenic/pericardiacophrenic (internal thoracic)
DEVELOPMENT OF THE DIAPHRAGM

SEPTUM TRANSVERSUM
Separates pericardial development (ventrally) from developing gut (dorsally). It moves to lie caudal to pericardial cavity. It Descends from neck to form the central tendon of the diaphragm.

BODY WALL (Transverse layer) and PLEUROPERITONEAL MEMBRANES
Both grow in to fuse with septum transversum and give the diaphragm.

DORSAL MESENTERY OF OESOPHAGUS
Completes the diaphragm posteriorly.

Note: Despite this complex development few defects occur in the diaphragm. Perhaps the severer ones are incompatible with life. The important sites for hernia are shown here.

ST = Septum transversum becomes central tendon
PPM = Pleuropertitoneal membranes become small area of muscle
DM = Dorsal mesentery becomes crura
BW = Body wall becomes bulk of muscle
DIAPHRAGM - OPENINGS & RELATIONS

**OPENINGS**

- **Caval (T8)**
  - Inferior vena cava & right phrenic nerve
  - Left phrenic nerve

- **Anterior hiatus (T9)**
  - Superior epigastric artery & vein

- **Oesophageal (T10)**
  - Oesophagus
  - Left & right vagus nerves
  - Oesophageal branches of left gastric artery/vein
  - Lymphatics

- **Aortic (T12)**
  - Aorta
  - Azygos vein & hemiazygos vein
  - Thoracic duct

- **Crura (T12)**
  - Greater, lesser & least splanchnic nerves

- **Behind medial arcuate ligament**
  - Sympathetic chain

- **Behind lateral arcuate ligament**
  - Subcostal (T12) neurovascular bundle

**RELATIONS**

- Right dome reaches 4th costal space (nipple) in expiration
- Left dome reaches 5th rib in expiration
- Superior - pericardium, basal lung segments
- Inferior - Right - liver, suprarenal, kidney
  - Left - stomach, suprarenal, kidney & spleen
- Posterior - Aorta, azygos veins, oesophagus, vagi, pleural folds
DIAPHRAGM - OPENINGS & RELATIONS

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  - Superior epigastric artery & vein
- Oesophageal (T10)
  - Oesophagus
  - Left & right vagus nerves
  - Oesophageal branches of left gastric artery/vein
  - Lymphatics
- Aortic (T12) (Strictly behind diaphragm)
  - Aorta
  - Azygos vein & hemiazygos vein
  - Thoracic duct
- Crura (T12)
  - Greater, lesser & least splanchnic nerves
- Behind medial arcuate ligament
  - Sympathetic chain
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HEART - SURFACES & SEPTUM

- Midline in middle mediastinum
- Valved muscular pump
- Size of a fist - 300g
- Cone shaped
- Surfaces: see figure but note that base is the posterior surface (left atrium)

- Anterior surface
  - 2/3rds right ventricle
  - 1/3rd left ventricle

- Inferior surface
  - 1/3rd right ventricle
  - 2/3rds left ventricle

INTERVENTRICULAR SEPTUM

- Right
- Left

- Bulges to right
- Lies vertically
- In coronal plane
- Attaches to AV rings

- Base (posterior)
  - Left atrium

- Left surface
  - Left ventricle

- Apex (anterior)
  - Inferior tip

- Superior membranous part (from AV cushions)

- Inferior muscular part (from ventricular wall)
As the visceral pericardium reaches up posteriorly on the left atrium it reflects off the pulmonary veins to become the parietal pericardium. This is the oblique sinus.
HEART - SURFACES & SEPTUM

- Midline in middle mediastinum
- Valved muscular pump
- Size of a fist - 300g
- Cone shaped
- Surfaces: see figure but note that base is the posterior surface (left atrium)

Base (posterior)
Left atrium

Left surface
Left ventricle

Anterior surface
2/3rds right ventricle
1/3rd left ventricle

Apex (anterior inferior tip)

Inferior surface
1/3rd right ventricle
2/3rds left ventricle

INTERVENTRICULAR SEPTUM

Right

Left

3-5cm

10cm

- Bulges to right
- Lies vertically
- In coronal plane
- Attaches to AV rings

Superior membranous part (from AV cushions)

Inferior muscular part (from ventricular wall)
HEART - FIBROUS SKELETON

- Remnant of Atrioventricular cushions
- Divides atria from ventricles
- Supports valves
- Electrically separates atria from ventricles
- Is origin of membranous interventricular septum

Tendon of Todaro sitting on central fibrous body & AV node just to its left (If central fibrous body calcifies it is then OS CORDIS)

A-B hold mitral valve
C-D hold tricuspid valve
The veins of the heart are more variable than the arteries. Drainage of the left & right ventricles commences with the great cardiac vein in the anterior interventricular groove. It runs left in the anterior atrioventricular (AV) groove where it collects the left marginal vein and then, in the posterior AV groove, it is joined by the oblique vein of the left atrium, the posterior ventricular vein and finally the middle cardiac vein which lies in the posterior AV groove & drains the left & right ventricles posteriorly. The confluence of these veins is the 3cm long coronary sinus, lying in the posterior AV groove. Just before the coronary sinus enters the right atrium to the left of the entry of the inferior vena cava, it is usually joined by the small cardiac vein which drains the right atrium & right ventricle. Sometimes the small cardiac vein drains directly into the right atrium. Two anterior cardiac veins drain the anterior aspect of the right ventricle & right atrium before crossing the right coronary artery to enter the right atrium. Some 20-30% of all drainage is in the venae cordis minimae (Thebesian veins) which drain directly into the chambers of the heart, mostly on the right side.
The ostia of these arteries are above the attachment of the base of the relevant cusp. The right from the anterior sinus & the left from the left posterior sinus.

The right artery passes anteriorly between the right atrial appendage & the pulmonary trunk into the right anterior atrioventricular (AV) groove & then the right posterior AV groove where it anastomoses with the circumflex branch of the left coronary artery. In 90% of people it gives the posterior interventricular artery which anastomoses with the termination of the anterior interventricular artery (left coronary) in this groove. The AV node is supplied by the right coronary artery in 90% of people.

The left coronary artery passes anteriorly between the left atrial appendage & the pulmonary trunk into the left anterior AV groove. It divides into anterior interventricular & circumflex arteries. The latter artery continues first in the anterior & then in the posterior AV grooves. It anastomoses with the terminal branches of the right coronary artery. In 10% of people it gives the posterior interventricular artery (left dominance) & also supplies the AV node. The anterior interventricular (anterior descending) passes down & around the apex of the heart to anastomose with the terminal branches of the posterior interventricular artery.
HEART - PERICARDIUM

PERICARDIUM
- Outer layer - Fibrous
- Blends with adventitia of aorta, pulmonary trunk, superior vena cava (not inferior vena cava), central tendon of diaphragm
- Inner layer - Serous
  - Visceral
  - Parietal
- Blood: pericardiocophrenic & internal thoracic
- Nerve: Phrenic to fibrous and parietal serous layers
  - Sympathetic for pain & muscles and vessels of heart
  - Nil to visceral layer

SINUSES OF PERICARDIUM

Transverse
Lies between the pulmonary artery and aorta in front and pulmonary veins and superior vena cava behind

Oblique
This is a pouch of pericardium between the pulmonary veins at the base of the heart where the visceral pericardium is reflected off the vessels to become the parietal pericardium
If the pericardial lining which makes up the oblique sinus of the pericardium is removed the structures posterior to it are exposed.
HEART - AUSCULTATION

As the valves open and close they produce sounds that are transmitted in the direction of the flow of blood. Thus, by picturing the heart and the positioning of the four valves it is easy to work out the likely points for maximal audiability of the sounds. The position of the valves, relative to the surface is shown on this diagram and the points at which auscultation is best achieved.

- **P** Pulmonary - 2nd left space, parasternally
- **A** Aortic - 2nd right space, parasternally
- **M** Mitral - 5th left space, mid clavicular line (apex)
- **T** Tricuspid - Over lower sternum
HEART - RIGHT ATRIUM

Musculi pectinati in true auricle
Superior vena cava
Limbus (remnant of septum seconunto)
Fossa ovalis (remnant of septum primum)
Crista terminalis (The dividing ridge between the smooth atrium (from sinus venosus) & trabeculated auricle (original atrium). Equivalent on surface is sulcus terminalis)

Inferior vena cava (Through diaphragm at T6)
Tricuspid orifice
SA node at base of SVC

Opening of the coronary sinus (★)
Between the opening of the inferior vena cava & the atrioventricular orifice. Protected by a small valve which prevents regurgitation during atrial contraction. Between this orifice and the septal cusp of the tricuspid valve lies the atrioventricular node (A-V node).

FETAL SHUNTING
In the fetus oxygenated blood passing up the IVC is diverted by the valve of the IVC into the foramen ovale & hence to the left atrium. Blood returning via the SVC passes down into the right ventricle.
HEART - LEFT ATRIUM

Base of heart (posterior surface). The left atrium is opened to show its smooth walled interior, apart from the musculi pectinati of the auricle.
4 large, valveless pulmonary veins drain into it.
On the interatrial wall there is a oval, thin area which is the left side of the fossa ovalis of the right atrium.
HEART - RIGHT VENTRICLE

Superior vena cava
Aorta
Pulmonary trunk
Pulmonary valve (2 anterior, 1 posterior cusps - PAPA)
Corpus arteriosus (infundibulum)
Interventricular septum bulges to right
Ventricular wall (3-5cm thick)
Trabeculae carneae
Septomarginal trabecula (moderator band - branch from right bundle)
Papillary muscle holding cusps with chordae tendineae

TRICUSPID VALVE
- Anterior, septal & posterior
- Attached to fibrous AV ring
- Admits tips of 3 fingers
HEART - LEFT VENTRICLE

Pulmonary artery

Aorta

Left ventricle wall 1cm thick

Right ventricle

Anterior cusp of mitral valve attached to anterior papillary muscle via chordae tendineae

Anterior cusp & sinus
(opening of right coronary artery)

Right posterior cusp & sinus

Posterior cusp of mitral valve attached to posterior papillary muscle via chordae tendineae

Left posterior cusp & sinus
(orifice of left coronary artery)

Traceae carneae

MITRAL VALVE
• Anterior cusp is larger, septal & thicker
• Posterior is smaller & has three scallops
• Admits the tips of 2 fingers
• Attached to fibrous AV ring
Endocardial cushions (yellow) are anterior and posterior; they meet in the centre to make a right and left atrioventricular orifices which become tricuspid and mitral.

Interventricular septum (muscular part) grows up from floor of original ventricle but leaves a gap superiorly which is filled later as the fibrous part of septum from the endocardial cushions.

Arrow: foramen primum
Arrow: foramen secundum (ovale)

Septum primum grows down to the endocardial cushions but before it reaches it, a gap appears above it. The initial gap below it is the foramen primum. The second gap above it is foramen secundum.

A second septum, septum secundum, grows down on the RIGHT, which just covers the top of septum primum. The gap between these two is the foramen ovale (secundum).

Before birth the pressure (P) in the right atrium is higher than in the left atrium as there is no circulation through the lungs. After birth the pressure rises in the left atrium and the septum primum fuses back against the septum secundum.
HEART - DEVELOPMENT

2 primitive blood vessels fuse to give a single pulsatile heart tube which runs down the back of the fetus with a mesentery.

The fused tube divides into 5 chambers with arterial and venous ends. The bulbus cordis fuses with ventricles to give smooth portions of ventricular outlets.

There is limited room for the developing heart and it thus kinks between the atrium and ventricle. Internally, the 4 chambers develop by means of the interatrial and interventricular septa. The heart continues to kink and fold as shown here.

*Truncus arteriosus* divides to give aorta and pulmonary trunks by the spiral aorticopulmonary septum.
*Sinus venosus gives* coronary sinus, SA node, oblique vein of left atrium, & then incorporates into atrium to give the smooth portions AV node and Bundle of His develop from the original atrium.
HEART - DEVELOPMENT OF MAJOR VESSELS AND ARCH ARTERIES

6 week fetus
- Aortic arches
- Right dorsal aorta
- Truncus arteriosus

7 week fetus
- Right dorsal aorta
- External carotid
- Left subclavian artery
- 7th segmental artery

8 week fetus
- External carotids
- Subclavian
- Brachiocephalic artery
- Ductus arteriosus

Infant
- Left subclavian artery
- Ligamentum arteriosum
- Ascending aorta

Notes: Aortic sac is distal part of truncus arteriosus. Distal subclavian arteries are from 7th intersegmental arteries. Distal pulmonary arteries are from buds from 6th arch into lungs.

Fate of arch arteries:
1st - parts of maxillary and external carotids
2nd - dorsal parts of arch arteries become stapedial & hyoid arteries.
3rd - common carotids and 1st parts of internal carotids
4th - Left: part of aortic arch. Right: proximal part of right subclavian
5th - Nil
6th - Left: proximal left pulmonary artery & ductus arteriosus
    Right: proximal right pulmonary artery
HEART DEVELOPMENT
FATE OF VENOUS VALVES

LEFT AND RIGHT VENOUS VALVES

Where the sinus venosus opens into the right atrium, to right of septum secondum, are the left and right venous valves. Upper ends fuse to give SEP'TUM SPUR'IIUM. Rest of left valve fuses with interatrial septum. Septum spurium and upper right valve become the CRISTA TERMINALIS. Lower right valve becomes the VALVE OF THE INFERIOR VENA CAVA and the VALVE OF THE CORONARY SINUS.
HEART - DEVELOPMENT OF CHAMBERS AND SEPTA

Endocardial cushions (yellow) are anterior and posterior; they meet in the centre to make a right and left atrioventricular orifices which become tricuspid and mitral.

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CONGENITAL ANOMALIES OF HEART

INTERATRIAL SEPTAL DEFECTS (ASD)
- Secundum - easy surgical graft
- Primum - Difficult surgery. Often associated with VSD

INTERVENTRICULAR SEPTAL DEFECTS (VSD)
- Usually the upper fibrous part

TETRALOGY OF FALLOT
- Pulmonary stenosis
- Right ventricular hypertrophy
- Fibrous interventricular septal defect
- Over-riding aorta (astride the two ventricles)

PATENT DUCTUS ARTERIOSUS

CO-ARTICATION OF AORTA
- Hypoplasia of 4th arch with post-stenotic dilatation and notching of ribs. Decreased pulse in left arm and below diaphragm

PERSISTENT RIGHT DORSAL AORTA
RETRO-OESOPHAGEAL RIGHT SUBCLAVIAN ARTERY
- Gives dysphagia lusoria

DOUBLE AORTIC ARCH
- Vascular ring enclosing trachea & oesophagus

CYANOTIC CONDITIONS
- Persistent truncus with VSD
- Transposition of aorta with patent ductus and VSD
- Fallot’s tetralogy
- Pulmonary atresia with patent ductus
- Tricuspid atresia with ASD

ACYANOTIC CONDITIONS
- Primary/secondary ASD
- Membranous/muscular
- VSD
- Patent ductus
AUTONOMIC NERVE SUPPLY TO HEART

Vagus cardiac branches
1. Superior from cervical region
2. Inferior from cervical region
3. From recurrent laryngeal nerve

Sympathetic chain ganglia
Superior cervical
Middle cervical
Inferior cervical
Thoracic T1-5

Superficial plexus
Lies on aortic arch between phrenic and vagus nerves

Deep plexus
Lies to right of ligamentum arteriosum, inferior & medial to aortic arch

CARDIAC PLEXUSES
**DIVISIONS OF THE MEDIASTINUM**

- **Superior mediastinum**: From 1st rib to a line joining the sternomanubrial junction to the disc between T4 and T5.

- **Inferior mediastinum**: All below the superior mediastinum. Divided into three parts:
  - **Anterior**: Includes T10 - oesophagus.
  - **Middle**: Includes T12 - Aorta.
  - **Posterior**

**MEDIASTINUM**

- This is the area of the thorax that lies between the lungs. Note that although the lungs reach up above the front of the 1st rib, the mediastinum does not. It stops at the level of the 1st rib. The great vessels lie in the superior mediastinum, the thymus and fat in the anterior part of the inferior, the heart in the middle and the oesophagus & aorta in the posterior parts of the inferior mediastinum.

- Note that, although it is stated here that the apex of the lung reaches above the FRONT of the 1st rib, it does not reach above the NECK of the 1st rib.
OESOPHAGUS

27cm long (45cm from teeth to cardia of stomach)
Nerves: Sensation and motora via vagus nerves
Lining: • Stratified squamous (non-keratinising) becoming columnar at stomach
• Thick muscularis mucosae ++
• Mucous glands in mucosa and submucosa
Endoscopic narrowings: From mouth at 17cm, 28cm, 45cm

Slight compression from:
- Cricoid cartilage
- Aorta
  - Left bronchus
- Diaphragmatic hiatus

Relations

Posterior: vertebrae, thoracic duct crosses to left at T5, hemiazygos/accessory hemiczygos cross to right at T8/9, descending aorta, first 2 intercostal arteries from aorta

Anterior: trachea to T4/5, recurrent laryngeal nerves, left bronchus, left atrium, diaphragm

Left: thoracic duct, aorta, left subclavian artery, lung

Right: lung, azygos vein (hence good side to approach the oesophagus

<table>
<thead>
<tr>
<th>1/3rds</th>
<th>MUSCLE</th>
<th>ARTERY</th>
<th>VEIN</th>
<th>LYMPH</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>Striated</td>
<td>Inferior thyroid</td>
<td>Inferior thyroid</td>
<td>Deep cervical</td>
<td>9cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>Striated/ smooth</td>
<td>Aortic branches</td>
<td>Azygos branches</td>
<td>Mediastinal</td>
<td>9cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>Smooth</td>
<td>Left gastric</td>
<td>Left gastric</td>
<td>Gastric</td>
<td>9cm</td>
</tr>
</tbody>
</table>
Inhaled foreign body is much more likely to enter the right bronchus because of the above facts.
**BRONCHOPULMONARY SEGMENTS**

![Diagram of bronchopulmonary segments]

Red = Upper lobe  Blue = Lower lobe  Green = Middle lobe

* Late branching due to cardiac pressure

**Mnemonic:** Starting on right at upper lobe, working down right lobe then down left lobe the segments are as follows:

**APALM APALM APAIS APAL**

**BRONCHI**

Blood supply: Bronchial arteries from aorta (2 on left, 1 on right)

Venous drainage: On right -azygos, left - hemiazygos. Also a little via bronchial veins and pulmonary veins

Nerve Supply: Pulmonary plexus at hilum - vagus and sympathetics

**SYMPATHETIC**

Vasoconstriction

Bronchodilatation (beta 2)

Suppress glandular secretion (alpha)

**PARASYMPATHETIC**

Vasodilatation

Bronchoconstriction

Increase glandular secretions

Sensation
KEY RELATIONS IN SUPERIOR MEDIASTINUM IN PROGRESSIVE LAYERS

- Oesophagus
- Azygos vein
- Aorta
- Pulmonary artery added
- Arch of aorta added
- Superior vena cava & brachio-cephalic veins added
Occasionally the azygos vein reaches the superior vena cava by passing through the substance of the right lobe trapping a segment of upper right lobe and creating an azygos fissure.

Other notes:
- The lingula of the left lobe arises from the upper bronchus
- Incomplete segmentation is common
- Left lung is longer and lower but lighter
**DEVELOPMENT OF LUNGS, PHARYNX AND OESOPHAGUS**

**Lungs** develop from the **Laryngotracheal groove** which is a longitudinal groove in the midline floor of the primitive pharynx, distal to the pharyngeal pouches. Off this grows the **Laryngotracheal diverticulum** from which lung buds arise.

Its **endoderm** gives:
- Bronchioles, pulmonary lining, epithelium of larynx, trachea, tracheal glands, epithelium of bronchi
- The surrounding **mesenchyme** gives everything else.

**Development of Pharynx and Oesophagus**
- These two separate by longitudinal folds growing in to give the **tracheo-oesophageal septum** in the primitive pharynx

**Primative pharynx**
- Laryngotracheal tube gives: Larynx, trachea, bronchi, lungs
- Oesophagus
THORAX - SURFACE MARKINGS

T4/5
Angle of Louis
Bifurcation of trachea
Start of aortic arch
SVC enters heart

Horizontal fissure

Spine T3
Oblique fissure
5th space
Lung

Pleura
Starts above middle of medial third of clavicle
Meet at rib 2. Diverge at rib 4 (left more than right)
Right is still parasternal at rib 6. Both rib 8 in mid clavicular line, rib 10 in mid axillary line and rib 12 posteriorly
(Mnemonic - 2-4-6-8-10-12)

Lung
2 spaces less than pleura below 6th rib

Heart
2nd left rib to 3rd right rib to 6th right rib (all parasternal) to 5th intercostal space midclavicular line (9cm from midline)
(Mnemonic 2-3-6-5/2)

Oblique fissure
Spine of T3 posteriorly to 6th rib anteriorly (medial border of abducted scapula)

Horizontal fissure
4th rib/costal cartilage anteriorly to 5th rib in mid axillary line (Mnemonic for both fissures 3-6-4-5)
Note that the indentations on the lung are post-mortem effects. They indicate the relationships in life.

- Hilum
  - Bronchi
  - Pulmonary arteries & veins
  - Bronchial arteries and veins
  - Lymphatics
  - Nerves
RIB ARTICULATION

Inner aspect of a typical rib
- Tubercles lateral: lateral costotransverse ligament. Medial: its own transverse process
- Transverse crest (intervertebral disc)
- Primary cartilaginous costochondral joint
- Transversus thoracis
- Subcostals
- Costal groove
- Innermost intercostals
- Superior demifacet (vertebral body above)
- Inferior demifacet (vertebral body below, ie same number as rib)
- Head
- Neck
- Posterolateral angle (articulation)
- Anterior angle (on outside) for External oblique abdominis 5-12
  Serratus anterior 1-8
  Latissimus dorsi 5-12

Ossification
- Posterior angle 8 weeks intra-uterine
- Head/tubercle 15 years. Fuse 25 years

RIB MOVEMENTS

Upper ribs (pump handle)

Rotation

1st rib Short, broad, most curved, single facet on head
2nd rib Poorly marked costal groove, rough area for serratus anterior & scalenus posterior
3-10 ribs Typical. 7th longest
11/12 ribs Floating, single facet, no tubercle, tapered end. 12th no groove
1-7 ribs articulate with sternum
8-10 ribs with each other

Muscles attached to outer ribs
- Serratus anterior 1-8
- External oblique abdominis 5-12
- Pectoralis minor 3, 4, 5
- Latissimus dorsi 9-12

Muscles attached to costal cartilages
- Pectoralis major 1-7 (often 2-6)

Lower ribs (bucket handle)

Gliding
**COSTOTRANSVERSE LIGAMENTS**

As the name implies, the costotransverse ligament connects the rib to the transverse process but it is a complex ligament in that it has three parts to it with somewhat confusing terminology.

**THE costotransverse ligament**
This fills the gap between the rib and its own transverse process

**LATERAL costotransverse ligament**
This lies posteriorly and extends from the transverse process to its own rib, just beyond the tubercle

**SUPERIOR costotransverse ligament**
This is a two layered ligament with the fibres at right angles to each other (corresponding and continuous with the intercostal muscles) that passes from the upper border of the neck of the rib to the transverse process of the vertebra above

---

**Other ligaments include:**
- **Anterior longitudinal ligament**
  Runs long anterior bodies & attached firmly to vertebral body and disc
- **Intra-articular ligament**
  From transverse crest of head of rib to intervertebral disc

**Radiate ligament (3 parts)**
- To body above (upper)
- To own body (lower)
- Hypochondral bow (middle) which lies deep to anterior longitudinal ligament and blends with intervertebral disc & fibres from other side
THE FIRST RIB

'The' costotransverse ligament

Tubercle

Ext/int intercostals

Scalenus medius

Serratus anterior

Sympathetic trunk

Supreme intercostal vein

Superior intercostal artery

T1 nerve root

Supracleural membrane

Subclavian artery

& vein separated by scalenus anterior

on scalene tubercle

with T1 root beneath artery

Costoclavicular ligament

Subclavius

Note:

- The under surface of the 1st rib is smoother
- When the rib is laid on a flat surface, the head touches the flat surface when the rib is the correct way up
Ossification

<table>
<thead>
<tr>
<th>Structure</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manubrium</td>
<td>5 months intra-uterine</td>
</tr>
<tr>
<td>1st sternebra</td>
<td>6 months intra-uterine</td>
</tr>
<tr>
<td>2nd sternebra</td>
<td>7 months intra-uterine</td>
</tr>
<tr>
<td>3rd sternebra</td>
<td>8 months intra-uterine</td>
</tr>
<tr>
<td>4th sternebra</td>
<td>9 months intra-uterine</td>
</tr>
<tr>
<td>Xiphoid</td>
<td>4th year</td>
</tr>
<tr>
<td>Xiphisternal joint</td>
<td>secondary cartilaginous</td>
</tr>
<tr>
<td>(Angle of Louis) Secondary cartilaginous joint (usually does not fuse)</td>
<td></td>
</tr>
<tr>
<td>Anterior intercostal membrane</td>
<td></td>
</tr>
<tr>
<td>Internal intercostal muscle</td>
<td></td>
</tr>
<tr>
<td>Transversus thoracis</td>
<td></td>
</tr>
</tbody>
</table>

- **Sternum**
  - Sternochondrostoid
  - Suprasternal (jugular) notch, T2/3
  - 1st sternocostal (primary cartilaginous)
  - 2nd sternocostal (Atypical synovial, double cavity)
  - 3-7 sternocostal (Atypical synovial, single cavity)
  - Rectus abdominis (+ 5,6,7 costal cartilages)
THYMUS

In anterior mediastinum
Bilobed, lobulated
Larger in children
Plays a major role in development of immune system
Blood supply: Internal thoracic artery
Venous drainage: Thymic to left brachiocephalic & some
to internal thoracic veins
Embryology: Endoderm (epithelium) of ventral 3rd pharyngeal
pouch (+/- ventral recess 4th pouch).
Lymphocytes from mesenchyme.

LOBULE

HISTOLOGY

Dark cortex
Light medulla

CORTEX

Small T lymphocytes +++
Epithelial reticular cells +/-

MEDULLA

Arteries in capsule only
Hassall’s corpuscles (3rd arch remnants)
Epithelial reticular cells ++
Lymphoblasts ++ (loose & immature)

Macrophages +
Capillaries & venules

Sheets of actively dividing T cells of varying maturity.
Epithelial reticular cells isolate them from the capillaries
giving a blood/thymus barrier.
Macrophages phagocyte defunct lymphocytes
Thoracic Inlet

- Costocervical trunk
- Superior intercostal
- Deep cervical
- T1 anterior ramus
- C8 anterior ramus
- Lower trunk of brachial plexus
- Subclavian artery & vein
- Brachiocephalic artery
- Vagus
- Thoric duct
- Inlet is 10cm wide
  5cm anteroposterior

Dome of Pleura

Covered by suprapleural membrane (Gibson’s fascia)
Held up by scalenus minimus (pleuralis) from transverse process of C7
Extends 4cm above middle of medial third of clavicle and first rib, BUT NOT above neck of first rib
Relations:
- Posterior: Sympathetic trunk, supreme intercostal vein, superior intercostal artery, T1 nerve root, 1st rib, thoracic duct on left
- Anterior: On right - brachiocephalic artery and vein
  On left - Subclavian artery and vein
- Superior: Costocervical trunk, thoracic duct on left

Mnemonic: Vagus nerves and phrenic nerves enter the chest between the arteries behind and the veins in front
TYPICAL INTERCOSTAL NERVE

- **Posterior (dorsal) Ramus**
- **Sympathetic chain**
- **Intervertebral foramen**
- **Lateral cutaneous branch**
- **Deep fascia**
- **Anterior cutaneous branch**

**Collateral (muscular) branch.** Motor to muscles & sensory to pleura & periosteum but not skin. Runs in neurovascular plane, just above the rib.
INTERCOSTAL NERVES AND ARTERIES

Remember:
- Nerve is always outside the artery
- 1st thoracic nerve has no lateral cutaneous branch
- Nerves T7 & T11 also supply the abdomen
DERMATOMES OF THORAX AND ABDOMEN
THE PHRENIC NERVE

- Phrenic nerve is the only motor supply to diaphragm
- A third of its fibres are sensory (as above)
- In the neck it lies on scalenus anterior
- It passes into the thorax with the large veins in front and the large arteries behind it
- Pain detected by the phrenic nerve from the diaphragmatic peritoneum from an inflamed gall bladder is referred to C4 nerve supply to the right shoulder tip via the supraclavicular nerves. There is no autonomic component to this type of referred pain
See autonomic nervous system section in Instant Anatomy for full details of this system. However, a useful way of remembering which fibres synapse in the sympathetic chain ganglia is as follows:

ALL SYMPATHETIC FIBRES ENTERING THE CHAIN FROM THE SPINAL CORD AS GREY RAMI COMMUNICANTES SYNAPSE IN THE GANGLION FROM WHICH THEY LEAVE FOR DISTRIBUTION EXCEPT THOSE TO "GUT" OR ADRENAL GLAND.

In practice this means that the splanchnic nerves (greater, lesser, least, lumbar & sacral) do not synapse until they reach their peripheral ganglia, whilst all others synapse in the chain ganglia.
HEART - ELECTRICAL SYSTEM

- Superior vena cava
- Pulmonary veins
- Sinu-atrial node
- Atrioventricular node
- Atrioventricular bundle with its left & right branches
- Septomarginal trabecula (moderator band)

Parasympathetic (vagus/cardiac plexus - inhibits activity. Cholinergic)

Sympathetic (cardiac nerves via cervical ganglia & T1-5. On coronary arteries) Excitatory

12 or so atrial pathways (specialised cardiac myocytes)

AV bundle of His (Purkinje fibres)

SAN

AVN

Left & right bundles

Ramifying sub-endocardial plexus
AUTONOMIC NERVE SUPPLY TO HEART

Vagus cardiac branches
1. Superior from cervical region
2. Inferior from cervical region
3. From recurrent laryngeal nerve

Sympathetic chain ganglia
Superior cervical
Middle cervical
Inferior cervical
Thoracic T1-5

Superficial plexus
Lies on aortic arch between phrenic and vagus nerves

Deep plexus
Lies to right of ligamentum arteriosum, inferior & medial to aortic arch

CARDIAC PLEXUSES
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Radiate ligament (3 parts)
- To body above (upper)
- To own body (lower)
- Hypochondral bow (middle) which lies deep to anterior longitudinal ligament and blends with intervertebral disc & fibres from other side
MUSCLES OF THE BACK 1

Arranged in three layers with three muscles on each layer
All supplied by posterior primary rami
Divided up as follows:

**SUPERFICIAL LAYER**
- Iliocostalis (ILC)
- Longissimus (LG)
- Spinalis (SP)

**INTERMEDIATE LAYER**
- Levator costarum (LC)
- Semispinalis (SS)
- Multifidus (M)

**DEEP LAYER**
- Interspinalis (IS)
- Intertransversalis (IT)
- Rotatores (R)

Rotatores (Spine to transverse process, in thorax only)

Interspinalis (Between spines)

Intertransversalis (between transverse processes)
THORAX - SURFACE MARKINGS
CLINICAL IMPLICATIONS

Access to thoracic aorta
Through the left chest (left thoracotomy)

Access to oesophagus
Through right chest (right thoracotomy)

(Both of these are usually through the 5th intercostal space by stripping up the periosteum of the rib below and incising through the rib bed)

Thoraco-abdominal incision
This is for large access to upper abdomen or chest
Through the 9th intercostal space on either side
9th Costal cartilage is usually excised
The diaphragm is incised radially to avoid damaging its nerve

Pericardial aspiration
Insert needle just to left of xiphoid

Pericardial window
Through left thoracotomy
5th costal cartilage excised
Pericardial flap cut

Heart transplantation
Via median sternotomy
En bloc - aorta, pulmonary trunk, both atriae
SVC, IVC, SA node are all left

Aspiration of pleural cavity
Sitting of drain in 4th space in mid axillary line
POSITION OF THORACIC STRUCTURES ACCORDING TO VERTEBRAL LEVELS

T2 Superior border of scapula.
T2/3 Suprasternal notch.
T3 Medial end of spine of scapula.
    Spine of T3 is posterior end of oblique fissure of lung.
T3/4 Top of arch of aorta.
T4 End of arch of aorta.
    Azygos vein enters SVC.
T4/5 Manubriosternal junction.
    (angle of Louis).
    Start of arch of aorta.
T5 Thoracic duct crosses midline.
T7 Inferior angle of scapula.
T8 Cavai opening in diaphragm.
    (IVC & right phrenic nerve)
    Left phrenic pierces diaphragm.
    Hemi-azygos veins cross to left.
T10 Oesophageal opening in diaphragm.
    (oesophagus, branches of left gastric vessels, vagus nerves)
T12 Aortic opening in diaphragm.
    (Aorta, azygos vein, hemi-azygos vein, thoracic duct)
    Coeliac axis.
    Splanchnic nerves pierce crura.
    Sympathetic trunk passes behind medial arcuate ligament.
    Subcostal bundle passes behind lateral arcuate ligament.
CLAVIPECTORAL FASCIA

- Clavicle
- Subclavius
- Costocoracoid ligament
- Pectoralis minor
- Suspensory ligament of axilla

Pierced by:
- Acromiothoracic trunk
- Cephalic vein
- Lateral pectoral n
- Lymphatics
UPPER LIMB LYMPHATICS

Infraclavicular
Central
Lateral
Supratrochlear

Apical
Subclavian lymph trunk
Posterior
Anterior

Mnemonic for axillary lymph nodes:
A - anterior
P - posterior
I - infraclavicular
C - central
A - apical
L - lateral

See page 69 in Instant Anatomy for details of drainage areas for each group of nodes
AXILLA
Between arm & thorax

A truncated cone

Posterior wall
- Subscapularis
- Teres major
- Latissimus dorsi

Medial wall
- Serratus anterior
to 4th rib

Scapula

Anterior wall
- Pectoralis major
- Pectoralis minor
- Clavipectoral fascia

Lateral wall
- Intertubercular (bicipital) groove
- Biceps tendon

Apex
- Clavicle
- Scapula
- Outer 1st rib

Floor
- Axillary fascia which is
  held by suspensory ligament
  & lies between anterior &
  posterior axillary folds, deep
  fascia of arm & serratus anterior

CONTENTS
A - Long head of biceps
B - Latissimus dorsi
C - Teres major
D - Long thoracic nerve
E - Axillary vein
F - Axillary artery & cords
G - Pectoralis minor
H - Coracobrachialis
I - Short head of biceps
  + lymph nodes
SUPRASPINATUS

Origin: 3/4 supraspinous fossa and upper spine of scapula

Insertion: Superior facet of greater tuberosity of humerus & joint capsule

Action: Abducts and stabilises shoulder

Nerve supply: Suprascapular (C5,6 upper trunk)

INFRASPINATUS

Origin: Medial 3/4 infraspinous fossa & intermuscular septa

Insertion: Medial facet of greater tuberosity of humerus and joint capsule

Action: Lateral rotation & stabilisation

Nerve supply: Suprascapular (C5,6 upper trunk)
**SUBSCAPULARIS**

- **Origin**: Medial 2/3 subscapular fossa
- **Insertion**: Lesser tuberosity of humerus, 1/2 medial lip of bicipital groove and joint capsule
- **Action**: Medial rotation & stabilisation
- **Nerve supply**: Upper & lower subscapular (C6,7 posterior cord)
**TERES MAJOR**

- **Origin:** Oval area on lower 1/3 lateral side of inferior angle of scapula
- **Insertion:** Medial lip of bicipital groove
- **Action:** Medial rotation, adduction, stabilisation of shoulder
- **Nerve supply:** Lower subscapular (posterior cord C5,6)

**TERES MINOR**

- **Origin:** Middle 1/3 lateral border of scapula
- **Insertion:** Inferior facet of greater tuberosity & joint capsule
- **Action:** Lateral rotation & stabilisation of shoulder
- **Nerve supply:** Axillary (C5,6 [posterior cord])
**AXIAL (CROSS) SECTION OF MID RIGHT ARM VIEWED FROM BELOW**

- Cephalic vein
- Radial nerve & profunda vessels
- Musculocutaneous nerve
- Brachialis
- Biceps
- Median nerve & brachial artery
- Basilic vein
- Ulnar nerve

**RELATIONS OF BRACHIAL ARTERY**

- **Medial:**
  - Upper half - ulnar nerve, basilic vein
  - Lower half - median nerve

- **Lateral:**
  - Upper half - median nerve, biceps
  - Lower half - biceps

- **Posterior:**
  - Upper third - triceps
  - Middle third - coracobrachialis
  - Lower third - brachialis
EVENTS OCCURING AT MID HUMERUS

- Insertion of deltid and coracobrachialis
- Start of origin of brachialis
- Ulnar nerve and superior ulnar collateral artery leave the anterior compartment
- Radial nerve emerges from spiral groove
- Median nerve crosses brachial artery
- Basilic vein perforates deep fascia
- Nutrient artery enters humerus
OSSIFICATION OF HUMERUS

Primary centre in mid shaft at 8 weeks interuterine
Secondary centre in head, greater and lesser
tuberosities at 1 year

Lower end and elbow is more complex and is
remembered best with the following mnemonic:

CRITOE

lateral | medial

Note
Bone growth in the upper limb
is at the upper humerus and at
lower radius and ulna

2 years  Capitulum
4 years  Radial head
6 years  Internal (medial) epicondyle
8 years  Trochlea
10 years Olecranon
12 years External (lateral) epicondyle
ANTERIOR ARM MUSCLES

BICEPS
Origin: Long head - Supraglenoid tubercle
Short head - coracoid
Insertion: Radial tuberosity & bicipital aponeurosis
Action: Flexes shoulder & elbow, Supinates
Nerve supply: Musculocutaneous

BRACHIALIS
Origin: Anterior/lower 1/2 humerus & medial and lateral intermuscular septum
Insertion: Coronoid process & tubercle of ulna
Action: Flexes elbow
Nerve supply: Musculocutaneous and twig from radial

CORACOBRACHIALIS
Origin: Coracoid
Insertion: Anteromedial humerus mid shaft
Action: Adducts and flexes shoulder
Nerve supply: Musculocutaneous

Note: Coracobrachialis is the equivalent to the three adductors in the leg. It is thus vestigially tripartite and a third head may remain as a supra-trochlear spur (ligament of Struthers)
Arises from two 'heads' in axilla, clasping 3rd part of axillary artery. Crosses artery from lateral to medial. Passes under biceps and onto or medial to brachialis. Between two heads of pronator teres, under fibrous arch of flexor digitorum superficialis with ulnar artery. Under flexor digitorum superficialis, emerging from its lateral border to lie between tendons of flexor carpi radialis and palmaris longus. Passes deep to flexor retinaculum to reach palm of hand.
ANTERIOR ARM

- Biceps
- Pectoralis major
- Deltoid
- Brachialis
- Medial intermuscular septum
- Lateral intermuscular septum
- Ulnar nerve & ulnar collateral artery
- Radial nerve & radial recurrent artery
- Brachioradialis
- Bicipital aponeurosis
- Latissimus dorsi
- Teres major

**Medial intermuscular septum**

- Pierced by:
  - Ulnar nerve
  - Ulnar collateral artery

- Gives origin to:
  - Brachialis (anteriorly)
  - Triceps (posteriorly)

**Lateral intermuscular septum**

- Pierced by:
  - Radial nerve
  - Radial recurrent artery

- Gives origin to:
  - Brachioradialis (anteriorly)
  - Extensor carpi radialis longus (anteriorly)
  - Triceps (posteriorly)
  - Brachialis (anteriorly)
AXIAL (CROSS) SECTION OF MID RIGHT ARM VIEWED FROM BELOW

- Cephalic vein
- Musculocutaneous nerve
- Radial nerve & profunda vessels
- Brachialis
- Biceps
- Median nerve & brachial artery
- Basilic vein
- Ulnar nerve

RELATIONS OF BRACHIAL ARTERY

Medial: Upper half - ulnar nerve, basilic vein
       Lower half - median nerve

Lateral: Upper half - median nerve, biceps
         Lower half - biceps

Posterior: Upper third - triceps
           Middle third - coracobraehialis
           Lower third - brachialis
POSTERIOR ARM MUSCLES

TRICEPS

Origin: Long head - infraglenoid tubercle
Medial head - Medial spiral groove, posterior humerus, medial & lateral inter-muscular septum
Lateral head - Superior/posterior humerus (linear)

Insertion: Long & lateral heads - flat tendon to posterior olecranon
Medial head - deep part of flat tendon and posterior capsule of elbow

Action: Extends elbow, weak extensor of shoulder
Long head stabilises abducted shoulder

Nerve supply: Radial (C7,8) long -medial- lateral - medial

ANCONEUS

Origin: Lower lateral epicondyle

Insertion: Posterior/lateral ulna & olecranon

Action: Weak extensor. Abducts elbow in pronation

Nerve supply: Radial
POSTERIOR ARM MUSCLES AND SPACES

Rhomboid major
Circumflex scapular artery
Infraspinatus
Teres minor
Teres major
Serratus anterior
Deltoid
Long head of triceps
Ulnar nerve
Flexor carpi ulnaris
Olecranon
Axillary nerve & posterior circumflex humeral artery
Medial head of triceps
Lateral head of triceps
Radial nerve & profunda brachii artery
LLCNA/PCNFA
Brachialis
Brachioradialis
Extensor carpi radialis longus
LLCNA - Lower lateral cutaneous nerve of arm
PCNFA - Posterior cutaneous nerve of forearm
DEEP CUBITAL FOSSA
RIGHT SIDE

CONTAINS

- Median nerve
- Brachial artery
- Biceps tendon
- Lymph nodes
- (laterally, under brachioradialis, radial & posterior interosseous nerves)

Mnemonic for order of structures from lateral to medial

T A N
(tendon-artery-nerve)
SUPERFICIAL CUBITAL FOSSA
RIGHT SIDE

Boundaries

Triangular area between:
- Pronator teres
- Brachioradialis
- Line between epicondyles

Roof

- Deep fascia of forearm
- Bicipital aponeurosis
- Median cubital vein
- Medial cutaneous nerve of forearm
- Lateral cutaneous nerve of forearm

Floor

- Brachialis
- Supinator

Diagram:
- Cephalic vein
- Basilic vein
- Brachial artery
- Median nerve
- Lateral cutaneous nerve of forearm
- Brachioradialis
- Biceps
- Bicipital aponeurosis
- Brachial teres
**Origin:** Tubercle of scaphoid & ridge of trapezium

**Insertion:** Pisiform & hook of hamate

**Into it:** Palmaris brevis & palmaris longus, palmar aponeurosis

**From it:** Thenar & hypothenar muscles

**Over it:** Ulnar artery & nerve, palmar cutaneous branch of median, palmar branch of radial artery

**Deep to it:** Median nerve & structures on diagram

**Note:** Synovial sheaths open laterally to allow access for small vessels to tendons
**FLEXOR RETINACULUM**

**Origin:** Tubercle of scaphoid & ridge of trapezium

**Insertion:** Pisiform & hook of hamate

**Into it:** Palmaris brevis & palmaris longus, palmar aponeurosis

**From it:** Thenar & hypothenar muscles

**Over it:** Ulnar artery & nerve, palmar cutaneous branch of median, palmar branch of radial artery

**Deep to it:** Median nerve & structures on diagram

**Note:** Synovial sheaths open laterally to allow access for small vessels to tendons
ANTERIOR FOREARM AND HAND MUSCLE ATTACHMENTS

Abbreviations:
AbDM - Abductor digiti minimi
AbPB - Abductor pollicis brevis
AbPL - Abductor pollicis longus
AdP - Adductor pollicis
ECRL - Extensor carpi radialis longus
FCR - Flexor carpi radialis
FCU - Flexor carpi ulnaris
FDM - Flexor digitii minimi
FDP - Flexor digitorum profundus
FDS - Flexor digitorum superficialis
FPB - Flexor pollicis brevis
FPL - Flexor pollicis longus
ODM - Opponens digiti minimi
OP - Opponens pollicis

Think of the muscles of the anterior forearm in groups according to their action:
1. Carpal movers
   - Flexor carpi ulnaris
   - Flexor carpi radialis
2. Finger movers
   - Flexor digitorum superficialis
   - Flexor digitorum profundus
3. Thumb movers
   - Flexor pollicis longus
4. Pronators
   - Pronator teres
   - Pronator quadratus
5. Others
   - Palmaris longus

See muscle section of Instant Anatomy for details of muscles and their nerve supply

- Adductor pollicis origin (oblique & transverse)
- 3 or 4 palmar interossei
- Pisohamate & pisometacarpal ligaments
PRONATION AND SUPINATION

AXIS

RADIAL HEAD - ULNAR STYLOID - LITTLE FINGER

Note that the true axis of the forearm is through the mid intercondylar point and the mid interstyloid point. Thus, through the middle finger. Therefore in FREE pronation and supination ulna is adducted and abducted whilst the radius rotates around it. This allows the hand to remain still in space.

ULNAR ABDUCTION

Anconeus

ULNAR ADDUCTION

Pronator teres (humeral head)
ORDER OF STRUCTURES AT WRIST

Ulnar (medial) side
- Flexor carpi ulnaris
- Ulnar nerve
- Ulnar artery
- Flexor digitorum superficialis
- Palmaris longus
- Median nerve
- Median nerve
- Flexor carpi radialis
- Radial artery
- Brachioradialis
- Superficial radial nerve

Radial (lateral) side
SYNOVIAL SHEATHS UNDER EXTECTOR RETINACULUM

- Extensor carpi radialis brevis
- Extensor carpi radialis longus
- Extensor pollicis brevis
- Extensor pollicis longus
- Extensor digitorum and indicis
- Extensor digiti minimi
- Extensor carpi ulnaris
- RADIUS
- ULNA
POSTERIOR FOREARM AND HAND MUSCLE ATTACHMENTS

Forearm extensors are divided into these groups:
- Carpal movers:
  - Extensor carpi ulnaris
  - Extensor carpi radialis longus
  - Extensor carpi radialis brevis
- Finger movers:
  - Extensor digitorum
  - Extensor indicis
  - Extensor digiti minimi
- Thumb movers:
  - 3 muscles/tendons of the snuff box

Thus the only fingers with an extra tendon, in addition to extensor digitorum, are index and little.

All 4 muscles arising deep in the forearm go to thumb (3: EPL, APL, EPB) and index finger (1: Extensor indicis).

Note that muscles arising from the lateral epicondyle arise from its FRONT and not the back of it.

See muscle section of Instant Anatomy for details of muscles and their nerve supply.

Abbreviations:
- ECRB - Extensor carpi radialis brevis
- ECRL - Extensor carpi radialis longus

2nd metacarpal is longest
Middle finger is longest

Triceps
Common extensor origin
Anconeus
Supinator
Posterior oblique line
Flexor carpi ulnaris
Flexor digitorum profundus
Extensor pollicis longus
Pronator teres
Abductor pollicis brevis
Abductor pollicis longus
Interosseous membrane
ECRB
ECRL
Dorsal interossei
Dorsal extensor expansion
Extensor pollicis brevis
Extensor pollicis longus
Extensor carpi ulnaris
Extensor carpi radialis longus
Extensor carpi radialis brevis
1. Between 1st metacarpal and trapezium there is a saddle condyloid joint that allows flexion, extension, adduction, abduction and rotation. The rotation is not free and depends on the degree of opposition.

2. All the other joints in the carpus are plane joints.

3. The carpometacarpal joints become progressively more mobile from thumb to little finger so that grip is more stable towards index finger and thumb.
FLEXOR RETINACULUM

Superficial part (Canal of Guyon)

Palmar branch of median nerve

Ulnar nerve & artery

Palmaris longus

Thenar muscles

Hypothenar muscles

LITTLE FINGER

ECU

EDM

Hamate

Capitate

Trapezium

Trapezoid

ECRL/B

Radial artery & nerve

FCR

EPB

EPL

Origin: Tubercle of scaphoid & ridge of trapezium

Insertion: Pisiform & hook of hamate

Into it: Palmaris brevis & palmaris longus, palmar aponeurosis

From it: Thenar & hypothenar muscles

Over it: Ulnar artery & nerve, palmar cutaneous branch of median, palmar branch of radial artery

Deep to it: Median nerve & structures on diagram

Note: Synovial sheaths open laterally to allow access for small vessels to tendons
USE OF HAND

Grip
Percussion
Agression/defence
Sensory
Expression
FINGER TO SHOW TENDONS AND DIGITAL NERVES & ARTERIES

Tendon of Flexor digitorum superficialis splits

To allow tendon of flexor digitorum profundus to reach the distal phalanx

CROSS SECTION OF FINGER

Dorsal

Dorsal (extensor) expansion

Digital vessels & dorsal & palmar digital nerves

Palmar

Tendon of flexor digitorum superficialis

Tendon of flexor digitorum profundus
DISSECTION OF PALM TO SHOW NERVES & THENAR & HYPOTHENAR MUSCLES

Note the communicating branch of the ulnar nerve with the median nerve in the palm.
PALMAR APONEUROSIS & PALMAR BREVIS

**Palmar aponeurosis**

- Extension of palmaris longus via flexor retinaculum
- Inserts into deep transverse ligament of palm and fibrous flexor sheaths
- Action: ties skin of palm and fingers down
- Central area is strong, thick and triangular

**Palmaris brevis**

- Origin: flexor retinaculum and medial border of proximal palmar aponeurosis
- Insertion: Dermis of ulnar side of hand
- Action: Wrinkles skin
- Nerve supply: Superficial branch of ulnar
PALMAR ARTERIAL ARCHES

Superficial arch is at the level of outstretched thumb

Deep arch is 1cm proximal to superficial arch

Ulnar artery gives superficial palmar arch with a connection from the radial artery

Radial artery gives deep palmar arch with connections from the ulnar artery
MEDIAL AND LATERAL PALMAR SEPTA
Posterior extensions from palmar aponeurosis

Medial: origins - hook of hamate, pisohamate ligament &
medial side of 5th fibrous flexor sheath
pierced by - deep branch of ulnar nerve & artery
Lateral: origins - tubercle of trapezium & lateral side of 2nd
fibrous flexor sheath
pierced by - Recurrent (muscular) branch of median
nerve

MID PALMAR SPACE (MID CENTRAL PALMAR SPACE)
Contains: 3-5 flexor tendons, 2-4 lumbricals, superficial palmar arch,
3-5 digital vessels & nerves
Communicates: Subcutaneous tissues at webs & extends dorsal to common
flexor sheaths

THENAR SPACE (LATERAL CENTRAL PALMAR SPACE)
Contains: tendons of flexor pollicis longus, flexors digitorum superficialis
& profundus to index finger, palmar digital nerves & vessels to
thumb & radial side of index finger
Communicates: Web of thumb & under flexor retinaculum
ATTACHMENTS OF SMALL MUSCLES OF THE HAND

See muscle section of Instant Anatomy for more details of these small muscles.
MUSCLE ATTACHMENTS TO FLEXOR RETINACULUM

Opponens

Flexor

Abductor

Hook of hamate

Pisiform

Tubercle of trapezium

Tubercle of scaphoid

LITTLE FINGER

THUMB
ATTACHMENTS OF SMALL MUSCLES OF THE HAND

See muscle section of Instant Anatomy for more details of these small muscles
INTEROSSEOUS MUSCLES

**PALMAR (PAD)**
- **Origin**: Anterior shafts 2, 4, 5-metacarpals
- **Insertion**: Dorsal expansion & proximal phalanx
- **Action**: Flex metacarpophalangeal & extend both interphalangeal joints. Adduct as per arrows below.
- **Nerve supply**: Ulnar

**DORSAL (DAB)**
- **Origin**: Inner shafts all metacarpals
- **Insertion**: Dorsal expansion & proximal phalanx
- **Action**: Flex metacarpophalangeal & extend both interphalangeal joints. Abduct as per arrows below.
- **Nerve supply**: Ulnar

**UNIPENNATE**
- They act by taking up the slack in the extensor expansion so that the pull of the long extensor is not wasted wholly on the metacarpophalangeal joints.

**BIPENNATE**
- 4
**LUMBRICALS**

**Origin:** 4 tendons from flexor digitorum profundus. Radial 2 are unipennate, ulnar 2 are bipennate.

**Insertion:** Extensor expansion over dorsum of proximal phalanx, distal to the insertion of interossei, on radial side of fingers 2-5. No bony attachments.

**Action:** Flexion of metacarpophalangeal joints and extension of both interphalangeal joints of all 4 fingers.

**Nerve supply:** Ulnar to ulnar 2, medial to radial 2 (can be 2:2, 3:1 or 1:3).
PALMAR APONEUROSIS & PALMAR BREVIS

Palmar aponeurosis

Extension of palmaris longus via flexor retinaculum
Inserts into deep transverse ligament of palm and fibrous flexor sheaths
Action: ties skin of palm and fingers down
Central area is strong, thick and triangular

Palmaris brevis

Origin: Flexor retinaculum and medial border of proximal palmar aponeurosis
Insertion: Dermis of ulnar side of hand
Action: Wrinkles skin
Nerve supply: Superficial branch of ulnar
ATTACHMENTS OF SMALL MUSCLES OF THE HAND

See muscle section of Instant Anatomy for more details of these small muscles
MAIN ARTERIES AND NERVES OF UPPER LIMB

- Lateral cord
- Musculocutaneous nerve
- Median nerve
- Radial nerve
- Ulnar nerve
- Supinator
- Superficial radial nerve
- Posterior interosseous nerve
- Radial artery
- Deep palmar arch
- Medial cord
- Posterior cord
- Brachial artery
- Common, anterior & posterior interosseous arteries
- Ulnar artery
- Pronator teres
- Main median nerve
- Anterior interosseous nerve
- Anterior interosseous artery from ulnar
- Posterior interosseous artery from ulnar
  (both via common interosseous artery)

Rule:
- Arteries can go between bones
- Nerves go around outside of bones

Summary:
- Anterior interosseous n from median
- Posterior interosseous n from radial
### Segmental Nerve Supply to Movements and Reflexes in Upper Limb

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<tr>
<td>C8,1</td>
<td>Lumbricais</td>
<td>Ulnar - deep branch/median</td>
</tr>
<tr>
<td>C8,1</td>
<td>Opponens digitii minimi</td>
<td>Ulnar - deep branch</td>
</tr>
<tr>
<td>C8,1</td>
<td>Opponens pollicis</td>
<td>Median - muscular branch</td>
</tr>
<tr>
<td>C8,1</td>
<td>Palmaris brevis</td>
<td>Ulnar - superficial branch</td>
</tr>
<tr>
<td>C8,1</td>
<td>Pronator quadretus</td>
<td>Anterior interosseous</td>
</tr>
</tbody>
</table>
CUTANEOUS NERVES OF UPPER LIMB

Supracleavicular (C3,4)

Upper lateral cutaneous nerve of arm (axillary C5,6)

Lower lateral cutaneous nerve of arm (radial 5,6)

Lateral cutaneous nerve of forearm (musculo-cutaneous C5,6)

Medial cutaneous nerve of arm (C8,T1)

Posterior cutaneous nerve of arm (radial C5,6,7,8)

Medial cutaneous nerve of forearm (C8,T1)

Lateral cutaneous nerve of forearm (musculo-cutaneous C5,6)

Posterior cutaneous nerve of forearm (radial C5,6,7,8)

Radial (C6,7,8)

Medial (C6,7,8)

ANTERIOR

POSTERIOR

Note: there is no lateral cutaneous branch of T1. The intercostal nerve T2, intercostobrachial, & T3 have anterior & posterior branches that anastomose with medial cutaneous nerve of arm to supply medial arm & floor of axilla

- Lateral cord
- Medial cord
- Posterior cord
Note the axial lines that separate non-consecutive dermatomes.
MEDIAN NERVE

Formed: By 2 heads anterior to 3rd part of axillary artery

Crosses: Brachial artery from lateral to medial

Lies: medial to brachial artery in cubital fossa

On: coracobrachialis then brachialis

Passes between: 2 heads of pronator teres

Lies between: flexor digitorum superficialis and profundus then deep to the flexor retinaculum

See page 120 in Instant Anatomy for branches
MUSCULOCUTANEOUS NERVE

Passes: Between conjoined heads of coracobrachialis then deep to biceps on brachialis

Supplies: Elbow joint & its muscles

Gives: Lateral cutaneous nerve of forearm by emerging on lateral side of biceps

See page 118 Instant Anatomy for its branches
RADIAL NERVE

**Leaves:** Axilla via lateral triangular space with profunda brachii artery

**Spirals:** Around behind upper fibres of medial head of triceps, against humerus only in lower groove

**Covered by:** Upper fibres of brachialis

**Passes through:** Lateral intermuscular septum to reach anterior compartment between brachialis and brachioradialis

**To lie:** Laterally in cubital fossa

See page 116 Instant Anatomy for its branches
ULNAR NERVE

**On:** Coracobrachialis

**Enters:** Posterior compartment via medial intermuscular septum

**Passes:** Posterior to medial epicondyle and between 2 heads of flexor carpi ulnaris

**Lies:** On flexor digitorum profundus and under flexor digitorum superficialis with ulnar artery on its lateral side

**Enters:** The hand by passing superficial to flexor retinaculum

See page 122 in Instant Anatomy for branches
NERVE LESIONS IN THE UPPER LIMB - 2

BRACHIAL PLEXUS - LOWER T1

KLUMPKE'S PALSY

AETIOLOGY: Pull on arm at breech delivery or apical carcinoma of lung

MUSCLE LOSS: Small muscles of hand - lumbricals and interossei

MOVEMENT LOSS: Flexion at metacarpophalangeal joints & diminished extension at interphalangeal joints

DOMINATED BY: Long extensors acting on metacarpophalangeal joints
Long flexors acting on interphalangeal joints

RESULT: Clawed hand ('main en griffe') with or without Horner's syndrome (ptosis/small pupil) if there is damage to sympathetic chain

SENSORY LOSS: T1 distribution - lower (+or- upper) inner arm & hand

TEST: Loss of bulk of 1st dorsal interosseous, inability to hold paper between outstretched fingers

NOTE: If C8 & T1 are involved, as with a cervical rib, there is weakness of small muscles & paraesthesia along ulnar border of arm & hand
NERVE LESIONS IN THE UPPER LIMB - 1

BRACHIAL PLEXUS - Upper C5,6

AETIOLOGY: Birth traction (Erb Duchenne palsy) or adult trauma (Erb’s palsy) eg motorbike accident

MUSCLE LOSS:
- Deltoid, short shoulder muscles, brachialis, biceps, supinator, brachioradialis

MOVEMENT LOSS:
- Abduction, external rotation of shoulder, supination, elbow flexion

DOMINATED BY:
- Latissimus dorsi (C6,7,8), pronator teres (C6,7), pectorals (C6,7,8)

RESULT:
- Atrophy, limpness of upper arm, internal rotation of shoulder, pronation of forearm, palm backwards - ‘hinting for tip’

SENSORY LOSS:
- Upper and lower lateral cutaneous nerve of arm from axillary and radial but only if C6 is involved, lateral cutaneous nerve of forearm (musculocutaneous)

SUMMARY:
- C5 controls shoulder flexion, abduction, lateral rotation and elbow flexion
- C6 controls supination including supinator
NERVE LESIONS IN THE UPPER LIMB - 3

RADIAL IN AXILLA

AETIOLOGY: Crutch pressure, fracture of humerus

MUSCLE LOSS: Triceps, extensors of wrist and fingers

MOVEMENT LOSS: Extensor weakness at elbow, wrist, metacarpophalangeal joints. Interphalangeal joints are alright because of intact interossei & lumbricals

RESULT: Wrist drop and inability to grip

SENSORY LOSS: Over 1st dorsal interosseous, +/- lower lateral cutaneous nerve of arm

TEST: Sensation as above. Power of brachioradialis, wrist extension & extension of elbow against resistance

WRIST DROP
NERVE LESIONS IN THE UPPER LIMB - 5

RADIAL (POSTERIOR INTEROSSEOUS) IN FOREARM

AETIOLOGY: Trauma, surgical mishap, fracture/dislocation of radial head

MUSCLE LOSS: Extensors of wrist and fingers, but extensor carpi radialis longus is spared

MOVEMENT LOSS: Extensor weakness of metacarpophalangeal joints. Interphalangeal joints are alright because of intact interossei & lumbricals. NO wrist drop & grip is alright as extensor carpi radialis longus is intact

RESULT: No wrist drop & grip alright. Extension of elbow is alright

SENSORY LOSS: No sensory loss if superficial radial alright

TEST: Power of extension of metacarpophalangeal joints

[Image of hand with 'X' through wrist drop test]
NERVE LESIONS IN THE UPPER LIMB - 4

RADIAL IN SPIRAL GROOVE

AETIOLOGY: Fracture mid shaft humerus, Saturday night palsy, injections

MUSCLE LOSS: Extensors of wrist and fingers, but triceps & anconeus are spared

MOVEMENT LOSS: Extensor weakness wrist, metacarpophalangeal joints. Interphalangeal joints are alright because of intact interossei & lumbricals

RESULT: Wrist drop and inability to grip. Extension of elbow is alright

SENSORY LOSS: Over 1st dorsal interosseous, lower lateral cutaneous nerve of arm is usually alright

TEST: Power of wrist extension

WRIST DROP
NERVE LESIONS IN THE UPPER LIMB - 6

ULNAR AT ELBOW

AETIOLOGY: Fracture/dislocation of elbow, damage behind medial epicondyle

MUSCLE LOSS: All intrinsic muscle of hand except radial 2 lumbricals, 4th & 5th slips of flexor digitorum profundus, flexor carpi ulnaris

RESULT: Clawing & loss of grip between fingers (see T1 lesion in brachial plexus) BUT less clawing of index & middle fingers because of intact lumbricals and less clawing than in a wrist injury of ring & little fingers because of loss of flexor digitorum profundus to these fingers. Also there is radial deviation

SENSORY LOSS: Ulnar side of hand and ulnar 1 1/2 fingers

TEST: Place paper between straight fingers. Try abducting fingers. Test sensation of 5th finger pulp. Froment’s sign (see separate illustration). Wasting of 1st dorsal interosseous. Test distal interphalangeal joint of little finger for ulnar 1/2 of profundus

CLAWED HAND
AETIOLOGY: Lacerations

MUSCLE LOSS: All intrinsic muscle of hand except radial 2 lumbricals, (NOT flexor digitorum profundus, NOT flexor carpi ulnaris)

RESULT: Clawed hand (no interossei therefore no flexion of metacarpophalangeal joints but instead they are extended by long extensors. There is flexion of interphalangeal joints by long flexors. No radial deviation. Note: LESS clawing of index & middle fingers because of intact median nerve to radial lumbricals but MORE clawing of ring & little fingers because of intact 1/2 flexor digitorum profundus than for an ulnar lesion at elbow

SENSORY LOSS: Ulnar 1 1/2 fingers. Dorsal & palmar cutaneous branches may be spared

TEST: Place paper between straight fingers. Try abducting fingers. Test sensation of 5th finger pulp. Froment's sign (see separate illustration). Wasting of 1st dorsal interosseous.

CLAWED HAND
NERVE LESIONS IN THE UPPER LIMB - B

ULNAR

TESTING FOR WEAKNESS OF INTEROSSEI - T1

FROMENT'S SIGN

Paper is pinched in the first web space between proximal phalanx of thumb and metacarpophalangeal joint of the index finger with the wrist in a neutral position. The metacarpophalangeal joints are extended and the thumb nail faces the patient to avoid trick movements. The side with the loss of adductor pollicis compensates by using flexor pollicis longus which flexes the distal interphalangeal joint of the thumb.
NERVE LESIONS IN THE UPPER LIMB - 10

MEDIAN NERVE - AT WRIST

AETIOLOGY: Laceration, carpal tunnel compression

MUSCLE LOSS: Thenar (except adductor pollicis)  
2 radial lumbricals

MOVEMENT LOSS: Abduction and opposition of thumb. Flexion alright  
due to intact flexor pollicis longus

RESULT: Wasting of thenar muscles to give an 'ape' hand. Long  
flexors intact so no Papal benediction

SENSORY LOSS: Radial 3 1/2 fingers -or- radial palm depending on palmar  
cutaneous branch

TEST: Sensory - loss of pulp of index finger. Motor - Abductor  
pollicis brevis (+ or - opposition). Interphalangeal joints  
and pronation all intact
CARPAL TUNNEL SYNDROME

AETIOLOGY: Anything causing diminution of size of carpal tunnel - inflammation, arthritis, hypothyroidism, idiopathic, tenosynovitis, old fractures. All can lead to compression of median nerve

SITE: Under flexor retinaculum in concavity of carpal bones

RESULT: Paraesthesia/anaesthesia & loss of motor function of thumb, index & middle fingers. BUT preservation of sensation of palm (palmar cutaneous branch of median comes off a few centimetres above carpal tunnel)

TEST: Tapping over carpal tunnel may lead to tingling in median distribution in hand. Sensation should be maintained in the radial side of the palm
NERVE LESIONS IN THE UPPER LIMB - 9

MEDIAN NERVE - SUPRACONDYLAR

**AETIOLOGY:** Supracondylar fracture/dislocation, tight bicipital aponeurosis, ligament of Struthers

**MUSCLE LOSS:** Pronator teres, flexors of wrist/fingers except half flexor digitorum profundus & flexor carpi ulnaris. Thenar muscles except adductor pollicis & 2 radial lumbricals

**MOVEMENT LOSS:** Loss of pronation, weak wrist flexion & abduction. No abduction or opposition of thumb and, as flexor pollicis is also lost, the thumb is useless. Long flexor tendons (flexor digitorum superficialis & profundus) to index & middle fingers lost

**RESULT:** Ulnar deviation of wrist, thenar wasting. Papal benediction on flexing fingers (see below)

**SENSORY LOSS:** Radial side of palm, fingers and nail beds of 3 1/2 fingers

**TEST:** Sensory - loss of pulp of index finger. Motor - Pronation. Abductor pollicis brevis (+ or - opposition), both interphalangeal joints of index finger and flexor pollicis longus by touching tip of thumb pulp to pulp of index (see below on left)

Papal benediction

- Thenar wasting
- Ulnar deviation
- Minimal flexion of digits 1-3
NERVE LESIONS IN THE UPPER LIMB - 13

LONG THORACIC NERVE OF BELL-C5,6,7

AETIOLOGY: Damage during surgery in the axilla

RESULT: Loss of serratus anterior leading to 'winging' of scapula. Decreased flexion and abduction of arm

SENSORY LOSS: Nil

TEST: Patient presses against wall and scapula on side of lesion will 'wing' (stick out backwards)

RIGHT WINGED SCAPULA WHILST PATIENT IS PUSHING AGAINST WALL
CLASSIFICATION OF JOINTS

**FIBROUS**
- Skull sutures, interosseous membranes, inferior tibiofibular, costotransverse 11 & 12

**CARTILAGINOUS**

**PRIMARY**
- Costochondral, 1st sternochondral, sphen-o-occipital

**SECONDARY**
- Midline symphyses, intervertebral

**SYNOVIAL**

**TYPICAL**
- Hyaline cartilage

**ATYPICAL**
- Fibrocartilage

**Cartilage on bony surfaces**

**PLANE**
- (Carpus/tarsus)

**CONDYLOID**
- (MCP)

**HINGE**
- (Interphalangeal)

**SADDLE CONDYLOID**
- (1st CMC)

**MODIFIED HINGE**
- (Knee)

**PIVOT**
- (Radial head, atlanto-axial)

**BALL AND SOCKET**
- (Hip, shoulder, sternoclavicular, talocalcaneo-navicular)
ACROMIOCLAVICULAR JOINT

Coracoclavicular ligament

Conoid

Trapezoid

Long head of biceps

Synovial
Atypical
Thick superior capsule (acromioclavicular ligament)
Incomplete fibrocartilaginous disc in upper joint
Strong coracoclavicular ligament
Nerve: Lateral supraclavicular (C4)
Movements: gliding (passive) and 20° of rotation of scapula
- Synovial
- Hinge
- Communicates with superior radio-ulnar joint
- Carrying angle 170° wider in female, flexes to mouth

**Capsule**
Attached superiorly above radial, coronoid, olecranon fossae. Inferiorly ulna, coronoid, olecranon

**Nerve supply:**
- Musculocutaneous, radial, ulnar and median

**Flexion:**
- Biceps, brachialis, (brachio-radialis, common flexors, pronator teres)

**Extension:**
- Triceps, anconeus

**LOWER LEFT HUMERUS**

**LIGAMENTS**
- Lateral collateral
- Anular
- Quadrate (under anular fibres in 2 directions)
- Posterior: Triceps bursa

**Relations**
- Anterior: Brochialis Biceps tendon Brochial artery Median nerve
- Radial (lateral) collateral ligament
- Posterior ligament (receives fibres from triceps)
- Lateral ligament (to lateral epicondyle)

**This angle is important radiologically**
- Anular ligament attaches to margins of radial notch. It blends with capsule and lateral
RADIO-ULNAR JOINTS

SUPERIOR

- Continuous with elbow joint

Nerve supply:

Anterior & posterior interosseous & median

Annular ligament:

Around neck, attached to edges of radial notch on ulna, not attached to radius. Blends with capsule above

Quadrate ligament:

Neck of radius to supinator fossa of ulna. Criss-cross fibres

Relations:

Anterior - Supinator & radial nerve
Posterior - Supinator

INFERIOR

- Separated from wrist joint by triangle of fibrocartilage attached at its base to the radius and its apex to the ulnar styloid
- Loose capsule pouches upwards to give a sacciform recess by pronator quadratus
PRONATION AND SUPINATION

**AXIS**

**RADIAL HEAD - ULNAR STYLOID - LITTLE FINGER**

Note that the true axis of the forearm is through the mid intercondylar point and the mid interstyloid point. Thus, through the middle finger. Therefore in FREE pronation and supination ulna is adducted and abducted whilst the radius rotates around it. This allows the hand to remain still in space.

**ULNAR ABDUCTION**

Anconeus

**ULNAR ADDUCTION**

Pronator teres (humeral head)

![Diagram of bone structures with labels: Olecranon, Radial notch, Trochlear notch, Brachialis, Biceps tendon and bursa, Sublime tubercle, Supinator fossa.]
SHOULDER JOINT (GLENOHUMERAL)

Shallow glenoid fossa - deepened by glenoid labrum
Synovial, Ball and socket
Humeral head is 1/3 hemisphere

Capsule: Strong & taut superiorly (anti-sag), inferiorly
       lax and inserted lower to allow wide abduction,
       flexion and extension
Synovium: Envelops biceps tendon, communicates with
          bursae anteriorly and posteriorly

LIGAMENTS:

Anterior

Coraco-acromial (strong ++)
Subacromial bursa (large)
Coracohumeral (strong)
Transverse humeral (intertubercular)
Opening of subscapular bursa
Axillary nerve

Glenohumeral 1, 2, 3
Anterior: superior, middle, inferior
(weak thickenings of capsule)

4: Subscapularis
5: Teres major
6: Supraspinatus
7: Short head biceps
8: Pectoralis minor

Blood: circumflex humerals
Nerves: Subscapular, suprascapular, axillary (Hilton’s law)
Bursae: Subscapular, subacromial, infraspinatus, supraspinatus
Stability: Bones (poor), Capsule (relatively poor), Muscles +++
           ligaments +++
Support: Rotator cuff (subscapularis, supraspinatus,
        infraspinatus, teres minor), long head biceps,
        triceps in abduction, muscles from chest to arm
SHOULDER JOINT (GLENOHUMERAL)

Shallow glenoid fossa - deepened by glenoid labrum
Synovial, Ball and socket
Humeral head is 1/3 hemisphere

Capsule: Strong & taut superiorly (anti-sag), inferiorly
lax and inserted lower to allow wide abduction,
flexion and extension

Synovium: Envelops biceps tendon, communicates with
bursae anteriorly and posteriorly

LIGAMENTS:

Coracohumeral (strong +++)
Coraco-acromial (strong +++)
Subacromial bursa (large)
Transverse humeral (intertubercular)

Opening of subscapular bursa

4: Subscapularis
5: Teres major
6: Supraspinatus
7: Short head biceps
8: Pectoralis minor

Axillary nerve

Glenohumeral 1, 2, 3
Anterior: superior, middle, inferior
(weak thickenings of capsule)

Blood: circumflex humerals
Nerves: Subscapular, suprascapular, axillary (Hilton’s law)
Bursae: Subscapular, subacromial, infraspinatus, supraspinatus
Stability: Bones (poor), Capsule (relatively poor), Muscles +++
ligaments +++
Support: Rotator cuff (subscapularis, supraspinatus,
infraspinatus, teres minor), long head biceps,
triceps in abduction, muscles from chest to arm
Relations
Superior: Supraspinatus, bursa, long head of biceps, coraco-acromial ligament
Inferior: Long head of triceps, axillary nerve, posterior circumflex humeral artery, teres major
Posterior: Infraspinatus, teres minor, deltoid
Anterior: Subscapularis, bursa, deltoid

Movements
Flexion: Pectoralis major, biceps, coracobrachialis, deltoid
Extension: Deltoid, latissimus dorsi, teres major
Adduction: Pectoralis major, latissimus dorsi, teres major
Abduction: Supraspinatus (0°-30°), deltoid & supraspinatus (30°-90°), scapular rotation, supraspinatus, deltoid (90°-160°)
Internal rotation: Subscapularis, teres major, latissimus dorsi
External rotation: Teres minor, infraspinatus, deltoid
Synovial
Atypical (fibrocartilage on joint surfaces)
Fibrocartilaginous disc dividing it into 2 cavities
Manubrial surface is concave
Ball & socket (all the features of)
Disc attached to capsule, acts as shock absorber
Capsule thick above and posteriorly
Fulcrum at costoclavicular ligament
Clavicle rotates 40°
Nerves: supraclavicular (C3,4)

Ligaments
Thickening of capsule (above and posteriorly)
These are the anterior & posterior sternoclavicular ligaments
Interclavicular
Costoclavicular (strong). External (anterior) fibres &
Internal (posterior) fibres
RADIO-ULNAR JOINTS

SUPERIOR

- Continuous with elbow joint

Nerve supply:

- Anterior & posterior interosseous & median

Annular ligament:

- Around neck, attached to edges of radial notch on ulna, not attached to radius. Blends with capsule above

Quadrate ligament:

- Neck of radius to supinator fossa of ulna. Criss-cross fibres

Relations:

- Anterior - Supinator & radial nerve
- Posterior - Supinator

INFERIOR

- Separated from wrist joint by triangle of fibrocartilage attached at its base to the radius and its apex to the ulnar styloid

- Loose capsule pouches upwards to give a sacciform recess by pronator quadratus
WRIST JOINT

- Proximal - radius & fibrocartilage
- Distal - Scaphoid, lunate (triquetral in extreme adduction)
- Synovial
- Triangular cartilage - holds radius and ulna together and separates radiocarpal joint from inferior radio-ulnar joint
- Capsular ligaments - thick collateral at sides
- Palmar radiocarpal ligaments - radius to lunate capitate. Strong+
- Movements - Flexion 80° Mostly midcarpal
  Extension 60° Mostly wrist
  Abduction 15°
  Adduction 60°
- Ossifies in membrane
- 1st to appear at 5 weeks intra-uterine
- Only one secondary centre at sternal end appears in teens
- One of last to fuse - at 26-30 years
- No medullary cavity
- Most fractures are indirect trauma. Occur at junction of lateral 1/3 and medial 2/3
- Subclavian protects vessels
- Ligaments are:
  - Costoclavicular
  - Coracoclavicular
  - Acromioclavicular
  - Sternoclavicular
MUSCLES ATTACHED TO COSTAL CARTILAGES

- Internal oblique abdominis
- Transversus abdominis
- Rectus abdominis
- Transversus thoracis (sternocostalis)
- Pectoralis major (1-7)
- Diaphragm
MUSCLES ATTACHED TO RIBS

- Scapula pulled away
- Levator scapulae
- Scalenus medius
- Scalenus anterior
- 8 slips of serratus anterior
- 4 slips of latissimus dorsi
- 8 slips of external oblique abdominis
RIGHT SCAPULA

- Trapezius
- Supraspinatus
- Levator scapulae
- Minor
- Romboid
- Major
- Lat. dorsi
- Ossification
  Primary centre at 8 weeks i.u.
  Secondary centres at 10 years

- Deltoid
- Coraco-brachialis
- Long head biceps
- Long head triceps
- Acromio-clavicular joint
- Teres minor
- Long head triceps
- Pectoralis minor
- Omohyoid
- Serratus anterior
- Subscapularis
- Subscapular bursa

- Appear at puberty
  2ry
  1ry
DELTOID

**Origin:** Lateral 1/3 clavicle, acromion, Spine of scapula to deltid tubercle

**Insertion:** Deltoid tubercle of humerus

**Action:** Abducts arm. Anterior fibres flex & medially rotate. Posterior fibres extend & laterally rotate

**Nerve supply:** Axillary (C5,6 posterior cord)

Special note
It is easy to see from the drawing that the way that the anterior & posterior fibres cross the joint, they will prevent the muscle from initiating abduction. But once supraspinatus has lifted the arm to 15 degrees all the deltid fibres will become abductors.
<table>
<thead>
<tr>
<th><strong>SUPRASPINATUS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin:</strong></td>
<td>3/4 supraspincous fossa and upper spine of scapula</td>
</tr>
<tr>
<td><strong>Insertion:</strong></td>
<td>Superior facet of greater tuberosity of humerus &amp; joint capsule</td>
</tr>
<tr>
<td><strong>Action:</strong></td>
<td>Abducts and stabilises shoulder</td>
</tr>
<tr>
<td><strong>Nerve supply:</strong></td>
<td>Suprascapular (C5, 6 upper trunk)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>INFRASPINATUS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin:</strong></td>
<td>Medial 3/4 infraspinous fossa &amp; intermuscular septa</td>
</tr>
<tr>
<td><strong>Insertion:</strong></td>
<td>Medial facet of greater tuberosity of humerus and joint capsule</td>
</tr>
<tr>
<td><strong>Action:</strong></td>
<td>Lateral rotation &amp; stabilisation</td>
</tr>
<tr>
<td><strong>Nerve supply:</strong></td>
<td>Suprascapular (C5, 6 upper trunk)</td>
</tr>
</tbody>
</table>
LATISSIMUS DORSI

**Origin:** Spines & supraspinous ligaments
T7 down to sacrum, lumbar fascia, posterior 1/3 iliac crest,
last 4 ribs & inferior angle of scapula

**Insertion:** Flat tendon into floor of bicipital groove

**Action:** Adducts, extends & medially rotates shoulder. Aids both inspiration & expiration

**Nerve supply:** Thoracodorsal from posterior cord
**LEVATOR SCAPULAE**

**Origin:** Posterior tubercles of transverse processes C1-4

**Insertion:** Upper medial border of scapula

**Action:** Raises medial end of scapula

**Nerve supply:** Dorsal scapular (C5 root)
**PECTORALIS MAJOR**

**Clavicular head**
- **Origin:** Medial half of clavicle
- **Insertion:** Anterior lamina (of trilaminar insertion) & lateral lip of bicipital groove, deep fascia, anterior lip of deltoid tuberosity

**Sternocostal head**
- **Origin:** Anterior & lateral manubrium, body of sternum, aponeurosis of external oblique, upper 7 costal cartilages (not always 1st or 7th)
- **Insertion:** Manubrial fibres to intermediate lamina. Sternocostal fibres to posterior lamina with highest fibres into capsule of shoulder
- **Action:** Flexion, adduction, internal rotation
- **Nerve supply:** Lateral & medial pectoral nerves
PECTORALIS MINOR

**Origin:** Ribs 3, 4, 5

**Insertion:** Coracoid process

**Action:** Protracts scapula with serratus anterior

**Nerve Supply:** Medial & lateral pectorals
PRONATOR TERRS & ITS RELATION TO MEDIAN NERVE

- Deep head from median coronoid
- Superficial head from common flexor origin
- Median nerve between 2 heads
RHOMBOID MAJOR

**Origin:** Spines of T2-5 & supraspinous ligaments

**Insertion:** Lower 1/2 posterior medial scapula

**Action:** Retracts & rotates scapula to rest position

**Nerve supply:** Dorsal scapular (C5 from root)

---

RHOMBOID MINOR

**Origin:** Spines C7 & T1 and lower ligamentum nuchae

**Insertion:** Posteromedial scapula level with spine

**Action:** Retracts & rotates scapula to rest

**Nerve Supply:** Dorsal scapular (C5 from root)
SERRATUS ANTERIOR

**Origin:** Upper 8 ribs and intercostal membranes

**Insertion:** Inner, medial border of scapula

**Action:** Protraction & lateral rotation of scapula

**Nerve supply:**
- Long thoracic nerve of Bell
  - C5 to slips 1 & 2
  - C6 to slips 3 & 4
  - C7 to slips 5, 6, 7, 8

1st slip visible in posterior triangle of neck
**SUBCLAVIUS**

**Origin:** 1st rib, costochondral junction

**Insertion:** Subclavian groove inferior middle clavicle

**Action:** Stabilises clavicle

**Nerve supply:** Nerve to subclavius (C5,6 off roots)
**SUBSCAPULARIS**

**Origin:** Medial 2/3 subscapular fossa

**Insertion:** Lesser tuberosity of humerus, 1/2 medial lip of bicipital groove and joint capsule

**Action:** Medial rotation & stabilisation

**Nerve supply:** Upper & lower subscapular (C6,7 posterior cord)
SUPINATOR AND ITS RELATION TO THE RADIAL NERVE

Radial nerve

SUPERFICIAL HEAD
Arises: lateral epicondyle & lateral & annular ligaments

Posterior interosseous nerve

Inserts: neck & shaft of radius between anterior & posterior oblique lines

DEEP HEAD
Arises: supinator crest & fossa

Action: Supinates. Best when arm is extended and biceps is not supinating

Nerve: posterior interosseous from radial
**Supraspinatus**

- **Origin:** 3/4 supraspinous fossa and upper spine of scapula
- **Insertion:** Superior facet of greater tuberosity of humerus & joint capsule
- **Action:** Abducts and stabilises shoulder
- **Nerve supply:** Suprascapular (C5,6 upper trunk)

**Infraspinatus**

- **Origin:** Medial 3/4 infraspinous fossa & intermuscular septa
- **Insertion:** Medial facet of greater tuberosity of humerus and joint capsule
- **Action:** Lateral rotation & stabilisation
- **Nerve supply:** Suprascapular (C5,6 upper trunk)
**TERES MAJOR**

- **Origin:** Oval area on lower 1/3 lateral side of inferior angle of scapula
- **Insertion:** Medial lip of bicipital groove
- **Action:** Medial rotation, adduction, stabilisation of shoulder
- **Nerve supply:** Lower subscapular (posterior cord C5,6)

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**TERES MINOR**

- **Origin:** Middle 1/3 lateral border of scapula
- **Insertion:** Inferior facet of greater tuberosity & joint capsule
- **Action:** Lateral rotation & stabilisation of shoulder
- **Nerve supply:** Axillary (C5,6 [posterior cord])
**TRAPEZIUS**

**Origin:** Superior nuchal line & crest, occiput, nuchal ligament, spines & supraspinous ligaments T1-12

**Insertion:** Lateral 1/3 clavicle, medial acromion, spine of scapula around to deltoid tubercle

**Action:** Lateral rotation, elevation, depression & retraction of scapula (lower fibres elevate body when arm is fixed. Upper fibres extend & laterally flex head & neck. Rotation is aided by serratus anterior)

**Nerve supply:** Spinal root of accessory (XI)

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**Triangle of auscultation**

- Infraspinatus
- Trapezius
- Latissimus dorsi
- Teres major
- Iliac crest
SURFACE ANATOMY

Bony prominences

Coracoid

Both above delto-pectoral groove

Lesser tuberosity
SURFACE ANATOMY

Function of any bone

- To give form
- Muscle attachments (not talus!)
- Movement
- Protection
- Metabolic
  - Ca, P
  - Haemopoiesis
**Palm**
- Distal skin crease - level of MP joints

**Wrist**
- Distal skin crease - level of proximal flexor retinaculum

**Middle skin crease** (proximal if only 2)
- Level of wrist joint

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**Superficial palmar arch**
- Level with outstretched thumb
- Made by ulnar artery
- 1/2 way between distal palmar crease and distal wrist crease

**Deep palmar arch**
- Made by radial artery
- 1cm short of superficial arch
SURFACE ANATOMY

PALPABLE NERVES

- Upper trunk (over 1st rib)
- Supraclavicular
- Median (over brachial artery)
- Ulnar (behind medial epicondyle)
- Median (between palmaris longus & flexor carpi radialis)
- Ulnar (lateral to pisiform)
- Dorsal cutaneous branch of radial (over extensor pollicis longus)
SURFACE ANATOMY

Palpable structures

- Acromioclavicular joint
- Medial & lateral epicondyles
- Olecranon
- Head of radius
- Anconeus (post. to above)
- Radial & ulnar styloids
- Dorsal (Lister's) tubercle of radius
- Hook of hamate
- Biceps tendon & aponeurosis
- Brachial & radial pulses
SURFACE ANATOMY

Henry's method for finding posterior interosseous nerve:

3 fingers below radial head as it runs into supinator.
SURFACE ANATOMY

Radial Nerve:

From the junction of the posterior axilla and arm to a point 2/3 down a line from acromion to lateral epicondyle then anterior to the lateral epicondyle.
SURFACE ANATOMY

Scapula

- Covers half ribs 2-7
- 8th first rib below
- Upper border T2
- Medial spine T3
- Lower border T7
SURFACE ANATOMY

SNUFF BOX

Boundaries
- Extensor pollicis longus
- Extensor pollicis brevis
- Abductor pollicis longus

Contents
- Trapezium
- Scaphoid
- Radial artery
- Cephalic vein
EXTERNAL OBLIQUE
From: anterior angles of last 8 ribs
To: xiphisternum, linea alba, pubic symphysis & crest, inguinal ligament, anterior 1/2 iliac crest.
Downward/medial
N: T7-12

INTERNAL OBLIQUE
From: anterior 2/3 iliac crest, lateral 2/3 inguinal ligament, lumbar fascia
To: costal margin, rectus sheath & linea alba.
Conjoint tendon to pubic crest and pectineal line.
Upward/medial
N: T7-12, ilioinguinal to conjoint tendon
**ABDOMINAL WALL MUSCLES**
**TRANSVERsus, RECTUS ABDominis, PYRAMIdalis**

**TRANSVERsus ABDominis**
- From: costal margin, lumbar fascia anterior 2/3 iliac crest, lateral 1/2 inguinal ligament
- To: rectus sheath & linea alba.
- Conjoint tendon to pubic crest & pectineal line
- Transverse
- N: T7-12, ilioinguinal to conjoint tendon

**RECTUS ABDominis**
- From: pubic crest, tubercle & symphysis
- To: costal cartilages 5, 6, 7, costal margin of 7, sternum & diaphragm
- N: T7-12
- (note: 3 morphological layers)

**PYRAMIdalis**
- From: front of body of pubis
- To: linea alba
- N: T12 (subcostal)
ABDOMINAL WALL MUSCLES
RECTUS SHEATH

EO External oblique
IO Internal oblique
TA Transversus abdominis
TF Transversalis fascia
ABDOMINAL WALL - THORACOLUMBAR FASCIA, NEUROVASCULAR PLANE & FASCIA OVER INGUINAL REGION

Thoracolumbar fascia
Note that external oblique does not attach to it, hence free edge

Transversus abdominis

Neurovascular plane between two muscles as indicated

Internal oblique

External oblique

Erector spinae

Psoas

Inginal ligament

Scarpa's fascia of abdomen attaches to fascia lata of thigh 2-3cm below inguinal ligament

fascia lata of thigh

Posterior

Anterior

FASCIA IN INGUINAL REGION
**TRANSPYLORIC PLANE**

- Suprasternal notch (T2/3)
- Transpyloric plane (L1) (1/2 way between)
- Pubic symphysis

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On transpyloric plane:

- L1 vertebra
- Pylorus
- Hila of kidneys
- Duodenojejunal flexure
- Fundus of gall bladder
- Neck of pancreas
- Origin of portal vein
- Transverse mesocolon
- 2nd part of duodenum
- Origin of superior mesenteric artery
- Hilum of spleen
- 9th costal cartilage
- End of spinal cord (just below)
POSTERIOR RECTUS SHEATH & UMBILICAL FOLDS

Viewed from behind

Linea alba

External oblique
Internal oblique
Transversus abdominis

Linea semilunaris

Arcuate line (5cm below umbilicus)

Superior & inferior epigastric arteries

Inferior epigastric artery gives the lateral umbilical fold

Internal iliac artery

Median umbilical ligament/fold (obliterated urachus)

Medial umbilical ligament/fold (obliterated umbilical artery)

Note: There are three folds but only two ligaments. The inferior epigastric artery raises a fold of peritoneum but clearly is not a ligament
POSTERIOR ABDOMINAL WALL

- 5 vertebrae
- Transverse process of L3 is largest
- Transverse process of L5 is conical

PSOAS MAJOR
Origin: Intervertebral discs T12/L1 to L4/5
Bodies of L1-5, transverse processes L1-5
Inserts: Lesser trochanter
Nerve: L1, 2, 3
Action: Flexes hip

PSOAS MINOR
Origin: Bodies T12, L1
Inserts: Fascia over psoas major behind inguinal ligament
Nerve: L1
Action: Weak spine flexor

QUADRATUS LUMBOorum
Origin: Transverse process L5
Iliolumbar ligament & posterior 1/3 iliac crest
Inserts: Medial 1/2 12th rib 8
transverse process L1-4
Nerve: T12-L4
Action: Holds down 12th rib

ILIACUS
Origin: Hollow of iliac fossa
Inserts: Psoas tendon & below lesser trochanter
Action: Flexes hip
Nerve: Femoral (L2, 3, 4)

LAYERS OF THORACOLUMBAR FASCIA
- TP = Transverse process
- ES = Erector spinae
- QL = Quadratus lumbar
- Attachment of transversus & internal oblique
- Spine/supraspinous ligaments
- Lumbar regions all 3 layers are present, thoracic region has posterior layer only
STOMACH - BLOOD SUPPLY & VENOUS DRAINAGE

Arterial supply

- Oesophageal branches
  - left gastric
- Coeliac trunk
  - Hepatic
- Right gastric
- Gastro-duodenal
- Superior pancreato-duodenal

- Short gastrics
- Splenic
- Left gastro-epiploic (greater curvature & omentum)
- Right gastro-epiploic (greater curvature & omentum)

Venous drainage

- Left gastric & oesophageal branches
- Portal
- Short gastrics
- Splenic
- left
- Gastro-epiploics
- Superior mesenteric
- right

* Pre-pyloric vein of Mayo but first described by Laterjet
STOMACH - LYMPHATIC DRAINAGE & NERVE SUPPLY

Cisterna chyli

Coeliac

Hepatic

Gastro-duodenal

Left gastric

Short gastric

Splenic

Left gastro-epiploic

Right gastric

Right gastro-epiploic

Sympathetics
Greater splanchnic nerves (T5-9) for decreasing motility, vaso-constriction, closing pylorus & sensation

Left vagus (hugs the anterior wall)

Right vagus (a little away from posterior wall)

Coeliac branch

Hepatic branch

Antral supply

Vagus nerves are 80% sensory. 20% motor for increasing motility, opening pylorus & initiating secretions

Anterior/posterior nerves of laterjet

Note: Highly selective vagotomy destroys vagus to fundus & body but preserves nerve to antral pump
STOMACH - MUSCLE COATS & CELLS

- Outer longitudinal
- Inner circular
- Incomplete oblique innermost
- Mucosal rugae caused by muscle fibres

Mucosal cells

Mucous cells (neutral)

Oxynic (parietal) cells
Acid production under influence of gastrin

Pepsin from zymogenic cells (lipase)

Entero/endocrine cells
G cells in pylorus produce gastric. Apud cells. VIP, 5 hydroxytryptamine, etc

Gastric gland

Mucous membrane

Note: The following are produced from the cells of the stomach:
Pepsin, hydrochloric acid, gastrin, intrinsic factor, somatostatin, serotonin and endomorphin
Oesophagogastric junction

- Effective sphincter/valve because:
- Circular fibres in diaphragm, right crus and oesophagus
- Phrenico-oesophageal ligament (fold of connective tissue)
- Angle of junction
- Mucosal folds
- Intra-abdominal pressure acting to compress the intra-abdominal oesophagus
STOMACH - RELATIONS

ANTERIOR
Abdominal wall
Left costal margin
Diaphragm
Left lobe of liver

SUPERIOR
Left dome of diaphragm

POSTERIOR
Lesser sac
Pancreas
Transverse mesocolon
Transverse colon
Left kidney/suprarenal gland
Spleen/splenic artery
**DUODENUM - POSTERIOR RELATIONS & LIGAMENT OF TREITZ**

**POSTERIOR RELATIONS OF DUODENUM**

**SECOND PART**
- Hilum of right kidney
- Right ureter

**FIRST PART**
- Lesser sac
- Pancreas
- Bile duct
- Portal vein
- Hepatic artery
- Gastro-duodenal artery

**THIRD PART**
- Right psoas
- Right genitofemoral nerve
- Right gonadal artery & vein
- Right ureter
- Inferior vena cava
- Aorta
- L3 vertebra

**FOURTH PART**
- Left sympathetic chain
- Left psoas
- Left genitofemoral nerve
- Left renal artery & vein
- Left gonadal artery & vein
- Inferior mesenteric vein

**LIGAMENT OF TREITZ**
2 parts, probably neither attached to crura
1. Slip of striated muscle from diaphragm at oesophageal opening, ending in connective tissue at coeliac artery
2. Fibromuscular (non striated) band from region of coeliac artery to duodenojejunal junction and 3th & 4th parts of duodenum
DUODENUM - GENERAL

10" (25cm) Greek for 10 fingers

SECOND PART (3" or 8cm)
- Retroperitoneal
- In transpyloric plane
- Downwards over hilum of right kidney
- Anterior: Gallbladder, hepatic flexure
- Medial: Pancreas, ampulla (posteromedial, 4" or 10cm from pylorus)
- Lateral: Ascending colon

FIRST PART (2" or 5cm)
- Ist 1/2 with mesentery, 2nd 1/2 without.
- Slightly longer in female
- Just above transpyloric plane
- Passes to right, upwards, backwards
- Anterior: Liver & gallbladder
- Superior: Epiploic foramen

Blood supply: Superior & inferior pancreaticoduodenal arteries, right gastric artery, right gastro-epiploic artery
Veins: Splenic, superior mesenteric & portal

THIRD PART (4" or 10cm)
- Retroperitoneal
- Below subcostal plane
- Passes forwards & to left
- Anterior: Small bowel mesentery, superior mesenteric artery & vein
- Superior: Head of pancreas
- Inferior: Jejunum

FOURTH PART (1" or 2.5cm)
- Mesentery begins
- Ascends to L2
- Ends as duodenojejunal junction
- Anterior: Transverse colon & mesocolon
- Left: Left kidney & ureter
- Superior: Body of pancreas
DUODENUM - HISTOLOGY

Villi/microvilli
Crypts of Lieberkühn
Apud cells in base
Circular muscle
Longitudinal muscle
Brunner’s glands producing alkaline mucus (only found in duodenum)

Note: Mucosa is thrown into folds called plicae circulares or valvulae conniventes
DUODENUM - POSTERIOR RELATIONS & LIGAMENT OF TREITZ

POSTERIOR RELATIONS OF DUODENUM

SECOND PART
- Hilum of right kidney
- Right ureter

FIRST PART
- Lesser sac
- Pancreas
- Bile duct
- Portal vein
- Hepatic artery
- Gastroduodenal artery

THIRD PART
- Right psoas
- Right genitofemoral nerve
- Right gonadal artery & vein
- Right ureter
- Inferior vena cava
- Aorta
- L3 vertebra

FOURTH PART
- Left sympathetic chain
- Left psoas
- Left genitofemoral nerve
- Left renal artery & vein
- Left gonadal artery & vein
- Inferior mesenteric vein

LIGAMENT OF TREITZ
2 parts, probably neither attached to crura
1. Slip of striated muscle from diaphragm at oesophageal opening, ending in connective tissue at coeliac artery
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SMALL INTESTINE

- Average length 6 metres (24 feet)
- Range 3-10 metres (10-33 feet)
- Patients can survive with 2/3 removed. Little if any effect by removing 1/3

JEJUNUM

- General
  - 2/5, red, wide bore, thick wall

- Macroscopic
  - Valvulae conniventes, plicae circulares ++, sparse arcades

- Mesentery
  - Lies superiorly, attached to left of aorta, less fat

- Histology
  - Tall villi
  - Long crypts

ILEUM

- General
  - 3/5, pink, narrow bore, thin wall,

- Macroscopic
  - Smooth wall, Peyer’s patches, multiple arcades

- Mesentery
  - Lies inferiorly, attached to right of aorta, fatty mesentery

- Histology
  - Short villi
  - Short crypts

Note: At base of crypts are Paneth cells that produce lysozyme
MECKEL’S DIVERTICULUM
SMALL BOWEL MESENTERY
SMALL BOWEL SECRETIONS

MECKEL’S DIVERTICULUM
Said to be present in 2-3% of people, 2-3 inches long and 2-3 feet from the ileoceleal valve but these statements are probably only 2/3 true!
May contain gastric, pancreatic, liver, carcinoid or lymph tissue
May attach to umbilicus via a vitello-intestinal tract which may or may not leak but may cause intestinal obstruction as a volvulus can wrap around it
Symptoms very similar to appendicitis
Lies on antimesenteric border of ileum

ORIGIN OF SMALL BOWEL MESENTERY
6 inches (15cm) long
Starts at the duodenojejunal junction, just to left of L2 vertebra and extends down and to the right to reach the right sacro-iliac joint at S2 sacral level
Contains superior mesenteric vessels, lymphatics and autonomic nerves

SECRETIONS FROM SMALL BOWEL
Mucus, lysozyme, secretin, somatostatin, cholecystokinin, serotonin and endomorphin
CAECUM
- On mesentery
- Below ileocaecal valve
- Retrocaecal fossa behind it
- 3 taenia meet at base of appendix in child
- Ileocaecal valve is a double fold of mucosa & circular muscle of ileum which acts as an anti-reflux mechanism

APPENDIX
- At McBurney's point
- 1/2"-9" (2-25cm) average 7-8cm
- Fully coated diverticulum
- Variable mesentery
- Appendicular artery usually from posterior caecal artery. It is an end artery hence appendix can easily become gangrenous
- Appendix moves posterior and medial with caecal expansion

Diagram:
- Taenia
- Anterior/posterior caecal to ileocolic artery
- Appendicular artery
- Lateral femoral cutaneous nerve (L2, 3)
- Femoral nerve (L2, 3, 4)
- Genitofemoral nerve (L1, 2)
- Gonadal vessels
- External iliac vessels
- Retro-ileal
- Pre-ileal
- 5%
- Subcaecal
- Pelvic
- 20%
- Retrocolic
- Retrocaecal
**ASCENDING AND TRANSVERSE COLON**

**ASCENDING COLON**
- 15cm (6”)
- From ileocaecal valve to hepatic flexure
- Retroperitoneal
- Anterior: Coils of small bowel & omentum

**Transversus abdominis**
- Iliac vein
- Iliac artery
- Right kidney
- Quadratus lumborum
- Iliacus

**Liver (anterior) cut away to show upper pole of kidney**

**TRANVERSE COLON**
- 45cm (18”)
- Between hepatic and splenic flexures
- Fixed at both ends
- Hangs on transverse mesocolon

**Transverse mesocolon**
- Hepatic flexure
- Splenic flexure
- Greater omentum
DESCENDING AND SIGMOID COLON

DESCENDING COLON
• 30cm (9-12”)
• From splenic flexure to brim of pelvis
• Retroperitoneal
• Appendices epiploicae ++
• Lies on psoas, iliacus, transversus abdominis, quadratus lumborum

• Posterior relations
  • Left subcostal artery/vein/nerve
  • Iliohypogastric nerve
  • Ilio-inguinal nerve
  • Lateral femoral cutaneous nerve
  • Genitofemoral nerve
  • Gonadal artery/vein
  • External iliac artery/vein

SIGMOID COLON
• 15-45cm (5-30”)
• From pelvic brim to S3 midline
• On mesentery
• Appendices epiploicae +++
• Taenia become progressively more as a longitudinal coat

Sigmoid colon is excised to expose the base of its mesentery which crosses:
• Common iliac artery bifurcation
• Left ureter
• left sacro-iliac joint
LARGE BOWEL - GENERAL

- Approximately 5 foot (1.4m)
- Partially retroperitoneal (see individual segments of bowel)
- Outer longitudinal muscle in three flat bands - Taenia Coli
- Taenia only in colon and caecum - not in rectum or appendix
- As taenia are shorter than the bowel they cause inner haustrations called Valvulae Conniventes
- Inner circular muscle
- Appendices epiploicae are little tags of fat at the bowel/ mesentery border - not in appendix, caecum or rectum
- Crypts with goblet cells but no villi
- Lymphatics: Alongside superior/inferior mesenteric vessels to para-aortics to coeliac and on upwards
- Nerves: Parasympathetic - vagus to 2/3 along transverse colon then S2,3,4 to rest of bowel. With sympathetics T10-L2 for vasoconstriction and pain. Note some pelvic organ pain is with parasympathetics
**RECTUM - VESSELS/LYMPHATICS**

- **Blood supply:** Superior rectal artery from inferior mesenteric
  Middle rectal artery from internal iliac. May be small
  Inferior rectal artery from internal pudendal
  Median sacral may contribute
  All arteries supply all layers

- **Venous drainage:** Superior rectal vein to inferior mesenteric which
  is portal. Middle rectal to internal iliac (systemic)
  Inferior rectal to internal pudendal to internal iliac (systemic)

- **Portosystemic anastomosis:** In upper anal canal where internal & external
  venousplexuses meet. Superior rectal vein (portal)
  meet middle/inferior (systemic)

- **Lymphatics:** Follow deep veins and arteries (black arrows below)
RECTUM - GENERAL

- 12cm long
- Starts at S3, ends at puborectalis (pelvic floor)
- No appendices epiploicae, no sacculations, no mesentery
- 3 folds of mucosa & circular muscle = Valves of Houston.
  2 on left, 1 on right
- Peritoneum:
  - Upper 4cm - front and sides
  - Middle 4cm - front only
  - Lower 4cm - beneath peritoneum of pelvic floor
- Muscle: Wide bands of longitudinal muscle anterior & posterior
  becoming a fibrous layer within the sphincters
  Circular muscle complete but thickened below as
  internal sphincter
- Nerves: Sympathetic - contract smooth muscle sphincters,
  relax bowel, transmit pain
  Parasympathetic - Relax smooth muscle sphincters,
  contract bowel, transmit feeling of fullness
- Lower third empty except during defaecation. Can distend
  laterally into ischio-anal fossae
- Upper two thirds distensible into abdominal cavity & can store
  faeces in constipation
RECTUM - RELATIONS

ANTERIOR

**Female**
- Recto-uterine pouch (of Douglas)
- Small bowel
- Vagina (posterior fornix)
- Uterus & bladder

**Male**
- Rectovesical pouch
- Small bowel
- Denonvillier's fascia
- Bladder
- Vas, seminal vesicle
- Prostate

POSTERIOR
Fascia, median sacral & rectal vessels, sympathetic trunk, pelvic splanchnic nerves, piriformis, sacral & coccygeal roots, sacrum, coccyx, anococcygeal body

LATERAL
Peritoneum, fat, nodes, obturator internus & its fascia, Alcock's canal & contents, levator ani & coccygeus, ischio-anal fossa, lateral (fascial) ligaments of rectum
ANAL CANAL - GENERAL

- 4 cm long, from pelvic floor (puborectalis) to outside
- Two distinct halves of 2 cm separated by dentate (pectinate) line

**Upper half (2 cm)**
- 12 anal columns/valves
- 3 cushions
- Insensitive to touch

**Lower half (2 cm)**
- Skin
- Sensitive to touch

3 spongy mucosal cushions in upper half, level with venous plexuses at 3, 7 & 11 o'clock. Contain arterial & venous blood. Help with continence, air tightness & mucus production. Enlargement leads to haemorrhoids (piles)

**UPPER HALF**
- Endoderm origin
- Columnar mucosa
- Columns, valves & cushions
- Autonomic nerves
- Mainly superior rectal artery
- Portal venous drainage
- Para-aortic lymph nodes
- Adenocarcinoma
- Site of haemorrhoids

**LOWER HALF**
- Ectoderm origin
- Squamous mucosa
- Skin
- Somatic nerves
- Mainly inferior rectal artery
- Systemic venous drainage
- Superficial inguinal nodes
- Squamous carcinoma
- No haemorrhoids
ANAL CANAL - SPHINCTERS

Puborectalis (angles rectum backwards & downwards)

Rectum

Coccyx

Perineal body

Deep Anal canal

Anococcygeal body

Subcutaneous

Pelvic floor (levator ani)

Circular muscle of rectum becomes internal sphincter (relaxes with moderate pressure from above)

Longitudinal muscle becomes fibrous in anal canal

Deep, superficial and subcutaneous external sphincters (voluntary but spontaneously relax at very high pressures from above)

CONTINENCE
Internal sphincter (involuntary)
External sphincter (voluntary)
Recto-anal angle (puborectalis)
Anal cushions & mucosal folds
Abdominal pressure on upper anterior part of lower rectum

NOTE:
Incontinence can be due to overflow around impacted faeces in constipation
8CM LONG
8MM WIDE

BILE DUCT

SUPRADUODENAL
Upper 1/3 in free edge of lesser omentum, on portal vein & to right of hepatic artery

RETRODUODENAL
Middle 1/3 behind 1st part of duodenum, moving to right of portal vein. On inferior vena cava

PARADUODENAL
Lower 1/3 in groove between head of pancreas & 2nd part of duodenum on right renal vein and inferior vena cava

Ampulla of Vater opens into 2nd part of duodenum on posteromedial wall, 10cm from pylorus

Blood supply: cystic, hepatic, gastroduodenal
Nerve supply:
Parasympathetic - anterior vagus for contraction of gall bladder, relaxation of sphincter of Oddi (+ cholecystokinin from small bowel)
Sympathetic - coeliac ganglion, relaxes gall bladder, afferent together with right phrenic

3 sphincters make up the sphincter of Oddi. Biliary always present - others may be missing

GDA is gastro-duodenal artery

GDA
IVC
IVC

Ampulla of Vater hepatopancreatic ampulla

Pancreatic duct

Bile duct

Duodenal papilla
DEVELOPMENT OF GALL BLADDER & PANCREAS

A diverticulum grows from the ventral wall of the duodenum which differentiates into hepatic ducts and liver. A second diverticulum from the hepatic duct gives the gall bladder and cystic duct. Pancreas develops from ventral and dorsal buds.

Hepatic duct
Gall bladder
Ventral pancreatic bud
Bile duct

4 weeks in utero

Dorsal pancreatic bud

5-6 weeks in utero

Ventral bud swings around posteriorly

Main pancreatic duct starts to connect to duct of ventral bud

Original opening of dorsal bud now becomes opening of accessory duct

Opening of ventral bud now becomes ampulla of vater

Accessory duct (Santorini)

Main duct (Wirsung)

Uncinate process. Superior mesenteric vessels are trapped between it and main pancreas

Note: Endocrine cells invade tissue at around 3 months in utero & begin activity around 5 months in utero
**BILIARY TREE - CYSTIC & ARTERIAL VARIATIONS**

**ARTERIAL VARIATIONS**
- In the vast majority of people the cystic artery arises from the right branch of the hepatic artery.
- In 27% it arises from the hepatic or common hepatic.
- In 5% it arises from the left branch of the hepatic.
- In 3% it arises from the gastroduodenal.
- In 1% it arises from either the superior pancreaticoduodenal, left gastric, coeliac or superior mesenteric.

27% from hepatic or lower.

**CYSTIC DUCT VARIATIONS**
- Long duct: low entry, often bound by connective tissue to bile duct.
- Right hepatic duct.
- Tortuous, overlaying bile duct.
- Very short cystic duct.
**GALL BLADDER**

- Fibromuscular sac - stores & concentrates bile. Holds 50ml
- Lined by simple columnar epithelium. Mucous cells at neck only
- Veins directly to liver bed then to hepatic veins. Occasionally join the portal vein
- Lymphatics to porta hepatitis
- Parasympathetics & sympathetics (see liver)
- Anterior: liver and abdominal wall
- Posterior: transverse colon & 1st part of duodenum

**Diagram Notes**

- Body & branches of cystic artery
- Right branch of hepatic artery
- Right/left hepatic ducts to common hepatic duct
- Calot's triangle
- Fundus - under 9th costal cartilage in transpyloric plane
- Neck with mucous cells leading to mucosal folds giving the spiral valve of Heister. When there is a swelling like this it is called Hartmann's pouch, usually formed by the presence, or previous presence of a stone
- Cystic duct lying below artery
- Bile duct
  - 8mm x 8cm
- Cystic node to pre-aortic
- Hepatic artery - note that there are a few small arteries from bed of liver therefore there is no gangrene when cystic artery thromboses
LIVER - GENERAL DESCRIPTION

- Wedge shaped
- Largest organ in body
- Weight 1500g
- 1500 blood flow per minute (30% of cardiac output)
- Lies: Right - 6-10 ribs/costal cartilages; Left - 6-7 costal cartilages
- Surfaces: anterior, superior, posterior, right - all smooth/convex
- Postero-inferior (visceral) concave & features ++
- Supports: IVC & hepatic veins (+ ligamentum teres & peritoneum)
- Nerve supply: Right vagus via coeliac ganglia, left directly to porta hepatitis. Sympathetics on vessels
- Reaches: T5 vertebra, nipples (5th intercostal space), xiphisternal joint

ANTERIOR RELATIONS

- Against ribs 7-11 in mid-axillary line on right
- Right & anterior
- Lung
- Pleura
- Ribs

Oesophagus
Falciform ligament
Ligamentum teres (obliterated umbilical vein)
Gall bladder (9th costal cartilage)

INFERIOR SURFACE SEEN FROM ABOVE

- Attachment of lesser omentum & ligamentum venosum
- Oesophagus/Stomach
- Ligamentum teres
- Gall bladder
- Left lobe
- Bare area
- Porta hepatis
- Right lobe
- Kidney, suprarenal, colon
- Upper coronary ligaments
- Lower coronary ligaments
- IVC
- Diaphragm
- Right triangular ligament
GENITOURINARY SYSTEM DEVELOPMENT - 1

Left urogenital ridge giving
Genital ridge from which the gonad develops
Nephrogenic ridge from which the urinary tract develops

Mesonephric duct: Giving vasa efferentia, vas, epididymis, appendix epididymis in males. Epoophoron, paraepoophoron, Gartner’s duct in females

Paramesonephric duct: Giving tubes, uterus, upper vagina in females

NEPHROGENIC RIDGE

Long
Dorsal
Mesoderm
Degenerating
Mature functioning
Differentiating

PRONEPHROS
Cranial end, non-functioning, lasts for 2 weeks then disappears, primitive. Its duct is connected to the cloaca & is taken over by the mesonephros

MESONEPHROS
Functional, takes over pronephric duct which then becomes mesonephric duct

METANEPHROS
Gives finite kidney, invaded by ureteric bud which grows off mesonephric duct
The CLOACA is a structure common to both the alimentary and the urogenital systems. It is split coronally by the urorectal septum to give the rectum posteriorly and the primative urogenital sinus anteriorly, starting at 4 weeks and finishing by 6 weeks.

URETER & KIDNEY DEVELOPMENT

From the mesonephric duct, the ureteric bud grows upwards to fuse with the metanephros (the metanephrigenetic cap). Together the metanephros and the ureteric bud give the finite kidney. The bud gives the renal pelvis, collecting ducts and calices. The metanephrigenetic cap gives the renal substance.
GENITOURINARY SYSTEM DEVELOPMENT - 3

FATE OF THE UROGENITAL SINUS

UPPER PART

Vesicourethral canal
- Upper male & whole of female urethra

LOWER PART

Lower 2/3 vagina, prostate, rest of male urethra

Bladder epithelium

Muscle & connective from surrounding mesenchyme

SUMMARY

Endoderm of vesicourethral canal
Mesoderm of lower mesonephric duct
Surrounding mesenchyme

Bladder + upper female urethra + whole of male urethra

DISTAL MALE URETHRA

Ureteric bud

Vesicourethral canal

Mesonephric duct

Bladder

Urethra

Incorporation into posterior urethra and bladder

Ectoderm

Endoderm (urethral plate)

Urethral fold

Final urethra
**GONADAL VESSELS**

**IN MALE**
Gonadal artery crosses pelvic brim 1/2 way between sacro-iliac joint and inguinal ligament to reach the deep inguinal ring.

**IN FEMALE**
Gonadal artery enters suspensory ligament of ovary at pelvic brim.

**GONADAL VEINS**

**VARICOCELE**
Distension of the pampiniform plexus of veins above the testis occurs because of retrograde filling back down the left testicular vein. It is secondary to incompetence of the valve where the testicular vein joins the left renal vein, perhaps due to the angle of entry. Sigmoid colic pressure, adrenal products entering the vein or a renal tumour may all make a varicocele worse.
OVARY

- Almond shaped - cm x 2 cm
- Attached to posterior aspect of broad ligament by mesovarium
- Attached to uterus by ligament of ovary
- Attached to lateral pelvic wall by suspensory ligament of ovary
- Artery: Ovarian from aorta at L2
- Vein: Left to left renal. Right to inferior vena cava
- Lymphatics: Para-aortics. (Iguinal via round ligament & opposite ovary in disease)
- Nerves: Sympathetic from aortic plexus. Vasoconstriction & pain Parasympathetics from pelvic plexus (vasodilatory & sensory but activity not known)
- Development: Intermediate cell mass of genital ridge. Mesonephric remnants are epoophoron, paroophoron, Gaertner's duct

RELATIONS

Overlain by
Ileum
Sigmoid

Lies in
Fossa between bifurcation of common iliac artery

Psoas

Tube

Ovary with low columnar epithelium but NO peritoneum

Ovary nerve

Obturator internus

Obturator nerve

Lies on
Obturator nerve
External iliac vein
Obturator internus muscle/fascia

Oogonia (primordial germ cells) give primary oocytes. Add single layer of granulosa cells to give primary follicle. Add more layers to give secondary follicle (6 million of these by 5 months intrauterine, one million at birth, 40,000 at puberty). At maturation these secondary follicles give ovarian follicle. With meiosis these give secondary a oocyte (ovum)
TESTIS

- 400 spaces divided by fibrous septa
- Each contains 2-4 convoluted seminiferous tubules
- Tubules are 60cm long & drain to 15-20 vasa efferentia which drain to the epididymis and then to vas deferens
- Complete cycle of production takes 64-70 days
- Left testis lies slight lower than right
- Coverings: Skin, dartos (with sympathetic supply), Colles fascia, external spermatic fascia, cremasteric fascia, internal spermatic fascia, tunica vaginalis
- Blood supply: Testicular artery, cremasteric/vas artery
- Venous drainage: Pampiniform plexus to testicular vein
- Lymph: Para-aortic nodes
- Nerve: Sympathetic (greater/lesser splanchnics) via coeliac ganglia. No parasympathetics
- Cells: Interstitial (Leydig) for hormones
  Sertoli for support and Mullerian Inhibiting Substance
  Germ cells for spermatogonia, primary spermatocytes, meiosis, secondary spermatocytes, spermatids, sperm
SPERMATIC CORD

VIA THE DEEP INGUINAL RING
- Vas
- Artery to vas (inferior vesical)
- Testicular artery (aorta)
- Cremasteric artery (inferior epigastric)
- Cremasteric vein (inferior epigastric)
- Testicular vein (IVC/left renal)
- Obliterated processus vaginalis
- Lymphatics
- Sympathetics
- Genital branch of genitofemoral nerve (L2) Supplies motor to cremaster, sensory to fascia, tunica, scrotal skin, round ligament & labia majus

IN CANAL
- All these
- Internal spermatic fascia
- Cremasteric fascia
- Cremaster muscle
- Ilio-inguinal nerve

OUTSIDE SUPERFICIAL RING
- All these
- External spermatic fascia

External spermatic fascia from external oblique

Cremasteric fascia/muscle from internal oblique/transversus

Internal spermatic fascia from transversalis fascia

Ilio-inguinal nerve

Lymphatics (to ext iliacs)

- Testicular artery
- Testicular veins (pampiniform plexus)
- Sympathetics
- Lymphatics (to para-aortics)

- Cremasteric artery
- Cremasteric vein

- Genital branch of genitofemoral nerve

- Vas
- Artery/vein of vas
- Lymphatics (to int iliacs)
- Processus vaginalis (obliterated)
UTERUS - BROAD LIGAMENT

- Double layer of peritoneum draped over uterus and tubes
- Distal ends of tubes stick out of posterior layer of it and lie free
- Between two layers are arteries and veins, round ligament, ligament of ovary, lymphatics. The ovary is partially covered by a separate posterior fold of the broad ligament (mesovarium) but the surface of the ovary is devoid of peritoneum to allow exit of the ova.
- The tubes lie in the upper edge of the broad ligament which is termed the mesosalpinx
- The ureters pass through the base of the broad ligament in close relationship to the uterine artery

Suspectory ligament of ovary (fold of peritoneum on the lateral pelvic wall) containing ovary artery/vein lymphatics, autonomic

Ovarian artery with tubal branch

External iliac vessels

Superficial inguinal nodes via round ligament

Uterine artery in base of broad ligament, above ureter, at level of os

Vaginal artery

Transverse cervical ligament (condensation of pelvic fascia)

Lymphatics to external & internal iliac & sacral nodes

To para-aortic nodes
UTERUS - GENERAL

- Pear shaped
- Usually anteverted to 90 degrees & anteflexed to 170 degrees
- Has no submucosa
- Histology - Cervix: Tall columnar epithelium becoming squamous outside, alkaline mucus
  Rest of uterus: Endometrium with glands, arterioles, smooth whorls of muscle, columnar epithelium
- Nerves - Motor: Parasympathetic activate muscle
  Sympathetic relax muscle. Both from pelvic plexus
  Sensory: Parasympathetic for cervix
  Sympathetic for uterus
- Blood supply (see broad ligament)
- Venous drainage: Highly plexiform to vesical and rectal plexuses
  Relations: Anterior - vesicouterine pouch, posterior/superior bladder anterior fornix, small bowel
  Posterior - Pouch of Douglas, ileum, sigmoid
  Lateral - Uterine vessels, ureter, lateral fornix, broad ligament

- Fallopian tube, 10cm long
  Ciliated columnar epithelium
  Outer longitudinal & inner circular muscle
- Uterine part of tube piercing uterine wall
- Tube is open to peritoneal cavity
- Cervical canal
- Internal os
- External os
- Lateral fornix
- Fundus Cavity
- Cornu
- Ampulla
- Isthmus
- Infundibulum leading to fimbria
**UTERUS - SUPPORTS & DEVELOPMENT**

- Supports are condensations of fascia known as parametrium
- Suspensory ligament of ovary, round ligament & broad ligament are NOT supportive
- Ligaments:
  - LATERAL: Transverse cervical (cardinal, Mackenrodt's)
  - POSTERIOR: Uterosacral
  - ANTERIOR: Pubocervical
- Muscles: Pubovaginalis 7 puborectalis are part of levator ani
  Perineal body and urogenital diaphragm

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**DEVELOPMENT:**
- Mesonephric duct
  - Paramesonephric duct from intermediate cell mass giving tubes, uterus, upper third vagina

**MESONEPHRIC REMNANTS:**
- Blind tubules
  - Epoophoron in mesosalpinx
  - Paraepoophoron in base of broad ligament
  - Gaertner's duct in lateral fornix

- Anomalies
  - Bicornuate uterus
  - Unicollis (+/- rudimentary horn)
  - Cervical atresia
  - Vaginal atresia
VAGINA - GENERAL

- 10cm long
- Potential space apart from posterior fornix which is real space
- Fornices: Anterior, lateral & posterior
- Artery: Vaginal branch of uterine, middle rectal, inferior vesical gives vaginal
- Veins: Pelvic floor plexus to internal iliac
- Nerves: Sympathetic from pelvic plexus for vasoconstriction, smooth muscle action, stretch sensation
  - Somatic - perineal branches of pudendal, ilio-inguinal at anterior introitus
- Lymphatics: External/internal iliac, sacral, superficial inguinal below hymen
- Support: levator ani (pubovaginalis) & perineal body
- Structure: Non keratinising stratified squamous epithelium, smooth muscle, sweat glands, no mucous glands
- Development: Upper third from paramesonephric ducts
  - Lower third from urogenital sinus

Shape:
- Wider left to right at top
- Wider anterior to posterior at introitus

Posteriors
- Right
- Left

Lateral wall (shorter than posterior)

Anterior wall (shorter than posterior)

Anterior view

Peritoneum over posterior fornix

Sagittal view

Long posterior wall
VAGINA - RELATIONS

ANTERIOR
- Bladder
- Urethra

POSTERIOR
- Pouch of Douglas
- Ampulla of rectum
- Perineal body
- Anal canal

LATERAL
- Ureter
- Uterine artery
- Levator ani
- Urogenital diaphragm

VESTIBULE OF VAGINA

Greater vestibular glands

Deep perineal pouch

Superficial pouch containing:
- Hymen
- Greater vestibular glands (Bartholin's glands)

Interrupted line gives site of hymen
VAS & SEMINAL VESICLE

- 45cm (18") long (as is femur, thoracic duct, spinal cord, transverse colon & teeth to cardia of stomach!!!)
- Artery: Superior (or inferior) vesical artery
- Nerve: Sympathetic for motor activity
- Origin: Mesonephric duct
- Course: Nothing lies between vas and peritoneum in pelvis

RIGHT VAS

External iliac vessels
Obliterated umbilical artery

Inferior epigastric vessels in medial edge of deep inguinal ring
Ureter

From scrotum

Obturator neurovascular bundle & fascia

RIGHT SEMINAL VESICLE (posterior view)

Ampulla of vas (sperm store)
Right ejaculatory duct heading for verumontanum

- 70% of ejaculate
- Does not hold sperm
- Thin walled sac
- Covered by Denonvillier's fascia
- Artery: Vesical and middle rectal
- Origin: Mesonephric duct
- Nerve: Sympathetic from L1
- Muscle: Outer longitudinal, inner circular
INGUINAL CANAL

4 cm tunnel in lower abdominal muscles
Runs downwards/medially between
depth and superficial inguinal rings
Anterior wall: external oblique, &
internal oblique for lateral 1/3
Roof: conjoint tendon
Floor: inguinal ligament
Posterior wall: transversalis fascia &
conjoint tendon

Deep ring is a hole
in transversalis fascia
(at mid point of inguinal
ligament)

Superficial ring is
V shaped defect in
external oblique

Internal oblique from lateral
2/3 of inguinal ligament

Internal oblique partially
removed to show transversus
(purple - from 1/2 inguinal
ligament) & deep ring

External oblique
cut open

Conjoint
tendon

1/2

Cord

Interfoveolar
ligament (edge of transversalis
fascia)

Deep ring

POSTERIOR WALL

Transversalis fascia
Conjoint tendon

Inferior epigastric artery

Pectineal line
INGUINAL LIGAMENT

- Anterior superior iliac spine
- Edge curled under
- Pubic body
- Pubic ramus
- Pubic crest
- Pubic tubercle
- Lacunar ligament. Extends upwards/backwards onto pectineal line along which it extends to become the pectineal ligament (of Astley Cooper)

- External (superficial) inguinal ring
- Iliohypogastric nerve
- Intercreural fibres
- Lateral crus to pubic tubercle
- Medial crus to symphysis
- Reflected part of inguinal ligament (from lateral crus to linea alba)
- External spermatic fascia from edges of superficial ring, pierced by ilio-inguinal nerve

Ilio-inguinal nerve lying on internal oblique in canal
ILIOHYPOGASTRIC, ILIO-INGUINAL & GENITOFEMORAL NERVES

ILIOHYPOGASTRIC NERVE
- Main branch of L1
- Sensory and motor
- Pierces internal oblique above anterior superior iliac spine
- Pierces external oblique above superficial inguinal ring
- Supplies: • Upper buttock (lateral cutaneous branch)
  • Transversus & internal oblique (lowest fibres)
  • Skin of mons pubis

ILIO-INGUINAL NERVE
- Muscular collateral branch of L1
- Motor and sensory
- Pierces internal oblique above anterior superior iliac spine
- Supplies: • Transversus & internal oblique (lowest fibres)
  • Conjoint tendon
- Then enters inguinal canal from above/lateral and leaves via superficial inguinal ring
- Supplies: • Upper medial thigh, anterior 1/3 scrotum, labia majora and root of penis

Diagram:
- Iliohypogastric nerve
- Transversus/internal oblique
- Conjoint tendon
- Subcostal (T12)
- Femoral branch of genitofemoral (L1)
- Genital branch of genitofemoral (L2). Supplies cremaster muscle, all spermatic fascia & tunica vaginalis, +/- a small area of scrotum
ABDOMINAL WALL
RIGHT DEEP INGUINAL RING FROM INSIDE

Note: If the obturator artery is missing then the superior pubic branch of the inferior epigastric takes over. This artery is then called an abnormal (aberrant) obturator artery. Whether or not an abnormal obturator artery is present, the superior pubic branch of the inferior epigastric may run anteromedial to the sac of a femoral hernia in the femoral ring. If so, it can easily be damaged during a hernia repair. In this illustration it runs posterolateral and is thus not a hazard.
**SPERMATIC CORD**

**VIA THE DEEP INGUINAL RING**
- Vas
- Artery to vas (inferior vesical)
- Testicular artery (aorta)
- Cremasteric artery (inferior epigastric)
- Cremasteric vein (inferior epigastric)
- Testicular vein (IVC/left renal)
- Obliterated processus vaginalis
- Lymphatics
- Sympathetics
- Genital branch of genitofemoral nerve (L2) Supplies motor to cremaster, sensory to fascia, tunica, scrotal skin, round ligament & labia majus

**IN CANAL**
- All these
- Internal spermatic fascia
- Cremasteric fascia
- Cremaster muscle
- Ilio-inguinal nerve

**OUTSIDE SUPERFICIAL RING**
- All these
- External spermatic fascia

- Testicular artery
- Testicular veins (pampiniform plexus)
- Sympathetics
- Lymphatics (to para-aortics)

- Cremasteric artery
- Cremasteric vein

- Genital branch of genitofemoral nerve

- Vas
- Artery/vein of vas
- Lymphatics (to int iliacs)
- Processus vaginalis (obliterated)
LIVER - GENERAL DESCRIPTION

- Wedge shaped
- Largest organ in body
- Weight 1500g
- 1500 blood flow per minute (30% of cardiac output)
- Lies: Right -6-10 ribs/costal cartilages; Left - 6-7 costal cartilages
- Surfaces: anterior, superior, posterior, right - all smooth/convex
- Posterior-inferior (visceral) concave & features
- Supports: IVC & hepatic veins (+ ligamentum teres & peritoneum)
- Nerve supply: Right vagus via coeliac ganglia, left directly to porta hepatitis. Sympathetics on vessels
- Reaches: T5 vertebra, nipples (5th intercostal space), xiphisternal joint

ANTERIOR RELATIONS

- Against ribs 7-11 in mid-axillary line on right
- Right & anterior
- Lung, pleura, ribs
- Oesophagus
- Falciform ligament
- Ligamentum teres (obliterated umbilical vein)

Gall bladder (9th costal cartilage)

INFERIOR SURFACE SEEN FROM ABOVE

- Falciform ligament
- Attachment of lesser omentum & ligamentum venosum
- Oesophagus/stomach
- Ligamentum teres
- Gall bladder
- Kidney, suprarenal, colon
- Left lobe
- Bare area
- Porta hepatitis
- Right triangular ligament
DEVELOPS
- In ventral mesogastrium
- As foregut ventral diverticulum which grows into septum transversum & induces generation of hepatocytes
- Grows into vitelline veins so that cells are directly exposed to blood

LOBULES
- Hepatic lobule (anatomical lobule - central hepatic vein & 3 biliary triads)
- Portal lobule (physiological lobule - central triad radiating to 3 hepatic veins)

HISTOLOGY
- Incomplete endothelium
- Hepatic column
- Sinusoid
- Kupffer cell
- Bile canaliculus (no lining)
- Space of Disse
LIVER - FETAL CIRCULATION & HEPATIC VEINS

Blood returns from the placenta via left umbilical vein which joins the left branch of the portal vein. Most of the blood crosses over into the ductus venosus and hence to the inferior vena cava. Some blood enters the portal circulation and again reaches the inferior vena cava via the hepatic veins.

HEPATIC VEINS

These veins drain the "cleansed" blood back into the systemic circulation from the liver. They do not follow the portobiliary segmentation. The veins suspend the liver from the inferior vena cava and are helped by the peritoneal reflections.

Right vein draining right lobe
Left vein draining left lobe
Middle vein draining central liver
Accessory veins drain the liver directly into the (opened) IVC

Portal veins right/left branches
Ductus venosus becoming ligamentum venosum
Left umbilical vein (via falciform ligament) becoming ligamentum teres
Inferior vena cava
The **porta hepatitis** is the area on the under surface of the liver at which the structures in the free edge of the lesser omentum enter/leave the liver. Peritoneum is reflected around it. It contains the following structures:
- Portal vein
- Left/right branches of hepatic artery
- Left/right hepatic ducts
- Lymphatics and lymph nodes
- Autonomic nerves

**Porta hepatitis**

**Hepatic artery left/anterior**

**Bile duct right/anterior**

**Portal vein central/posterior**

**Cross (axial) section of free edge of lesser omentum looking up**

**Right**

**Anterior**

**Left**

**Structures as indicated above**

**Entry to lesser sac**

**IVC**

**Posterior**

**PRINGLE'S MANOEUVRE**
Manual compression of free edge of lesser omentum to occlude hepatic artery
A diverticulum grows from the ventral wall of the duodenum which differentiates into hepatic ducts and liver. A second diverticulum from the hepatic duct gives the gall bladder and cystic duct. Pancreas develops from ventral and dorsal buds.

**Hepatic duct**

**4 weeks in utero**

**Gall bladder**

**Ventral pancreatic bud**

**Dorsal pancreatic bud**

**Bile duct**

**5-6 weeks in utero**

**Ventral bud swings around posteriorly**

**Main pancreatic duct starts to connect to duct of ventral bud**

**Original opening of dorsal bud now becomes opening of accessory duct**

**Opening of ventral bud now becomes ampulla of vater**

**Accessory duct (Santorini)**

**Main duct (Wirsung)**

**Uncinate process. Superior mesenteric vessels are trapped between it and main pancreas**

**Final arrangement**

**Note:** Endocrine cells invade tissue at around 3 months in utero & begin activity around 5 months in utero.
PANCREAS - GENERAL

- Exocrine volume much greater than endocrine
- Lies retroperitoneal, largely in the transpyloric plane
- 15 cm long, lobulated with fine capsule
- Alveoli of serous secretory cells lead to ductules then to principal ducts
- Islets of Langerhans lie between alveoli
- Main duct (Wirsung) leads to ampulla of Vater
- Accessory duct (Santorini) from uncinate process opens proximally, may be absent, often communicates with main duct
- Arteries: Gastro-duodenal, inferior/superior pancreaticoduodenal, arteria pancreatica magna from splenic
- Veins: Pancreaticoduodenal. Superior to portal, inferior to superior mesenteric
- Lymphatics: in groove between head and duodenum & root of superior mesenteric artery and vein
- Nerves: Parasympathetic (posterior vagus) to stimulate exocrine secretion. Sympathetic for vasoconstriction and pain
- Secretion: Secretin & cholecystokinin (from small bowel) cause release of trypsin, lipase, bicarbonate. Alpha islet cells give glucagon, beta cells give insulin, delta give somatostatin
PANCREAS - RELATIONS

Anterior: lesser sac, pylorus, 1st part of duodenum, superior mesenteric artery & vein, transverse mesocolon, stomach
Superior: splenic artery
Lateral on right: 2nd part of duodenum, ampulla of Vater
Lateral on left: hilum of spleen
Posterior: left crus of diaphragm, psoas, right renal vein, inferior vena cava, bile duct, spleen, left renal vessels, left kidney, left suprarenal gland, coeliac plexus, inferior mesenteric vein, splenic vein, portal vein, superior mesenteric artery & vein, aorta
ATTACHMENTS OF MESENTERIES WITH BOWEL EXCISED

The purpose of this diagram is to illustrate the width of the 'bare area' of peritoneum that would be left on the posterior abdominal wall if the bowel was excised. If the pink area is narrow then the bowel was on a mesentery. If it is wide then the bowel was retroperitoneal. Note that the majority of the duodenum has been left undisturbed.

- Right subphrenic space
- Left subphrenic space
- Meso-oesophagus
- Lienorenal & gastro-splenic ligaments
- Phrenicocolic ligament
- Left paracolic gutter
- Left infracolic compartment
- Caecal mesentery
- Small bowel mesentery
- Intersigmoid fossa alongside sigmoid mesocolon (1/2 way along pelvic brim to S3 mid-line)

Note: lesser sac is left subhepatic space

Note: Small bowel mesentery runs from the left L2 transverse process to the right sacro-iliac joint (S2). It is 6 inches (15cm) long and crosses left psoas, aorta, IVC, right psoas, right ureter, right common iliac bifurcation & into right iliac fossa.
Lienorenal & Gastroplenic Ligaments

**Lienorenal Ligament**
- Splenic artery
- Splenic vein
- Tail of pancreas

This area related to stomach

Posteromedial to spleen

**Gastroplenic Ligament**
- Left gastro-epiploic
- & short gastric arteries

Left gastro-epiploic artery

Short gastric arteries

Lienorenal ligament

Stomach

Left kidney
DEVELOPMENT OF LESSER SAC

A

B

C

Pretend a large balloon is inserted into the abdomen via the umbilicus (A) & inflated to cover contents. It extends around liver but is prevented from completely surrounding it by attachments of inferior vena cava - hence bare area. It covers stomach (S), colon (C) & small bowel (SB).

Between stomach & colon there is a prolapse of peritoneum - greater omentum.

Small bowel moves forwards (B), & its covering peritoneum is dragged with it to give a mesentery. Stomach rotates so that its right side is now facing posteriorly (E, F, G). Peritoneum that was on its right side (grey) expands behind stomach to give lesser sac. It pushes up behind liver, covered posterior wall of stomach, upper wall of transverse colon & 1/2 pancreas. It also pushes between layers of greater omentum to give 4 layers.

Access to lesser sac becomes a small hole (C) as the stomach rotates in coronal plane (G). The hole is posterior to lesser omentum & is aditus (opening) of lesser sac/foramen of Winslow/epiploic foramen. Lesser omentum is remnant of ventral mesentery (D, E, F, G) joining stomach to liver (C).

Note: Spleen forms in dorsal mesentery of stomach (G) & thus is in far left wall of lesser sac. Liver develops (not shown) similarly in the ventral mesentery.
PERITONEAL CAVITIES AND LESSER SAC

- Subphrenic space
- Bare area of liver
- Midline sagittal view of abdomen
- Lesser sac
- Lesser omentum
- Pancreas
- gastrocolic omentum
- Transverse mesocolon
- Duodenum (retroperitoneal)
- 4 layers of greater omentum
- Small bowel mesentery
- Greater sac

Opening of lesser sac (foramen of Winslow)

Arrows indicate the structures that are covered by the peritoneum on the posterior wall of the lesser sac

Meso-oesophagus & left triangular ligament

Retroperitoneum

Gastroplenic ligament

Lienorenal ligament

Caudate lobe

Portal vein

IVC

Foramen (above) viewed from in front and foramen (below) viewed the right side
PERITONEAL RECESSES

There are a number of small recesses, as shown below, that are potential areas for internal herniation of bowel or other structures.

Ligament of Treitz
Thin band of smooth muscle from right crus, passing anterior to aorta/renal vessels but behind pancreas, to blend with outer coat of duodenojejunal flexure.

- Superior duodenal fold & recess
- Paraduodenal fold & recess
- Inferior duodenal fold & recess
- Inferior mesenteric vein
- Retroduodenal recess
- Ascending colon
- Caecal fold
- Inferior ileocaecal recess. Under vascular fold of caecum
- Superior ileocaecal recess. Under ileocaecal fold (bloodless fold of treves)
- Retrocaecal recess
- Meso-appendix
**PELVIS - GENERAL**

- True pelvis is below pelvic brim
- False pelvis is above pelvic brim

**LATERAL WALL**
- Ilium, ischium, pubis
- Obturator membrane & internus muscle
- Sacrotuberous & sacrospinous ligaments
- Pelvic fascia
- Piriformis

**ANTERIOR WALL**
- Symphysis pubis
- Body of pubis
- Pubic rami

**POSTERIOR WALL**
- Sacrum
- Coccyx
- Piriformis
- Sacral plexus
- Sacral fascia

**White line for attachment of levator ani**

**Other**
- Obturator
  - foramen
  - membrane
  - muscle (internus)
  - fascia
  - canal
- Piriformis
- Sacrospinous ligament
- Sacrotuberous ligament
- Superficial transverse perinei
- Ischiocavernosus
PELVIC FLOOR

- Covered superiorly and inferiorly with fascia (epimysium)
- Nerve supply for levator ani is perineal branch of S4, S5 for coccygeus
SCIATIC FORAMINA
STRUCTURES ENTERING & LEAVING

LEAVING GREATER SCIATIC FORAMEN
- Superior gluteal nerve (L4,5,S1) & vessels
- Piriformis muscle (S1,2)
- Inferior gluteal nerve (L5,S1,2) & vessels
- Sciatic nerve (L4,5,S1,2,3)
- Posterior femoral cutaneous nerve (S1,2,3)
- Perforating cutaneous nerve (S2,3)
- Nerve to quadratus femoris (L4,5,S1)
- Nerve to obturator internus ((L5,S1,2)
- Pudendal nerve (S2,3,4)
- Internal pudendal artery

ENTERING LESSER SCIATIC FORAMEN
- Internal pudendal artery
- Pudendal nerve
- Nerve to obturator internus

EXITING LESSER SCIATIC FORAMEN
- Tendon of obturator internus
- Internal pudendal vein
# PELVIC BONES - SEX DIFFERENCES

Looking at the pelvic bones it should be possible to tell whether they come from a male or a female. Many of the pointers here will be helpful. Remember that the purpose of bones is to give form, provide muscle attachments, give protection, provide movement and they also have metabolic functions.

<table>
<thead>
<tr>
<th>FEMALE</th>
<th></th>
<th>MALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not so heavy</td>
<td>BUILD</td>
<td>Heavy</td>
</tr>
<tr>
<td>Short segment of long cone</td>
<td>SHAPE</td>
<td>Long segment of short cone</td>
</tr>
<tr>
<td>Gynaecoid</td>
<td>INLET</td>
<td>Android</td>
</tr>
<tr>
<td>1/3 1/3 1/3</td>
<td>SACRUM</td>
<td>1/4 1/2 1/4</td>
</tr>
<tr>
<td>&gt;90° SUBPUBIC ANGLE</td>
<td>&lt;90°</td>
<td>Round</td>
</tr>
<tr>
<td>Oval CANAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal</td>
<td>MUSCLE MARKINGS</td>
<td>Marked</td>
</tr>
<tr>
<td>Smooth</td>
<td>ISCHIOPubic CREST</td>
<td>Rough (crenula)</td>
</tr>
<tr>
<td>Elongated (triangular)</td>
<td>OBTURATOR FOSSA</td>
<td>Rounded (oval)</td>
</tr>
<tr>
<td>Nearly right angled</td>
<td>GREATER SCIATIC NOTCH</td>
<td>Less than right angle (J shaped)</td>
</tr>
<tr>
<td>Greater</td>
<td>PUBIC TUBERCLE TO ACETABULAR MARGIN V DIAMETER OF ACETABULUM</td>
<td>Equal or less</td>
</tr>
</tbody>
</table>

**OUTLET:** From coccyx to inferior border of symphysis pubis

**INLET:** From promontary ot sacrum to superior border of symphysis pubis
Male Perineum - Vessels and Nerves

This rather complicated diagram below depicts the arrangement of vessels and nerves in the male perineum but it largely applicable to both sexes. The grey wedge represents the urogenital diaphragm seen from below. The small diagram is the key to the larger one to show the orientation.

Branches of the perineal nerve
1. Deep transverse perinei & external sphincter
2. Ischiocavernosus
3. Bulbospongiosus
4. Sensory to urethra
5. Superficial transverse perinei
6. Posterior scrotal/labial

Dorsal artery/nerve of penis
Artery to bulb
Deep artery of penis
Urethral artery
Transverse perineal artery
Perineal branch
Internal pudendal artery
Dorsal artery of penis
Alcock's canal
Deep dorsal vein of penis
Branches to corpus cavernosum

Medial/lateral posterior scrotal (labial) artery/nerve to posterior 2/3 scrotum. Connects with inferior rectal & branches of posterior femoral cutaneous nerve

Nerves shown on one side & arteries on other
Dorsal nerve of penis
Perineal branch
Pudendal nerve

Intermediate rectal artery/nerve to external sphincter, anal canal & circum-anal skin
ISCHIOANAL (ISCHIORECTAL) FOSSA

- Wedge shaped & filled with fat
- Crossed by inferior rectal nerve & artery
- Has Alcock’s canal in its lateral wall
- Base: Perineal skin
- Medial: Anal canal, levator ani
- Lateral: Ischial tuberosity, obturator internus
- Apex: White line
- Anterior: Perineal body, urogenital diaphragm, anterior recess
- Posterior: Posterior recess, gluteus maximus, sacrotuberosus ligament, anococcygeal body, horseshoe connection
- Contains: Fat, Alcock's (pudendal) canal, internal pudendal artery, pudendal nerve, inferior rectal artery/nerve, perineal branch of S4, perforating cutaneous nerve
**Female Perineum Vessels and Pouches**

**Blood Supply**
- Internal pudendal artery
  - Inferior rectal artery
  - Dorsal artery of clitoris

**Nerve Supply**
- Pudendal nerve
  - Inferior rectal
  - Dorsal nerve of clitoris

**Muscular Branches**
- Artery to bulb
- Muscular branches

**Deep Perineal Pouch** (between perineal membrane below & superior fascia of urogenital diaphragm above)
- Vagina
- Deep transverse perinei
- Urethra
- Dorsal nerve of clitoris
- Sphincter
- Dorsal/deep clitoral arteries urethrae

**Superficial Perineal Pouch** (everything below perineal membrane)
- 2 crura & ischiocavernosus
- Bulb & bulbospongiosus
- Superficial transverse perinei
- Perineal body
- Perineal artery/nerve/branches
- Vestibular glands

**Coronal Section** through urogenital diaphragm at level of vagina
**Female Perineum - General**

- The perineum is that part of the trunk distal to the pelvic diaphragm.
- 2 triangles lying at nearly a right angle to each other
  - Urogenital - covered in below with urogenital diaphragm
  - Anal - covered only with skin & fascia (+/- gluteus maximus)

**Diagram**

- Bulb of vestibule covered by bulbospongious (removed)
- Perineal membrane
- Posterior edge of urogenital diaphragm
- Internal pudendal artery, pudendal nerve & branches
- Gluteus maximus
- Anococcygeal body

**Legend**

- # Ischiocavernosus overlying crus
- ★ Arrow indicates anterior recess of ischioanal recess

**Greater Vestibular Glands (Bartholin)**
Round (<1cm) glands at 4 & 8 o’clock behind bulb, 2cm duct into posterolateral vaginal orifice. In superficial perineal pouch.
Homologues of Cowper’s glands in males. Cysts & infection possible

**Paraurethral Glands (Skene)**
Mucous glands opening just inside urethra. Homologue of prostate

**Lesser Vestibular Glands**
Not shown. Multiple small mucous glands opening between vagina & urethra

**Labia Majora** - joined back & front by anterior & posterior commissures. Round ligament of uterus ends in front of each.

**Labia Minora** give clitoral prepuce. **Clitoris** - 2 small corpora cavernosa. **Bulb** - spongy erectile tissue in labia minora.
Deep perineal pouch (between perineal membrane below & superior fascia of urogenital diaphragm above). Contains
- Membranous urethra
- Deep transverse perinei
- Sphincter urethrae (external sphincter)
- Bulbourethral glands (Cowper's). They drain into urethra below the perineal membrane
- Internal pudendal vessels
- Dorsal nerve of penis
- Note that the external sphincter has striated muscle extensions around lower prostatic urethra, above the urogenital diaphragm that are called the intrinsic urethral mechanism
PENIS - CONSTITUENT PARTS & URETHRA

URETHRA
- Prostatic approximately 2.5cm
- Membranous 2cm
- These two together make the posterior urethra
- Bulbous & pendulous make the anterior urethra. Approximately 20cm
- Blood: Artery to bulb to glans & corpus spongiosum
  Deep artery to penis to corpus cavernosum
  Dorsal artery of penis to skin, fascia, glans
  Urethral artery from dorsal artery
- Veins: Superficial & deep dorsal veins of penis
- Lymph: Skin to superficial inguinal nodes, glans, corpora, urethra
  to deep inguinal nodes
- Nerves: Skin & glans from posterior scrotal & dorsal nerve of penis
  from pudendal. Sympathetics for ejaculation, parasympathetics to corpora for erection.
- Receives: Ejaculatory ducts, bulbo-urethral glands, urethral glands

Suspenory ligament of penis (fibrous tissue from pubis to tunica)
Pierced by deep dorsal vein
SACRUM - POSTERIOR ATTACHMENTS & DURAL SAC

- Posterior view of sacrum
- Laminae
- Median spinous crest
- Articular facet
- Medial articular crest (fused articular processes)
- Sacro-iliac joint (plane-synovial)
- Lateral transverse crest (fused transverse processes)
- Posterior & middle layers of lumbar fascia
- Gluteus maximus
- Sacrospinous ligament
- Erector spinae
- Sacrotuberous ligament
- Posterior sacro-iliac ligament
- Sacral cornua & hiatus (a superficial part of the posterior sacrococcygeal ligament closes this off)

SACRAL Dimple
- S2
- End of dural sac
- Posterior inferior iliac spine
- Mid sacro-iliac joint

Lateral view of sacrum
- Spinal cord ends at lower border of L1
- Dural sac (subarachnoid space) ends at S2. It contains CSF, nerve roots & filum terminale (pia that extends to the coccyx)
- Extradural space below S2 with loose fat and veins
- Anterior/posterior sacrococcygeal ligaments
- Pubococygeus
- Iliococcygeus
- Coccygeus
SACRUM - GENERAL & SACRO-ILIAC JOINT

- 5 fused vertebrae (may be 6 or 7)
- L5 may be sacralised
- Spinabifida occulta common
- Iliolumbar ligament from iliac crest to tip of 5th lumbar transverse process. Quadratus lumborum arises from it

Lateral view

Posterior sacro-iliac ligament strong ++

Viewed from above

Anterior sacro-iliac ligament (thickening of joint capsule) weaker

All these ligaments need to be strong to prevent sacrum sliding forwards

Sacro-iliac joint jagged surfaces minimal movement but synovial

Anterior view

Attachment of pelvic (Waldeyer’s) fascia

Central mass

Median sacral artery

Sympathetic chain

Piriformis (lateral mass & costotransverse bar of 2,3,4)

Anterior rami

Order of structures from posterior to anterior is:
Bone, periosteum, piriformis, anterior ramus, pelvic fascia, lateral sacral artery, branches of iliac artery, ureter, peritoneum, bowel
SPLAEN - GENERAL

- Size of a fist (1 x 3 x 5 inches) 2.5cm x 8cm x 13cm
- 200g in weight. Lies on ribs 9-11
- Part of the reticuloendothelial system
- Becomes palpable when it is twice normal size
- Thin capsule, has notch & moves on respiration (cf. kidney)
- Functions: Erythropoiesis, effete erythrocyte removal, immune defence (beta cells) and blood storage
- Blood supply: Splenic artery from coeliac trunk
- Venous drainage: Splenic vein to portal system
- Lymph: Coeliac (para-aortic)
- Nerve: Sympathetic from coeliac plexus

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Note: lower pole is normally no further anteromedial than mid axillary line
Spleen - Relations & Development

Relations:
- Diaphragm
- Left margin of lesser sac
- Stomach
- Phrenicocolic ligament
- Left kidney
- Pancreas, splenic vein & artery
- Splenic flexure of transverse colon

Development:
In dorsal mesoderm in dorsal mesogastrium

Right:
- Ventrum
- Stomach
- Developing spleen
- Dorsum
- Far left margin of lesser sac

Left:
- Gastroplenic ligament
SUPRARENAL (ADRENAL) GLANDS

- Medulla: Neural ectoderm
- Cortex: Mesoderm
- Lie: Outside Gerota's fascia
- Colour: Yellowy/brown
- Arteries: Suprarenal direct from aorta. Branches of inferior phrenic and renal
- Veins: Right short to inferior vena cava, left to renal
- Shape: Right pyramidal (hat-shaped)
  Left crescentic (cup-shaped)

RELATIONS

Anterior: Right lobe of liver
Inferior vena cava
Anterior: Lesser sac
Stomach
Posterior: Right crus of
diaphragm
Posterior: Left crus of diaphragm

Medial: Coeliac ganglia
Inferior phrenic arteries

Note: The short length of the right suprarenal vein can make it difficult to ligate it at surgery. The right gland is tucked up under the inferior vena cava.
BLADDER - GENERAL

- Epithelium: Transitional - Rubberly, watertight, lax, stretchy, no glands
- Muscle: Whorls of smooth muscle - detrusor
- Arteries: Superior/inferior vesical, obturator, inferior gluteal, uterine, vaginal
- Veins: Converge to vesicoprostatic plexus in males
  Converge to plexus at base of broad ligament in female
  Then to internal iliac
- Lymphatics: Internal & external nodes
- Nerves: Sympathetic (male only at bladder neck) closes bladder neck at ejaculation. Inhibitory, vasomotor, pain in both sexes
  Parasympathetic - motor to detrusor, sensory for full bladder, some pain, autonomic stretch reflex in infants, later modified by cortical inhibition

Ureter enters bladder obliquely to give submucosal tunnel which prevents reflux back up the ureter

Median umbilical ligament (urachus)
Apex
Fundus
Base
Neck
Retropubic space (cave of Retzius)

Trigone
- Flat
- Triangular
- Ureteric orifices at superior angles
- Bladder neck at inferior angle
- Interureteric bar (2-5cm)
GENITOURINARY SYSTEM DEVELOPMENT - 1

Left urogenital ridge giving
Genital ridge from which the gonad develops
Nephrogenic ridge from which the urinary tract develops

Mesonephric duct  Giving vasa efferentia, vas, epididymis, appendix epididymis in males. Epoophoron, paroepophoron, Gartner’s duct in females

Parameresonephric duct  Giving tubes, uterus, upper vagina in females

NPHROGENIC RIDGE
Long
Dorsal
Mesoderem

Degenerating
Mature functioning
Differentiating

PRONEPHROS
Cranial end, non functioning, lasts for 2 weeks then disappears, primitive. Its duct is connected to the cloaca & is taken over by the mesonephros

MESONEPHROS
Functional, takes over pronephric duct which then becomes mesonephric duct

METANEPHROS
Gives finite kidney, invaded by ureteric bud which grows off mesonephric duct
The CLOACA is a structure common to both the alimentary and the urogenital systems. It is split coronally by the urorectal septum to give the rectum posteriorly and the primitive urogenital sinus anteriorly, starting at 4 weeks and finishing by 6 weeks.

URETER & KIDNEY DEVELOPMENT

From the mesonephric duct, the ureteric bud grows upwards to fuse with the metanephros (the metanephrogenic cap). Together, the metanephros and the ureteric bud give the finite kidney. The bud gives the renal pelvis, collecting ducts and calices. The metanephrogenic cap gives the renal substance.
GENITOURINARY SYSTEM DEVELOPMENT - 3

FATE OF THE UROGENITAL SINUS

UPPER PART
- Vesicourethral canal
  - Upper male & whole of female urethra

LOWER PART
- Bladder epithelium
  - Muscle & connective from surrounding mesenchyme

Lower 2/3 vagina, prostate, rest of male urethra

SUMMARY
- Endoderm of vesicourethral canal
- Mesoderm of lower mesonephric duct
- Surrounding mesenchyme

Bladder + upper female urethra + whole of male urethra

DISTAL MALE URETHRA
- Ectoderm
- Endoderm (urethral plate)
  - Urethral fold
  - Final urethra

Incorporation into posterior urethra and bladder

Ureteric bud
- Mesonephric duct
- Vesicourethral canal
- Bladder
- Ureter
- Vas
KIDNEYS - GENERAL

- 120g each, 11x6x4cm, 1200ml blood/minute
- Retroperitoneal, move 2.5cm on respiration
- Pelvis faces medially/anterior
- 1 million nephrons/kidney
- Lymphatics to para-aortics
- Sympathetic from T12-L1 for vasoconstriction & pain
- Parasympathetics from vagus. Function unknown

Order of structures from anterior to posterior V-A-U (vein, artery, ureter)

Left renal vein is longer making left nephrectomy easier

Segmental blood supply (Polar & capsular vessels give minimal collateral supply)
KIDNEY - RELATIONS

Note: The perirenal fascia is attached around the renal pelvis but is open below so that pus or extravasated urine can track inferiorly.

Cross (axial) section of left side looking up
- Posterior
- Erector spinae
- Quadratus lumborum
- Lumbar fascia
- Perinephric fascia (Gerota's)
- Perinephric fat
- Fibrous capsule
- Inferior vena cava
- Aorta
- Pancreas
- Peritoneum

Posterior relations both sides
- Diaphragm & costodiaphragmatic recess

Rib 12, subcostal neurovascular bundle - vein, artery, nerve
- Quadratus lumborum
- Psoas

Anterior relations
- Suprarenal glands
- Spleen & its vessels
- IVC
- Stomach
- 2nd part duodenum
- Small bowel
- Splenic flexure
- Hepatic flexure

= peritoneal covering
PROSTATE - DEVELOPMENT

Endodermal outpouch of glands from urethral part of the orogenital sinus. Fibromuscular stroma forms from the surrounding mesenchyme. Female equivalent is paraurethral glands.

Between 13-15 weeks the cords develop a lumen and glandular acini under the influence of high levels of dihydrotestosterone. The tissue is invaded by blood vessels and autonomic nerves.

Bulbo-urethral glands develop in deep perineal pouch by lateral budding from urethra.

At 16 weeks there is the classical layering of ducts into mucosal (periurethral) opening directly into urethra (1). Plus short ducts from submucosal glands, also in central zone (2). In peripheral zone are main prostactic ducts from para-urethral glands (3).

Vesicle
Vas
Inner (central) zone - glands develop later
Outer (peripheral) zone - glands develop here first, mostly lateral

Posterior prostatic urethral wall
Verumontanum
Urethral crest
Ejaculatory ducts
Prostatic ducts
Prostatic utricle (utriculus masculinis - Mullerian)
PROSTATE - GENERAL

- Produces 30% of ejaculate volume
- Pyramidal, size of a chestnut (2×3×4 cm)
- Has a posterior groove
- Apex on pelvic floor, base above
- Arteries: Inferior vesical, middle rectal, +/- pudendal
- Veins: Plexus around sides & base of gland to internal iliac
- Nerves: Sympathetic for ejaculation & smooth muscle contraction
  Parasympathetic for erection & secretomotor of acini

Apex is the most inferior part of the prostate (lateral to it, on each side, is the inferolateral surface)
PROSTATE - LOBES

There are two ways of viewing the lobes of the prostate

Old surgical view:
- Anterior lobe
- Middle lobe
- Posterior lobe (lateral extensions of which gave lateral lobes which were only significant if the prostate was hypertrophied)

Modern zonal view:
- True capsule (outside which is a false capsule of pelvic fascia)
- Posterior lobe with lateral extensions
- Dorsal vein of penis draining into prostatic venous plexus then vesico-prostatic plexus then iliac veins

Now the lobes are arranged in zones
- A central zone, above the ejaculatory duct, with a middle lobe and part of the anterior lobe
- A peripheral zone, below the ejaculatory duct with posterior and lateral lobes
• 25cm long  
• Kidney to bladder  
• Posterior: Psoas, genitofemoral nerve, sacroiliac joint, common iliac artery bifurcation  
• Anterior: Right- Duodenum, right gonadal artery, right colic artery, ileal mesentery, superior mesenteric artery  
  Left- Left gonadal artery, left colic artery, sigmoid mesentery  
• Passing under it: Vas, uterine artery  
• Related to it: Lateral fornix in female  
• Blood supply: Renal, gonadal, common iliac, vesical, vaginal & occasional small branches from aorta  
• Nerves: Autonomic  
• Points of potential hold up: Pelviureteric junction, pelvic brim, ureterovesical junction  

It is recognisable as it:  
• Is the most superficial structure in the pelvis  
• Shows peristalsis  
• Sticks to the posterior surface of the peritoneum  
• Passes around the pelvic brim to 1cm short of the ischial spine the swings medially.  
• Enters the bladder at the level of the pubic tubercle on a plain abdominal X-ray
URETHRA

- Prostatic approximately 2.5cm
- Membranous 2cm
- These two together make the posterior urethra
- Bulbous & pendulous make the anterior urethra. Approximately 20cm
- Blood: Artery to bulb to glans & corpus spongiosum
  - Deep artery to penis to corpus cavernosum
  - Dorsal artery of penis to skin, fascia, glans
  - Urethral artery from dorsal artery
- Veins: Superficial & deep dorsal veins of penis
- Lymph: Skin to superficial inguinal nodes. Glans, corpora, urethra to deep inguinal nodes
- Nerves: Skin & glans from posterior scrotal & dorsal nerve of penis from pudendal. Sympathetics for ejaculation, parasympathetics to corpora for erection.
- Receives: Ejaculatory ducts, bulbourethral glands, urethral glands

Suspensory ligament of penis
(fibrous tissue from pubis to tunica)
Pierced by deep dorsal vein

Deep artery of penis

Artery to bulb

Bulb

Bulbo-urethral glands

Navicular fossa with Littre glands & ducts pointing upstream, anterior & lateral. Meatus is antero-posterior slit

Blood for glans from dorsal artery & artery to bulb
LUMBOSACRAL SYMPATHETICS

Lumbar & sacral splanchnic nerves leave the sympathetic chain ganglia as preganglionic fibres. They do not synapse if they are destined to go to the gut. They synapse later in the hypogastric and pelvic plexuses.

L1
L2
L3
L4
L5
S1
S2
S3
S4
S5

Spinal nerve
Visceral branch

Lumbar splanchnics (L1-5)
Aortico-renal ganglia
Superior hypogastric plexus

Sacral splanchnics (S1-5)

Hypogastric nerves (mixed pre/post ganglionic)

All preganglionic visceral branches

Inferior hypogastric plexuses (pelvic plexus)

Somatic nerve
ABDOMINOPELVIC AUTONOMICS

See Instant Anatomy for further detail

GSN: Greater splanchnic nerve
LRSN: Lesser splanchnic nerve
LTSN: Least splanchnic nerve
CG: Coeliac ganglion
ARG: Aorticorenal ganglion
RP: Renal plexus
SRP: Suprarenal plexus
AAP: Abdominal aortic plexus
IMP: Inferior mesenteric plexus
SHP: Superior hypogastric plexus
IHP: Inferior hypogastric plexus
ABDOMINAL REFERRED PAIN

There are two types of referred pain. The first is detected by visceral sensory fibres travelling with the sympathetic systems such as bowel irritation, distension or inflammation. This is carried back to the sympathetic chain & spinal cord at the relevant level & referred to the appropriate dermatome. For instance, pain from the foregut (e.g. stomach) is referred to T5-9 dermatome (epigastrium) via the greater splanchnic nerves, small bowel problems to the peri-umbilical region via lesser splanchnic nerves & large bowel to suprapubic region via least splanchnic nerves. Pain is midline as gut is embryologically a midline structure. Kidneys (renal pain) can lateralise as they are not of midline origin. Note that pain from some pelvic organs (e.g. uterus) travels via the parasympathetics (S2,3,4) to give backache.

A second type of referred pain involves the somatic system only. The best example is irritation of the peritoneum over an inflammed gall bladder which is detected by the phrenic nerve (C3,4,5). The pain is then referred to the shoulder tip via the C4 dermatome, also somatic. It is only because the C4 nerve has two areas of distribution so far away from each other that this type of referred pain occurs.

Foregut pain referred to epigastrium via greater splanchnic nerves (T5-9)

Midgut pain referred to peri-umbilical region via lesser splanchnic nerves (T10,11). Only when the parietal peritoneum (somatic) over the appendix becomes inflammed does the pain localise into the right iliac fossa

Hindgut pain referred to suprapubic region via least splanchnic nerves (T12)
DERMATOMES OF THORAX AND ABDOMEN
ILIOHYPOGASTRIC, ILIO-INGUINAL & GENITOFEMORAL NERVES

ILIOHYPOGASTRIC NERVE
- Main branch of L1
- Sensory and motor
- Pierces internal oblique above anterior superior iliac spine
- Pierces external oblique above superficial inguinal ring
- Supplies:
  - Upper buttock (lateral cutaneous branch)
  - Transversus & internal oblique (lowest fibres)
  - Skin of mons pubis

ILIO-INGUINAL NERVE
- Muscular collateral branch of L1
- Motor and sensory
- Pierces internal oblique above anterior superior iliac spine
- Supplies:
  - Transversus & internal oblique (lowest fibres)
  - Conjoint tendon
- Then enters inguinal canal from above/lateral and leaves via superficial inguinal ring
- Supplies:
  - Upper medial thigh, anterior 1/3 scrotum, labia majora and root of penis

Genital branch of genitofemoral (L2). Supplies cremaster muscle, all spermatic fascia & tunica vaginalis, +/- a small area of scrotum
SACRAL PLEXUS

L4,5, S1, 2, 3, 4, 5

On piriformis and covered by parietal pelvic fascia

See peripheral nerve section of Instant Anatomy for full details
There are 6 branches from the sacral roots before they divide into anterior and posterior divisions. They all begin with the letter “p”:

6 BRANCHES OF THE SACRAL ROOTS
- Nerve to piriformis (S1, 2)
- Perforating cutaneous nerve (S2, 3)
  (perforates sacrotuberous ligament)
- Posterior femoral cutaneous nerve (S1, 2, 3)
- Pudendal nerve (S2, 3, 4)
- Perineal branch of S4 (to levator ani)
- Pelvic splanchnics (S2, 3, 4)
  - Parasympathetic motor to bladder, hind gut, erection.
  - Sensory for distension & pain of bladder, lower uterus, lower colon & rectum

FROM ANTERIOR DIVISIONS
- Nerve to quadratus femoris (L4, 5, S1)
- Nerve to obturator internus (L5, S1, 2)
- Tibial portion of sciatic nerve (L4, 5, S1, 2, 3)

FROM POSTERIOR DIVISIONS
- Superior gluteal (L4, 5, S1)
- Inferior gluteal (L5, S1, 2)
- Common peroneal portion of sciatic nerve (L4, 5, S1, 2)
UTERUS - BROAD LIGAMENT

- Double layer of peritoneum draped over uterus and tubes
- Distal ends of tubes stick out of posterior layer of it and lie free
- Between two layers are arteries and veins, round ligament, ligament of ovary, lymphatics. The ovary is partially covered by a separate posterior fold of the broad ligament (mesovarium) but the surface of the ovary is devoid of peritoneum to allow exit of the ova.
- The tubes lie in the upper edge of the broad ligament which is termed the mesosalpinx.
- The ureters pass through the base of the broad ligament in close relationship to the uterine artery.

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Susppensory ligament of ovary (fold of peritoneum on the lateral pelvic wall containing ovary artery/vein, lymphatics, autonomies)

Round ligament of uterus to labium majus. Blood supply branch of ovarian & inferior epigastric arteries

Transverse cervical ligament (condensation of pelvic fascia)

Mesovarium

Mesosalpinx

Ligament of ovary

Ovary

Ureter

Vagina

Broad ligament

Vaginal artery

Ligament in base of broad ligament, above ureter, at level of os

Ovarian artery with tubal branch

To para-aortic nodes

Superficial inguinal nodes via round ligament

External iliac vessels

Lymphatics to external & internal iliac & sacral nodes
LIVER - GENERAL DESCRIPTION

- Wedge shaped
- Largest organ in body
- Weight 1500g
- 1500 blood flow per minute (30% of cardiac output)
- Lies: Right-6-10 ribs/costal cartilages; Left-6-7 costal cartilages
- Surfaces: anterior, superior, posterior, right - all smooth/convex
  Postero-inferior (visceral) concave & features ++
- Supports: IVC & hepatic veins (+ ligamentum teres & peritoneum)
- Nerve supply: Right vagus via coeliac ganglia, left directly to porta hepatitis. Sympathetics on vessels
- Reaches: T5 vertebra, nipples (5th intercostal space), xiphisternal joint

ANTERIOR RELATIONS

Against ribs 7-11 in mid-axillary line on right

Right & anterior

Lung

Pleura

Ribs

Oesophagus

Falciform ligament

Ligamentum teres

Gall bladder (obliterated umbilical vein)

T10

Attachment of lesser omentum & ligamentum venosum

Oesophagus/Stomach

Ligamentum teres

Gall bladder

INFERIOR SURFACE SEEN FROM ABOVE

Left lobe

Bare area

Porta hepatitis

Right triangular ligament

Kidney, suprarenal, colon

Diaphragm

Upper Coronary ligaments

Lower

IVC
LIENORENAL & GASTROSPLenic LIGAMENTS

LIENORENAL LIGAMENT
- Splenic artery
- Splenic vein
- Tail of pancreas

This area related to stomach

Spleen

Pancreas

Left kidney

Splenic flexure (antero-inferior to spleen)

Posteromedial to spleen

GASTROSPLenic LIGAMENT
- Left gastro-epiploic
- Short gastric arteries

Lienorenal ligament

Stomach

Left gastro-epiploic artery

Stomach

Short gastric arteries

Pancreas

Left kidney

Spleen
LIENORENAL & GASTROSPLENIC LIGAMENTS

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- Splenic artery
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Posteromedial to spleen

This area related to stomach

Splenic flexure (antero-inferior to spleen)

GASTROSPLENIC LIGAMENT
- Left gastro-epiploic
- & short gastric arteries
UTERUS - BROAD LIGAMENT

- Double layer of peritoneum draped over uterus and tubes
- Distal ends of tubes stick out of posterior layer of it and lie free
- Between two layers are arteries and veins, round ligament, ligament of ovary, lymphatics. The ovary is partially covered by a separate posterior fold of the broad ligament (mesovarium) but the surface of the ovary is devoid of peritoneum to allow exit of the ova.
- The tubes lie in the upper edge of the broad ligament which is termed the mesosalpinx
- The ureters pass through the base of the broad ligament in close relationship to the uterine artery
DUODENUM - POSTERIOR RELATIONS & LIGAMENT OF TREITZ

POSTERIOR RELATIONS OF DUODENUM

SECOND PART
- Hilum of right kidney
- Right ureter

FIRST PART
- Lesser sac
- Pancreas
- Bile duct
- Portal vein
- Hepatic artery
- Gastroduodenal artery

THIRD PART
- Right psoas
- Right genitofemoral nerve
- Right gonadal artery & vein
- Right ureter
- Inferior vena cava
- Aorta
- L3 vertebra

FOURTH PART
- Left sympathetic chain
- Left psoas
- Left genitofemoral nerve
- Left renal artery & vein
- Left gonadal artery & vein
- Inferior mesenteric vein

LIGAMENT OF TREITZ
2 parts, probably neither attached to crura
1. Slip of striated muscle from diaphragm at oesophageal opening, ending in connective tissue at coeliac artery
2. Fibromuscular (non striated) band from region of coeliac artery to duodenojejunal junction and 3th & 4th parts of duodenum
**PROSTATE - GENERAL**

- Produces 30% of ejaculate volume
- Pyramidal, size of a chestnut (2x3x4 cm)
- Has a posterior groove
- Apex on pelvic floor, base above
- Arteries: Inferior vesical, middle rectal, +/- pudendal
- Veins: Plexus around sides & base of gland to internal iliac
- Nerves: Sympathetic for ejaculation & smooth muscle contraction
  Parasympathetic for erection & secretomotor of acini

**Diagram**

- Anterior surface
- Posterior surface
- Levator ani (puboprostaticae)
- Bladder
- Rectovesical fascia of Denonvillier - 2 fused layers of peritoneum
- Puboprostatic ligaments (pelvic fascia)
- Puborectalis (around rectum)
- Membranous urethra (external sphincter)
- Apex is the most inferior part of the prostate (lateral to it, on each side, is the inferolateral surface)
ABDOMINAL WALL MUSCLES
EXTERNAL & INTERNAL OBLIQUE

EXTERNAL OBLIQUE
From: anterior angles of last 8 ribs
To: xiphisternum, linea alba, pubic symphysis & crest, inguinal ligament, anterior 1/2 iliac crest.
Downward/medial
N: T7-12

INTERNAL OBLIQUE
From: anterior 2/3 iliac crest, lateral 2/3 inguinal ligament, lumbar fascia
To: costal margin, rectus sheath & linea alba.
Conjoint tendon to pubic crest and pectineal line.
Upward/medial
N: T7-12, ilioinguinal to conjoint tendon
POSTERIOR ABDOMINAL WALL

- 5 vertebrae
- Transverse process of L3 is largest
- Transverse process of L5 is conical

PSOAS MAJOR
Origin: Intervertebral discs T12/L1 to L4/5
Bodies of L1-5, transverse processes L1-5
Inserts: Lesser trochanter
Nerve: L1,2,3
Action: Flexes hip

PSOAS MINOR
Origin: Bodies T12,L1
Inserts: Fascia over psoas major behind inguinal ligament
Nerve: L1
Action: Weak spine flexor

QUADRATUS LUMBORUM
Origin: Transverse process L5
Iliolumbar ligament & posterior 1/3 iliac crest
Inserts: Medial 1/2 12th rib & transverse process L1-4
Nerve: T12-L4
Action: Holds down 12th rib

ILIACUS
Origin: Hollow of iliac fossa
Inserts: Psoas tendon & below lesser trochanter
Action: Flexes hip
Nerve: Femoral (L2,3,4)

LAYERS OF THORACOLUMBAR FASCIA

TP= Transverse process
ES= Erector spinae
QL= Quadratus lumborum

Attachment of transversus & internal oblique

Spine/supraspinous ligaments

Lumbar regions all 3 layers are present, thoracic region has posterior layer only
• Covered superiorly and inferiorly with fascia (epimysium)
• Nerve supply for levator ani is perineal branch of S4, S5 for coccygeus
ABDOMINAL WALL MUSCLES
TRANSVERSUS, RECTUS ABDOMINIS, PYRAMIDALIS

TRANSVERSUS ABDOMINIS
From: costal margin, lumbar fascia anterior 2/3 iliac crest, lateral 1/2 inguinal ligament
To: rectus sheath & linea alba.
Conjoint tendon to pubic crest & pectineal line
Transverse
N: T7-12, ilioinguinal to conjoint tendon

RECTUS ABDOMINIS
From: pubic crest, tubercle & symphysis
To: costal cartilages 5, 6, 7, costal margin of 7, sternum & diaphragm
N: T7-12
(note: 3 morphological layers)

PYRAMIDALIS
From: front of body of pubis
To: linea alba
N: T12 (subcostal)
SURFACE ANATOMY OF ABDOMINAL WALL

ANTERIOR
- Dermatomes
  - T6: nipples
  - T8: xiphoid
  - T10: umbilicus
  - T12: pubis
- Linea alba: midline
- Spleen: ribs 9, 10, 11
- Transpyloric plane (L1)
- Subcostal plane (L2)
- Supracristal plane (L4)
- Linea semilunaris: tip of 9th costal cartilage to pubic tubercle

BUT mid point of inguinal ligament is half way between pubic tubercle and anterior superior iliac spine

Mid-inguinal point: half way between pubic symphysis & anterior superior iliac spine

POSTERIOR
- Scapulae
- Hila of kidneys are 5cm from midline
- Sacral dimples (SS)
- Mid point of sacro-iliac joints
- End of dural sac Posterior superior iliac spine
DERMATOMES OF THORAX AND ABDOMEN
On transpyloric plane

- L1 vertebra
- Pylorus
- Hila of kidneys
- Duodenojejunal flexure
- Fundus of gall bladder
- Neck of pancreas
- Origin of portal vein
- Transverse mesocolon
- 2nd part of duodenum
- Origin of superior mesenteric artery
- Hilum of spleen
- 9th costal cartilage
- End of spinal cord (just below)
Order of structures behind medial malleolus from anterior to posterior:
- Tibialis posterior, flexor digitorum longus, posterior tibial vein & artery, tibial nerve, flexor hallucis longus
Mnemonic: Timothy Donetsk All Nervous Housemaids

Flexor retinaculum
Tip of medial malleolus to medial calcaneal process and plantar aponeurosis
ANKLE, SUBTALAR AND TALOCALCANEONAVICULAR JOINTS

ANKLE (talocrural)
- Effectively a hinge joint but-
- Trochlear surface is slightly wider anteriorly so that there is a slight wiggle in full flexion
- Forces are transmitted to talus from tibia
- Plantar flexion - 30-50°
- Dorsiflexion - 20-30°
- Inversion injury may 1. tear ligaments, 2. pull off lower fibula, 3. pull of lower tibia & fibula

TALOCALCANEONAVICULAR
- Made up of 2 parts
  - Talocalcaneal (2 facets)
  - Talonavicular

SUBTALAR (3 facets)
- Talocalcanean (posterior & separate, 1 facet)
- Talocalcaneal part of talocalcaneonavicular (2 facets)

MIDTARSAL (2 facets, ball and socket)
- Calcaneocuboid
- Talonavicular part of talocalcaneonavicular

INVERSION
- Always with some adduction of toes
- Muscles: Tibialis anterior/posterior (+/- flexor hallucis longus)

EVERSION
- Always with some abduction of toes
- Muscles: Peronei longus/drevis (+ flexion), tertius (+ extension)
- As all these tendons insert distal to the midtarsal joint, this joint moves first and a little, soon reaches its maximum and the torque is then transmitted to the midtarsal joint which gives most of each movement
ANKLE LIGAMENTS

MEDIAL
- Talonavicular
- Spring ligament
  (plantar calcaneonavicular)
  - Thick, strong, non-elastic
  - From sustentaculum tali to navicular
  - Upper surface articulates with head of talus

Deltoid/medial collateral
1. Tibiotalar (superficial/deep)
2. Tibiosustentacular (middle)
   (tibiocalcanean)
3. Tibio-spring ligament (middle)
4. Tibionavicular (anterior)

LATERAL
- Tibiofibular (anterior/posterior)
- Tarsal Metatarsal
- Calcaneofibular (5)
- Lateral talocalcaneal (6)
- Cervical (7)
- Bifurcate (8)

OTHERS
- Posterior
  - Deltoid
  - Groove for flexor hallucis longus
  - Posterior process of talus

Tibiofibular part of it is Inferior transverse ligament

COLOUR CODING FOR LIGAMENTS
- Inferior tibiofibular
- Ankle
- Subtalar/midtarsal

short long
Plantar
**BONES AND ARCHES OF RIGHT FOOT**

**ARCHES**
- Longitudinal Medial (high): Calcaneus, talus, navicular, medial cuneiform, metatarsal
- Lateral (flat): Calcaneus, cuboid, metatarsal
- Transverse (high): Cuboid, cuneiforms, navicular

**Supports**
- Bony - Talus (keystone for longitudinal)
- Cuneiforms (wedged for transverse)
- Ligamentous - Spring ligament for longitudinal
- Plantar ligaments & plantar fascia for longitudinal
- Muscular - Flexor hallucis longus for longitudinal
- Peroneus longus/brevis for both
- Short plantar muscles for both
RIGHT CALCANEUS

Articular surfaces for talus
Anterior
Middle
Peroneal trochlea (tubercle)

SUPERIOR SURFACE

Posterior articular surface for talus

Posterior surface

Tendo calcaneus attaching to posterior surface of calcaneus

Bursa
Adventitial bursa

Subcutaneous surface

Primary ossification centre at 3 months intra-uterine

Secondary centre appears 6-7 years, fuses 14-16 years
RIGHT TALUS

SUPERIOR SURFACE

Surface for medial malleolus

Talus has a single primary ossification centre that appears at 6 months intra-uterine

Box outlines posterior process with its medial (MT) & lateral (LT) tubercles

Trochlear surface

Surface for lateral malleolus

Groove for flexor hallucis longus

Mnemonic “TPP” reminds that the TALUS has a POSTERIOR PROCESS with 2 tubercles. The lateral tubercle has a separate ossification centre (age 7-13) that may fail to fuse in 7% of feet giving an "OS TRIGONUM"

INFERIOR SURFACE

Anterior

Calcaneal articular surfaces

Sustentaculum tali grooved by flexor hallucis longus

Middle

Posterior calcaneal articular surface

NOTE: Talus has no muscle attachments, it is almost entirely intra-articular & its blood supply to its body is via its neck with the risk of avascular necrosis with a fracture
DORSUM OF LEFT FOOT

- Extensor digitorum longus
- Extensor hallucis longus
- Dorsal interossei
- Extensor hallucis brevis (part of extensor digitorum brevis)
- Peroneus tertius
- Tibialis anterior
- Peroneus brevis
- Inferior extensor retinaculum
- Lateral malleolus
- Superior extensor retinaculum
- Extensor digitorum brevis

**Extensor digitorum brevis**
- Arises: Superior/anterior calcaneus
- Inserts: 4 tendons. Proximal phalanx
  big toe (could be called extensor hallucis brevis) & into long extensor tendons to 2, 3, 4.
- Acts: Extends toes 1–4 when foot is fully dorsiflexed
- Nerve: Deep peroneal (L5, S1)
- Note: This muscle breaks the rule in that, as a short "digitorum" muscle it does not supply the 5th digit
  (cf. Flexor Digitorum superficialis in hand)

**Dorsal interossei (4)**
- Bipennate

For details of interossei see muscle section of Instant Anatomy
MUSCLE ATTACHMENTS TO RIGHT FOOT

- Dorsal expansion of extensor digitorum longus/brevis
- Extensor hallucis longus
- Extensor hallucis & digitorum brevis
- Dorsal interossel
- Tibialis anterior
- Tibialis posterior
- Navicular
- Cuboid
- Talus
- Calcaneus
- Tendo calcaneus
- Dorsum
- Sole

Tarsal sinus
- Between talocalcaneonavicular & talocalcaneal joints
- Contains ligaments between bones
- Closed off by cervical ligament, extensor digitorum brevis, extensor retinaculum

Talus:
- No muscles attached, almost entirely intra-articular, neck blood supplies body (avascular necrosis with fracture likely)
BONES AND ARCHES OF RIGHT FOOT

**Longitudinal Medial (high):** Calcaneus, talus, navicular, medial cuneiform, metatarsal

**Lateral (flat):** Calcaneus, cuboid, metatarsal

**Transverse (high):** Cuboid, cuneiforms, navicular

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**Cuneiforms (wedged for transverse)**

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**Plantar ligaments & plantar fascia for longitudinal**

**Muscular - Flexor hallucis longus for longitudinal**

**Peroneus longus/brevis for both**

**Short plantar muscles for both**
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PLANTAR APONEUROSIS
Condensation of deep fascia

- Plantar skin + nail beds
  - Medial plantar nerve
  - Lateral plantar nerve

- Abductor digit minimi
- Abductor hallucis

- Superficial transverse metatarsal ligament

- Saphenous nerve
- Lateral plantar artery/nerve
- Medial calcaneal nerve (tibial)
- Sural nerve
- Plantar fascia

**Origin:**
- Posterior calcaneal tuberosity

**Insertion:**
- 5 slips into toe pads/skin
- Edges of fibrous flexor sheaths
- Superficial transverse metatarsal ligaments
- Medial & lateral septa into 1st & 5th metatarsals
THIRD LAYER OF SOLE OF LEFT FOOT

3 MUSCLES
2 LIGAMENTS

Adductor hallucis

Flexor hallucis brevis

Medial plantar nerve

Spring ligament (plantar calcaneonavicular)

Flexor digiti minimi brevis

Lateral plantar nerve

Long plantar ligament

- Under surface of calcaneus between posterior tuberosity & anterior tubercle to ridge & tuberosity of cuboid & bases of 2nd, 3rd & 4th metatarsals
- Peroneus longus runs deep to it

See muscle section of Instant Anatomy for details of muscles
THE NEUROVASCULAR PLANE

Lies between 1st and 2nd layers
Has arteries lying marginal & nerves central

PLANTAR ARCH (lateral plantar artery)

There are anastomotic vessels from this arch that pass:
1. Between the 1st & 2nd metatarsals to dorsalis pedis artery
2. Between 2/3, 3/4, 4/5 metatarsals to dorsal metatarsal arteries
SECOND LAYER OF SOLE OF LEFT FOOT

2 MUSCLES
2 TENDONS

Lumbricals
- Lateral 3 are bipennate & are between tendons of flexor digitorum longus (lateral plantar nerve).
- Medial one from medial side of 1st tendon & is unipennate (medial plantar nerve).

Flexor accessorius
- 2 heads.
- Pulls flexor digitorum longus tendons so that they pull straight.
- Assists the long tendons with flexion of lateral 4 toes when ankle is flexed (lateral plantar nerve).

Tendon of flexor digitorum longus
- Crosses superficial to flexor hallucis longus.
- Receives flexor accessorius.
- Gives off lumbricals.
- Receives 2 slips from flexor hallucis longus to 2 medial tendons.
- To base of distal phalanges via fibrous flexor sheaths.

Tendon of flexor hallucis longus
- Grooves sustentaculum tali.
- Crossed by flexor dig longus.
- Gives slips to medial 2 tendons of flexor digitorum longus.
- Into base of distal phalanx.
- Synovial sheath throughout (opened distally here).

See muscle section of Instant Anatomy for details of muscles.
FOURTH LAYER OF SOLE OF LEFT FOOT

1 MUSCLE
1 LIGAMENT
3 TENDONS

Plantar interossei - 3
- Arise medial sides of 3, 4, 5 metatarsals
- Insert medial bases of proximal phalanges with slips to dorsal expansion of 3, 4, 5
- Adduct 3, 4, 5 toes & assists lumbricals to extend interphalangeal joints & flex metatarso-phalangeal joints
- Deep branch of lateral plantar nerve
- Unipennate

Dorsal interossei

Tibialis anterior tendon
- Inserts into medial side of base of 1st metatarsal & medial cuneiform

Peroneus longus tendon
- In synovial sheath between long & short plantar ligaments
- Across cuboid & cuneiforms
- Into lateral base of 1st metatarsal & medial cuneiform

Short plantar ligament (plantar calcaneocuboid)
- Anterior calcaneal tubercle to cuboid

Tibialis posterior tendon

See muscle section of Instant Anatomy for details of muscles
POSTERIOR LOWER RIGHT LEG & TENDONS AT MEDIAL ANKLE

Gastrocnemius medial head

Plantaris

Fabella (sesamoid) in lateral head of gastrocnemius

Popliteus

Anterior tibial artery

Tibialis posterior

Peroneal (fibular) artery

Tibial nerve

Flexor digitorum longus

Flexor hallucis longus

Tibialis posterior

Flexor hallucis longus

Tendons in foot

Order of structures behind medial malleolus as indicated by arrow:

Tibialis posterior, flexor digitorum longus, posterior tibial vein & artery, tibial nerve, flexor hallucis longus

Mnemonic: Timothy Doth Vex All Nervous Housemaids
FIRST LAYER OF SOLE OF LEFT FOOT

3 MUSCLES

Abductor hallucis
Flexor digitorum brevis
Abductor digiti minimi

Decussating chiasma of flexor digitorum brevis deep to tendon of flexor digitorum longus

See muscle section of Instant Anatomy for details of muscles
SECOND LAYER OF SOLE OF LEFT FOOT

2 MUSCLES
2 TENDONS

Lumbricals
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- Medial one from medial side of 1st tendon & is unipennate (medial plantar nerve)

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THIRD LAYER OF SOLE OF LEFT FOOT

3 MUSCLES
2 LIGAMENTS

Adductor hallucis

Flexor hallucis brevis

Medial plantar nerve

Spring ligament (plantar calcaneonavicular)

Flexor digiti minimi brevis

Lateral plantar nerve

Long plantar ligament

• From sustentaculum tali to navicular
• Tibialis posterior runs superficial to it

• Under surface of calcaneus between posterior tuberosity & anterior tubercle to ridge & tuberosity of cuboid & bases of 2nd, 3rd & 4th metatarsals
• Peroneus longus runs deep to it

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FOURTH LAYER OF SOLE OF LEFT FOOT

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1 LIGAMENT
3 TENDONS

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Plantar interossei - 3
Arise medial sides of 3, 4, 5 metatarsals
Insert medial bases of proximal phalanges with slips to dorsal expansion of 3, 4, 5
Adduct 3, 4, 5 toes & assists lumbricals to extend interphalangeal joints & flex metatarso-phalangeal joints
Deep branch of lateral plantar nerve
Unipennate

Tibialis anterior tendon
Inserts into medial side of base of 1st metatarsal & medial cuneiform

Peroneus longus tendon
In synovial sheath
Between long & short plantar ligaments
Across cuboid & cuneiforms
Into lateral base of 1st metatarsal & medial cuneiform

Short plantar ligament (plantar calcaneocuboid)
Anterior calcaneal tubercle to cuboid

Tibialis posterior tendon

See muscle section of Instant Anatomy for details of muscles
STRUCTURES PASSING THROUGH THE GREATER & LESSER SCIATIC FORMINA

VIA GREATER SCIATIC FORAMEN
- Superior gluteal vessels
- Superior gluteal nerve
- PIRIFORMIS
- Inferior gluteal vessels
- Inferior gluteal nerve
- Sciatic nerve
- Perforating cutaneous nerve
- Posterior femoral cutaneous nerve
- Nerve to quadratus femoris
- Nerve to obturator internus
- Pudendal nerve
- Internal pudendal vessels

VIA LESSER SCIATIC FORAMEN
- Tendon of obturator internus
- Nerve to obturator internus
- Internal pudendal vessels
- Pudendal nerve
GLUTEAL REGION 2

SUPERIOR GLUTEAL NERVE L4,5,S1
Gluteus Medius
Gluteus minimus
Tensor fasciae latae

INFERIOR GLUTEAL NERVE L5,S1,2
Gluteus maximus

NERVE TO OBTURATOR INTERNUS L5,S1,2
Obturator internus
Superior gemellus

NERVE TO QUADRATUS FEMORIS L4,5,S1
Quadratus femoris
Inferior gemellus

NOTE

An easy way to remember these root values is that the highest and lowest nerves have the same value (L4,5,S1) and the two middle nerves have the same roots (L5,S1,2)
GLUTEAL REGION 1

Gluteus maximus & Inferior gluteal nerve (L5, S1, 2)

Gluteus medius

Gluteus minimis

Tensor fasciae latae

Superior gluteal artery & nerve (L4, 5, S1)

1. Gemellus superior
2. Obturator internus
3. Gemellus inferior

Obturador externus

3. Quadratus femoris

Posterior femoral cutaneous nerve & perforating cutaneous nerve

Sciatic nerve

See muscle section of Instant Anatomy for details of muscles
GLUTEAL REGION 2

SUPERIOR GLUTEAL NERVE L4,5,S1

Gluteus Medius
Gluteus minimis
Tensor fasciae latae

INFERIOR GLUTEAL NERVE L5,S1,2

Gluteus maximus

NERVE TO OBTURATOR INTERNUS L5,S1,2

Obturator internus
Superior gemellus

NERVE TO QUADRATUS FEMORIS L4,5,S1

Quadratus femoris
Inferior gemellus

NOTE

An easy way to remember these root values is that the highest and lowest nerves have the same value (L4,5,S1) and the two middle nerves have the same roots (L5,S1,2)
CUTANEOUS NERVE SUPPLY OF BUTTOCKS

Posterior primary rami

Iliohypogastric (L1)

Subcostal (T12)

Lateral femoral cutaneous nerve (L2, 3)

Posterior femoral cutaneous nerve (S1, 2, 3)

Perforating cutaneous nerve (S2, 3) (perforates the sacrotuberous ligament)

NOTE: Pain may be referred between pelvis (autonomics S2, 3) and the posterior femoral cutaneous nerve (S2, 3)
HIP JOINT 1

- Ball and socket
- Synovial
- Ligamentum teres in fovea

ANGLE OF NECK ON SHAFT

CHILD: 160°
MALE: 120°
FEMALE: 100°
ANTERIOR THIGH & HIP FLEXORS

See muscle section of Instant Anatomy for details of these muscles.

Note on Psoas/iliacus:
Despite some opinions it is probable from recent experiments that these muscles act purely as flexors of the hip and not rotators. However, in the presence of a fractured neck of femur the line of axis changes and they produce external rotation.
HIP JOINT 4

BURSAE
- Psoas may communicate into hip joint
- Trochanteric
- Ischial

NERVES
- Femoral (because of rectus femoris)
- Sciatic (because of quadratus femoris)
- Obturator - posterior division

RELATIONS
- Gluteus
- Medius
- Minimus
- Rectus femoris
- Bursa Iliopsoas
  Femoral nerve, artery, vein
- Piriformis
- Gemellus superior
  Obturator internus
- Gemellus inferior
- Sciatic nerve
- Quadratus femoris (its nerve #)
- Pectineus
- Obturator externus

POSTERIOR

ANTERIOR
HIP JOINT 3

CAPSULE

Strong ++
Anterior: Covers whole neck to intertrochanteric line
Posterior: Covers neck half way to intertrochanteric crest
Reflects: Back as retinaculum which carries the blood supply

2 ANASTOMOSES

Trochanteric (at greater trochanter):
- Descending superior gluteal
- Inferior gluteal
- Ascending branches of medial & lateral circumflex femoral

Cruciate (at lesser trochanter):
- Transverse branches of medial & lateral circumflex femoral
- Descending branch of inferior gluteal
- Ascending branch of 1st perforating artery

Mnemonic:
Upper anastomosis does not receive branch from lowest artery,
lower anastomosis does not receive branch from highest artery.
**Hip Joint 5**

**Ligaments**

**Anterior**
- Rectus femoris

**Posterior**
- Ischiofemoral
  - Weak, from postero-inferior margin of acetabulum
- Psoas

**Iliofemoral**
- Strong ++
  - From low on anterior inferior iliac spine to intertrochanteric line
  - Y shaped (triangular ligament of Bigelow)

**Pubofemoral**
- Ilipectineal eminence & superior pubic ramus
HIP JOINT 4

BURSAE

- Psoas may communicate into hip joint
- Trochanteric
- Ischial

NERVES

- Femoral (because of rectus femoris)
- Sciatic (because of quadratus femoris)
- Obturator - posterior division

RELATIONS

POSTERIOR

ANTERIOR

Bursa
Iliopsoas
Femoral nerve,
artery, vein

Gluteus

Medius

Minimus

Rectus femoris

Piriformis

Gemellus superior
Obturator internus
Gemellus inferior

Sciatic nerve

Quadratus femoris
(its nerve #)

Obturator externus

Pectineus
HIP JOINT 6

HIP MOVEMENTS

Abduction
Gluteus medius, gluteus minimus, tensor fasciae latae
(+/− piriformis)

Adduction
Adductors brevis, longus, magnus (pectineus, gracilis, iliopsoas)

Flexion
Psoas, iliacus, rectus femoris, sartorius, (pectineus, tensor fasciae latae). Note soft tissue limitation

Extension
Gluteus maximus, semitendinosus, semimembranosus, adductor magnus, long head biceps femoris. Note capsule & ligaments limitation

External rotation
Gluteus maximus, (piriformis, obturators internus & externus, gemelli, quadratus femoris

Internal rotation
Anterior fibres of gluteus medius & minimis
POSTERIOR RIGHT THIGH

See section on muscles in Instant Anatomy for details of muscles.

Sciatic nerve (This nerve may divide into its two components anywhere from the pelvis to the popliteal fossa).

Long head biceps femoris

Semitendinosus

Semitendinosus

Adductor magnus

Short head biceps femoris

Tibial nerve

Common peroneal (fibular) nerve

Oblique popliteal ligament (this is one of several insertions of semimembranosus)

Mnemonic for remembering insertions onto medial upper tibia (anterior to posterior): "SAY GRACE BEFORE TEA, MUM" Sartorius, Gracilis, before, Semitendinosus, Semimembranosus

Adductor magnus

Medial collateral ligament

Semitendinosus

Medial collateral ligament

MEDIAL LOWER FEMUR AND UPPER TIBIA
KNEE JOINT 1

Attachments to lower right femur
Posterior view

Back, high, lateral
Mnemonic: AL
(anterior - lateral)

Anterior cruciate ligament

Adductor magnus

Medial head of gastrocnemius

Medial collateral ligament

Lateral head of gastrocnemius

Lateral collateral ligament

Plantaris

Popliteus

Medial condyle
(narrow/rounded)

Posterior cruciate ligament

Forward, low, medial
Mnemonic: PM
(posterior - medial)

Lateral condyle
(broad/flat)

Intercondylar notch
RIGHT PATELLA

- Largest sesamoid bone in body
- Mobile from side to side
- Quadriceps pull obliquely along the line of the femur & this tends to lateral dislocation.
- There are 3 factors that prevent lateral displacement of patella

1. Larger lateral condyle of femur
2. Tension in medial retinacular fibres
3. Direction & insertion of lowest fibres of vastus medialis

Upper lateral part is site of bipartite patella
Apex
Anterior view
Anterior/posterior is obvious

Posterior view
Patella tendon attaches to the tibial tubercle
Lateral/posterior surface is: Larger, longer, more steeply sloped

ARTICULATION WITH FEMUR

1. In extension
2. In slight flexion
3. In flexion
4. In full flexion

Lateral Medial

OSSIFICATION

Several centres between 3 & 6 years that fuse at puberty (they appear as child starts running). Sometimes a separate centre superior/lateral at 6 years - fuses at puberty
KNEE JOINT 5

LIGAMENTS OF RIGHT KNEE

Medial

Lateral

Posterior

Iliotibial tract

MEDIAL COLLATERAL LIGAMENT
- Broad, long & thick
- Strong
- Attached to capsule & medial meniscus
- Limits full extension & thus helps with locking

LATERAL COLLATERAL LIGAMENT
- Thick, cordlike
- Not attached to joint structures
- Limits full extension & thus helps with locking

OBLIQUE POPLITEAL LIGAMENT
- Upward extension of semimembranosus tendon
- Limits extension & thus helps with knee locking

NOTE
- Knee is largest joint in body
- It is a modified hinge joint
- The line of the body weight is anterior to the knee
KNEE JOINT 2

MENisci

Liable to tears when flexed knee is twisted
Function: transfers forces, keep bones together, helps locking

UPPER SURFACE OF RIGHT TIBIA

Anterior cruciate ligament
Iliotibial tract
Transverse ligament

MEDIAL

Medial collateral ligament

Posterior cruciate ligament

LATERAL

Lateral collateral ligament

Intercondylar eminence with medial & lateral intercondylar tubercles

MEDIAL MENISCUS
- Wider C
- Medial lip slopes up
- Attaches as shown but also to medial collateral ligament
- More liable to damage than lateral meniscus

LATERAL MENISCUS
- Smaller, tighter C
- Lateral lip slopes down
- Not attached to lateral collateral ligament
- Attached as shown
- Lightly attached to popliteus & is retracted by it on flexion
KNEE JOINT 3

CRUCIATE LIGAMENTS

From: Anterolateral tibia
To: Posterior on medial side of lateral femoral condyle
Limits: Extension & anterior draw & is taut on locking
Test: Pull tibia forwards on femur

VIEW FROM MEDIAL SIDE

ANTERIOR CRUCIATE

LATERAL

MEDIAL

POSTERIOR CRUCIATE

From: Posteromedial tibia
To: Anterior on lateral side of medial femoral condyle
Limits: Posterior slide of tibia on femur.
Lax: On standing
Used: Down stairs & on hills
Test: Push tibia back on femur

Mnemonic:

AL: Anterior goes laterally
PM: Posterior goes medially
Capsule is attached to the bony margins of the tibia and femur. It has several thickenings shown below called internal ligaments:

1. Thickened medially to make Short Internal (medial) Ligament which attaches to medial collateral ligament outside & to the medial meniscus inside as the coronary ligaments.
2. Arcuate Popliteal Ligament. This is Y shaped and the lateral part of it is often known as the Short External (lateral) ligament. Popliteus tendon passes medially to it.
3. Medial and lateral Patellar Retinacular Fibres. These reinforce the capsule anteriorly. The medial ones are important as they help to prevent the patella dislocating laterally.
KNEE JOINT 6

BURSAE AND SYNOVUM

Synovium lines the inside of the capsule and is attached to the bony edges. It extends into the suprapatellar bursa. The cruciate ligaments and popliteus tendon lie outside it (see figure below).

Tibial plateau to show how the synovium is attached to its edges but the cruciate ligaments lie outside it.

Bursae associated with tendons and muscles

1. Under sartorius, gracilis, semitendinosus
2. Under medial head of gastrocnemius (often into joint)
3. Under lateral head of gastrocnemius (sometimes into joint)
4. Under lateral collateral ligament
5. Under popliteus (into joint)
6. Under semimembranosus
KNEE JOINT 7

BLOOD & NERVE SUPPLY, MOVEMENTS

BLOOD SUPPLY

Genicular arteries
- Popliteal gives: Superior (medial and lateral)
  - Middle
  - Inferior (medial and lateral)
- Femoral gives: Descending branch from profunda

NERVES

- Posterior division of obturator
- Femoral
- Sciatic (both parts)

MOVEMENTS

Flexion: Semimembranosus, semitendinosus, biceps, gracilis, sartorius (gastrocnemius, plantaris, popliteus)

Extension: Quadriceps femoris, iliobibial tract (gluteus maximus, tensor fasciae latae)

Internal rotation (with knee flexed): Semimembranosus, semitendinosus, gracilis, sartorius

External rotation (with knee flexed): Biceps
KNEE JOINT 8

LOCKING OF KNEE

LOCKING

Full extension → Taut anterior cruciate → No further symmetrical extension → Medial femoral condyle moves back - lateral condyle moves forwards

Tensor fasciae latae & gluteus maximus tighten iliotibial tract

Knee hyperextends and locks

UNLOCKING

Popliteus externally rotates femur on tibia → Locked ligaments loosen → Hamstrings can then flex knee
Order of structures across dorsum of foot in direction of arrow: Tibialis anterior, extensor hallucis longus, anterior tibial artery/vein, deep peroneal nerve, extensor digitorum longus, peroneus tertius

Mnemonic: Timothy Has A Very Nasty Disease, Paratyphoid
AXIAL (CROSS) SECTION LOWER LEG

- Deep peroneal nerve
- Anterior tibial vessels
- Flexor digitorum longus
- Extensor digitorum longus & peroneus tertius
- Superficial peroneal nerve
- Peroneus longus & brevis
- Peroneal vessels
- Gastrocnemius aponeurosis
- Sural nerve
- Sural communicating nerve
- Tibial nerve
- Tibialis posterior
- Tibialis anterior
- Tibia
- Flexor hallucis longus
- Long saphenous vein & saphenous nerve
- Posterior tibial vessels & Tibial nerve
- Plantaris
- Short saphenous vein
RIGHT POPLITEAL FOSSA DEEP DISSECTION

CONTENTS
- Popliteal artery & vein
- Tibial nerve
- Common peroneal (fibular) nerve
- Fat
- Lymph nodes

NOTE ON POPLITEAL ARTERY
- 8" long
- Starts medial to tibial nerve
- Ends lateral to tibial nerve
- Vein always between two

MEDIAL
- Superior medial & lateral genicular arteries
- Gastrocnemius
- Semimembranosus

LATERAL
- Adductor magnus
- Short head
- Biceps
- Long head
- Plantaris/gastrocnemius
- Middle genicular & muscular arteries
- Inferior medial & lateral genicular arteries
- Peroneus longus

ARTERIES
1. Anterior tibial
2. Peroneal
3. Posterior tibial

Flexor digitorum longus
Tibialis posterior
Plantaris
RIGHT POPLITEAL FOSSA
SUPERFICIAL DISSECTION

- Diamond shaped
- Borders:
  - Upper medial - Semimembranosus (& semitendinosus)
  - Upper lateral - Biceps femoris
  - Lower medial - Gastronemius (medial head)
  - Lower lateral - Plantaris & gastrocnemius (lateral head)
  - Floor - Popliteus, capsule, femur
  - Roof - Short saphenous & communicating veins
    - Lateral sural cutaneous nerve
    - Sural communicating nerve
    - End of posterior femoral cutaneous nerve
    - Fascia lata
FEMORAL TRIANGLE

BOUNDARIES
- Superior: Iliacus
- Inguinal ligament
- Lateral: Medial border of sartorius
- Medial: Medial border of adductor longus
- Roof: Fascia lata
- Floor: Marked muscles with adductor brevis just showing. It has the anterior division of the obturator nerve on its surface

Contains
- Femoral nerve
- Femoral artery
- Femoral vein
- Deep inguinal nodes
ADDUCTOR CANAL
(HUNTER’S/SUBSARTORIAL)

Sartorius

Nerve to vastus medialis

Saphenous nerve

Spirals from lateral to medial over artery. Gives infrapatellar branch through sartorius. May or may not go through adductor hiatus but emerges into lower leg between sartorius and gracilis

Femoral artery is always between vein & saphenous nerve.
Femoral vein spirals from medial to artery in femoral triangle to posterior to artery in canal.
Femoral artery gives descending genicular artery as it leaves the adductor hiatus

Adductor hiatus

Transmits:
- Femoral artery & vein
- Saphenous nerve (usually)
- Small genicular branch of posterior division of obturator nerve

Relations

Boundaries

Lateral
- Vastus medialis

Medial/floor
- Adductor longus
- Adductor magnus

Roof
- Fascia
- Sartorius
- Subsartorial plexus
  (contributed to by:
  - Anterior branch of obturator
  - Medial cutaneous n of thigh
  - Saphenous nerve
  Supplies: Skin of medial thigh)
CROSS (AXIAL) SECTION OF MID LEFT THIGH LOOKING UP

Note: There is no posterior intermuscular septum. It would divide adductor magnus if present.
ADDUCTOR CANAL (HUNTER’S/substrartorial)

**Relations**
- Femoral artery is always between vein & saphenous nerve.
- Femoral vein spirals from medial to artery in femoral triangle to posterior to artery in canal.
- Femoral artery gives descending genicular artery as it leaves the adductor hiatus.

**Nerve to vastus medialis**
Spirals from lateral to medial over artery. Gives infrapatellar branch through sartorius. May or may not go through adductor hiatus but emerges into lower leg between sartorius and gracilis.

**Saphenous nerve**

**Adductor hiatus**
Transmits:
- Femoral artery & vein
- Saphenous nerve (usually)
- Small genicular branch of posterior division of obturator nerve

**Boundaries**
- Lateral:
  - Vastus medialis
- Medial/floor:
  - Adductor longus
  - Adductor magnus

**Roof**
- Fascia
- Sartorius
- Subsartorial plexus (contributed to by:
  - Anterior branch of obturator
  - Medial cutaneous n of thigh
  - Saphenous nerve
- Supplies: Skin of medial thigh)
**FASCIA LATA**

- Tensor fasciae latae
  - To margin of medial tibial condyle
  - To patella
  - To margin of lateral tibial condyle
  - To head of fibula

**ILIOTIBIAL TRACT**

- Thickening of fascia lata over greater trochanter after insertion of tensor fasciae latae and gluteus maximus.
- Attaches to anterior surface of lateral tibial condyle. It maintains knee in hyper-extension.

**ATTACHMENTS OF FASCIA LATA**

- Pubic tubercle
- Inguinal ligament
- ASIS
- Outer margin of iliac crest
- Iliac tubercle
- Posterior gluteal Line
- Sacrotuberous ligament
- Along pectineal line
- Below pubic tubercle
- Body of pubis
- Ischial tuberosity
FEMORAL SHEATH & CANAL

The big black arrow is passing downwards from the femoral ring, superiorly, via the femoral canal and into the femoral triangle.
The femoral sheath surrounds the canal, femoral vein and femoral artery but NOT the femoral nerve.
The femoral branch of the genitofemoral nerve is surrounded by sheath but the nerve pierces its anterior wall to reach the skin of the femoral triangle.

**ANTERIOR LAYER OF SHEATH**
- Transversalis fascia

**POSTERIOR LAYER OF SHEATH**
- Psoas fascia  
  (both these layers of fascia fuse with adventitia of femoral artery 1" below inguinal ligament)

**CONTENTS OF SHEATH**
- Femoral vein
- Femoral artery
- Femoral canal
- Lymphatics

**ADDITIONAL FUNCTION OF SHEATH**
- Allows expansion of femoral vein
ATTACHMENTS TO RIGHT FEMUR 2
GREATER TROCHANTER

NOTES:
- Branch of obturator artery supplies fovea of femoral head via ligamentum teres.
- Growing ends of lower limb is either side of knee.
- Nutrient arteries enter obliquely at growing end.
- Femur is 1st long bone to appear at 7 weeks.
Branch of obturator artery via ligamentum teres to fovea of head of femur

MEDIAL THIGH

See muscle section of Instant Anatomy for details of muscles

OBURATOR NERVE

From anterior divisions of anterior primary rami of L2, 3, 4

Anterior branch:
Lies between adductors longus & brevis, contributes to subsartorial plexus for medial thigh skin, supplies adductors longus, brevis & gracilis

Posterior branch:
Lies between adductors brevis & magnus, supplies adductor magnus, obturator externus & knee joint via a small branch that passes through the adductor hiatus

Medial collateral ligament of knee (probably a remnant of the tendon of the hamstring portion of adductor magnus that was originally attached to the tibia)

ADDUCTOR HIASUS

Transmits femoral artery, femoral vein, the small genicular branch of the posterior branch of the obturator nerve and usually the saphenous nerve
GENERAL PATTERN OF ARTERIES AND NERVES IN RIGHT LOWER LEG

- Common peroneal (fibular) artery
- Popliteal artery
- Sciatic nerve
- Tibial nerve
- Anterior tibial artery
- Anterior tibial nerve
- Deep peroneal (fibular) nerve
- Common peroneal (fibular) nerve
- Peroneal (fibular) artery
- Posterior tibial artery
- Medial/lateral plantar nerves & arteries

Superficial peroneal (fibular) nerve
Anterior tibial artery (becomes dorsalis pedis)
## SEGMENTAL NERVE SUPPLY TO MUSCLES

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<th>MUSCLE</th>
<th>NERVE</th>
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<td>Segmental</td>
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<tr>
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<td>Adductor brevis</td>
<td>Obturator</td>
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<tr>
<td>L2,3</td>
<td>Adductor longus</td>
<td>Obturator</td>
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<tr>
<td>L2,3</td>
<td>Gracilis</td>
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<tr>
<td>L2,3</td>
<td>Sartorius</td>
<td>Femoral</td>
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<tr>
<td>L2,4</td>
<td>Iliacus</td>
<td>Femoral</td>
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<td>L3,4</td>
<td>Obturator externus</td>
<td>Obturator</td>
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<tr>
<td>L3,4</td>
<td>Pectineus</td>
<td>Femoral (+/- obturator)</td>
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<tr>
<td>L3,4</td>
<td>Quadriceps femoris</td>
<td>Femoral</td>
</tr>
<tr>
<td>L3-S1</td>
<td>Adductor magnus</td>
<td>Obturator &amp; sciatic</td>
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<tr>
<td>L4,5</td>
<td>Tibialis anterior</td>
<td>Deep peroneal (fibular)</td>
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<tr>
<td>L4-S1</td>
<td>Gluteus medius</td>
<td>Superior gluteal</td>
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<tr>
<td>L4-S1</td>
<td>Gluteus minimis</td>
<td>Superior gluteal</td>
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<tr>
<td>L4-S1</td>
<td>Inferior gemellus</td>
<td>N to quadratus femoris</td>
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<tr>
<td>L4-S1</td>
<td>Lumbricals</td>
<td>Medial &amp; lateral plantar</td>
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<tr>
<td>L4-S1</td>
<td>Plantaris</td>
<td>Tibial</td>
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<tr>
<td>L4-S1</td>
<td>Popliteus</td>
<td>Tibial</td>
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<tr>
<td>L4-S1</td>
<td>Quadratus femoris</td>
<td>N to quadratus femoris</td>
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<td>Tensor fasciae latae</td>
<td>Superior gluteal</td>
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<td>L4-S2</td>
<td>Semimembranosus</td>
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<td>Semitendinosus</td>
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<td>Extensor digitorum longus</td>
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<td>Extensor hallucis longus</td>
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<td>Obturator internus</td>
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<td>Superior gemellus</td>
<td>N to obturator internus</td>
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<tr>
<td>L5-S2</td>
<td>Biceps femoris</td>
<td>Sciatic (tibial &amp; common peroneal)</td>
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<td>S1,2</td>
<td>Abductor digit minimi</td>
<td>Lateral plantar</td>
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<td>Adductor hallucis</td>
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<td>S1,2</td>
<td>Piriformis</td>
<td>N to piriformis</td>
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<tr>
<td>S1,2</td>
<td>Quadratus plantae</td>
<td>Lateral plantar</td>
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</table>
SEGMENTAL NERVE SUPPLY TO MOVEMENTS AND REFLEXES IN LOWER LIMB

**HIP:**
- Flexion: L2,3
- Extension: L4,5
- Adduction/internal rotation: L1,2,3
- Abduction/external rotation: L5,S1

**KNEE:**
- Flexion: L5,S1
- Extension: L3,4

**ANKLE:**
- Dorsiflexion (extension): L4,5
- Plantarflexion (flexion): S1,2
CUTANEOUS NERVE SUPPLY OF BUTTOCKS

Posterior primary rami

Iliohypogastric (L1)

Subcostal (T12)

Lateral femoral cutaneous nerve (L2, 3)

Perforating cutaneous nerve (S2, 3) (perforates the sacrotuberous ligament)

Posterior femoral cutaneous nerve (S1, 2, 3)

NOTE: Pain may be referred between pelvis (autonomics S2, 3) and the posterior femoral cutaneous nerve (S2, 3)
SEGMENTAL NERVE SUPPLY TO MOVEMENTS AND REFLEXES IN LOWER LIMB

HIP:
- Flexion: L2,3
- Extension: L4,5
- Adduction/internal rotation: L1,2,3
- Abduction/external rotation: L5,S1

KNEE:
- Flexion: L5,S1
- Extension: L3,4

ANKLE:
- Dorsiflexion (extension): L4,5
- Plantarflexion (flexion): S1,2
RIGHT SCIATIC NERVE VIEWED FROM BEHIND

- Nerve to quadratus femoris (L4, S1)
- Inferior gemellus
- Quadratus femoris
- Semitendinosus
- Semimembranosus
- Long head of biceps femoris
- Hamstring half of adductor magnus
- Tibial (L4, S1, 2, 3)
- Common peroneal (fibular) (L4, S1, 2)
- Hip joint
- Piriformis
- Superior gemellus
- Obturator internus
- Nerve to obturator internus (L5, S1, 2)
- Short head of biceps femoris

PELVIS

THIGH
VARIATIONS IN SCIATIC NERVE

Covered by

87%  Gluteus maximus
12%  Long head biceps femoris
1%   Short head biceps femoris

Nerve lies on:
- Superior gemellus
- Tendon of obturator internus
- Inferior gemellus
- Quadratus femoris
- Adductor magnus
6 P'S FROM THE ROOTS OF THE SACRAL PLEXUS

There are 6 nerves that emerge from the sacral roots that all begin with the letter "P". This provides an easy way of remembering them.

1. Nerve to Piriformis (S1,2)
2. Perforating cutaneous nerve (S2,3)
3. Posterior femoral cutaneous nerve (S1,2,3)
4. Pudendal nerve (S2,3,4)
5. Perineal branch of S4
6. Pelvic splanchnics (parasympathetics) (S2,3,4)

See notes on greater and lesser sciatic foramina for which of these pass out through each foramen, if at all.

SCIATIC NERVE

Anterior division

Tibial to flexors (L4,5,S1,2,3)
Nerve to obturator internus (L5,S1,2)
Nerve to quadratus femoris (L4,5,S1)

Posterior division

Common peroneal to extensors
Superior gluteal (L4,5,S1)
Inferior gluteal (L5,S1,2)
NERVE LESIONS IN THE LOWER LIMB

NERVES TO PSOAS AND ILIACUS:
No pelvic swing on walking

FEMORAL:
Loss of hip flexion & knee extension.
Loss of sensation anterior thigh & medial leg

OBTURATOR:
Loss of adduction of thigh.
Loss of sensation inner thigh

SUPERIOR GLUTEAL:
Loss of abduction at hip. Pelvic dip on walking

INFERIOR GLUTEAL:
Loss of extension at hip. Buttock wasting

SCIATIC:
Loss of all motor except adduction & flexion of thigh & extension of knee.
Loss of sensation lower leg & foot

TIBIAL (HIGH):
Loss of flexion of toes & inversion of foot.
Loss of sensation of sole of foot, inferior aspect of toes & nail beds

COMMON PERONEAL (TIBIAL) (HIGH):
Loss of extension of toes & foot (footdrop).
Loss of sensation of lateral lower leg & upper foot

ROOT COMPRESSION:
Prolapsed discs catches nerve that emerges at the next intervertebral foramen and not one at the same level as the disc. For example, disc lesion of the L4/5 space catches L5 nerve.
COMPARTMENT SYNDROMES
OF LOWER LIMB

SITE
Between tough deep fascia, intermuscular septa, bones and interoseous membrane

CAUSE
Trauma/infection leads to swelling, increased pressure, decreased perfusion, then ischaemia and tissue death

SYMPTOMS & SIGNS
Pain, decreased muscle & nerve function, pain on passive movement. Pulse may be lost (30mmHg or more is enough to cause damage)

ANTERIOR
Pain, decreased dorsiflexion, extension of toes, sensation in first dorsal skin cleft

LATERAL
Pain, decreased plantar flexion, inversion, sensation of dorsal foot and toes

POSTERIOR
Divided by deep transverse intermuscular septum into superficial and deep syndromes. Superficial gives decreased plantar flexion and sural nerve sensation. Deep gives decreased plantar & toe flexion, tibial nerve sensation
LOWER LIMB SURFACE & APPLIED ANATOMY 1

Anterior superior iliac spine

Deep inguinal ring - "mid point of inguinal ligament"

Femoral artery - "mid inguinal point"

Adductor longus - locates pubic tubercle

Pubic symphysis

One finger laterally - femoral nerve. One finger medially - femoral vein

Sacral dimple (PSIS)

ASIS

1/2

1/3

Sciatic nerve

Feel for anterior superior iliac spine, greater trochanter, ischial tuberosity & posterior superior iliac spine (dimple)

Ischial tuberosity

Femoral artery in thigh

Surface markings with hip flexed, externally rotated, slightly abducted

Pulse at mid inguinal point

2/3

Adductor tubercle

The artery lies for 2/3 along the line indicated above
Shenton's Line is a useful observation when looking at an X-ray of a pelvis/hip. In the normal appearances this line is smooth and unbroken.

**Note:** When measuring to see if there is shortening of the lower limb it can be measured from the umbilicus to the medial malleolus. This may give an APPARENT shortening when the two sides are compared. However, only if the legs are measured from the anterior superior iliac spine to the medial malleolus will TRUE shortening be detected.