Core Surgical Sciences course for the Severn Deanery

Surgical Anatomy: Head, neck and neuroanatomy – detailed learning objectives/stations

The session will be taught in small groups, with examination of prosections, and three rotating stations: neck, head, and neuroanatomy.

Anatomy of the Neck

1. Topography and triangles of the neck

You should be able to:

Describe the general topography of the neck, including layers of fascia and compartments:

- Deep cervical investing fascia - attaches to hyoid bone, lower border of mandible and mastoid process, superior nuchal line, external occipital protuberance; splits around sternocleidomastoid, trapezius and parotid gland; attaches to spine and acromion of scapula, clavicles and manubrium
- Carotid sheath – from base of skull to aortic arch; around neurovascular compartment; thin over internal jugular vein, allowing dilation
- Pretracheal fascia – from hyoid down to aortic arch; around visceral compartment: larynx/trachea, pharynx/oesophagus; splits to envelope thyroid gland
- Prevertebral fascia – around musculoskeletal compartment: cervical vertebrae and attached muscles; forms axillary sheath around brachial plexus

Describe and identify the boundaries and contents of the posterior triangle of the neck:

- Bounded by sternocleidomastoid, trapezius, clavicle; roofed by investing fascia; floored by prevertebral fascia lying over splenius capitis, levator scapulae and scalenus medius and brachial plexus (emerging from interscalene groove)
- Spinal accessory nerve enters deep surface sternocleidomastoid about 3cm below mastoid process; emerges a third of the way down posterior border, disappears 2/3 way down anterior edge of trapezius
- Inferior belly omohyoid, transverse cervical and suprascapular vessels run horizontally across posterior triangle

Describe and identify the boundaries, subdivisions and contents of the anterior triangle:

- Bounded by scm, lower border mandible, midline
- Subdivisions: Submental, submandibular, carotid, muscular triangles
- Suprahyoid muscles: mylohyoid, digastric, stylohyoid, geniohyoid; facial nerve supplies stylohyoid and posterior belly of digastric; mylohyoid and anterior belly of digastric supplied by nerve to mylohyoid (from inferior alveolar nerve); geniohyoid supplied by C1 fibres hitchhiking with hypoglossal nerve; digastric assists lateral pterygoid in opening mouth; stylohyoid and geniohyoid elevate hyoid; mylohyoid elevates floor of mouth during swallowing

- Submandibular gland hooks around posterior border of mylohyoid; submandibular nodes lie within and around it; facial artery hooks around the gland and grooves it; parasympathetic supply from superior salivary nucleus… nervus intermedius… chorda tympani… lingual nerve… submandibular ganglion; duct opens on sublingual papilla beside frenulum; lingual nerve loops under duct; about 15 ducts from sublingual gland drain into submandibular duct, the rest open on sublingual fold
- Infrahyoid muscles: sternohyoid, sternothyroid, thyrohyoid, omohyoid; all supplied by ansa – except thyrohyoid – own nerve from C1 fibres hitch-hiking with hypoglossal; stabilise hyoid, depress larynx to lower voice (try feeling position of thyroid notch while making high and low pitched noises)

2. Pharynx, larynx and thyroid gland

Describe and identify the pharynx:

- Fibromuscular tube ~12cm long; longitudinal muscles, constrictors
- Pharyngobasilar fascia forms walls of nasopharynx
- Inferior constrictor - no raphe, acts as sphincter; Killian's dehiscence between thyropharyngeus and cricopharyngeus parts - weakness where mucosa may herniate to form pharyngeal diverticulum
- Supplied by branches of facial and maxillary arteries
- Supplied by pharyngeal plexus (CnIX afferent; CnX efferent) but stylopharyngeus by CnIX; mucosa of nasopharynx supplied by maxillary nerve via pterygopalatine ganglion

Describe and identify the larynx:

- Cartilages: thyroid, cricoid, arytenoid, corniculate and cuneiform, epiglottis
- Muscles: only posterior cricoarytenoids abduct cords; vocalis (part of thyroarytenoid) shortens and relaxes vocal cords, altering pitch of voice; cricothyroid stretches vocal cords and raises pitch of voice; all mm supplied by rec laryngeal except cricothyroid - external laryngeal nerve
- Cricothryoid and cricoarytenoid joints - synovial
- Vestibular and vocal folds - ventricle or laryngeal sinus lies between
- Superior and inferior laryngeal arteries from superior and inferior thyroid arteries respectively

Describe and identify the thyroid gland:

- Isthmus anterior to tracheal rings 2-4 (divided in tracheostomy); lobes reach up to oblique line of thyroid cartilage and down to 6th tracheal ring; overlaps common carotid artery posterolaterally
- Recurrent laryngeal nerves lie in groove between trachea and oesophagus
- Pyramidal lobe may be present at isthmus – glandular development of thyroglossal duct; may be attached to hyoid by fibrous strand or even a muscle; accessory thyroid glands may exist along path of thyroglossal duct
- Superior thyroid artery ligated close to superior pole of each lobe in thyroidectomies
- Thyroidea ima artery to isthmus in ~3%
- Venous plexus on surface of gland drains to superior, middle and inferior thyroid veins

3. Nerves and vessels of the neck

Describe and identify the cervical plexus

- Formed by the upper 4 anterior primary rami of cervical spinal nerves; emerges through interscalene groove between anterior and middle scalene; lies deep to upper scm
- Superficial cervical plexus comprises cutaneous nerves: lesser occipital (C2); great auricular (C2,3); tranverse cervical (C2,3); supraclavicular (C3,4) – NB C1 has no cutaneous supply
- Deep cervical plexus includes deep bracnhes to neck muscles; C1 fibres hitchhiking with hypoglossal nerve – forming superior root of ansa cervicalis (nervus descendens hypoglossi) and nerves to thyrohyoid and geniohyoid; inferior root of ansa (nervus descendens cervicalis) – C2, 3 – loops around internal jugular to meet superior root; ansa supplies all strap/infrahyoid muscles except thyrohyoid; phrenic nerve (C3,4,5) – runs down on anterior scalene behind prevertebral fascia, passing between subclavian artery and vein, down into thorax
- NB lower 4 anterior primary rami of cervical spinal nerves form brachial plexus

Describe the cervical sympathetic trunk:

- Inferior cervical ganglion lies behind origin of vertebral artery; usually fused with 1st thoracic to form stellate ganglion; middle cervical ganglion lies anterior to carotid tubercle (C6); superior cervical ganglion level with C2/3
- No white rami from cervical sympathetic trunk; grey rami pass to all cervical spinal nerves; cardiac branches from cervical ganglia run down behind carotid and subclavian arteries
- Superior, middle and inferior ganglia give branches to carotid, middle thyroid and vertebral arteries respectively
- Damage to cervical sympathetic trunk results in Horner's syndrome: constricted pupil, ptosis (loss of smooth muscle in levator palpebrae), loss of facial sweating

Identify the subclavian artery and describe its branches:

- Subclavian pulse palpable in anteroinferior angle of posterior triangle
- From 1st part: vertebral artery, thyrocervical trunk, inferior thyroid arteries
- From 2nd part (deep to anterior scalene): costocervical trunk
- From 3rd part: dorsal scapular (runs deep to levator scapulae)
- Recurrent laryngeal nerve loops under right subclavian artery; thoracic duct loops over left (empties into right subclavian, internal jugular or their junction)

Describe and identify the carotid arteries:

Common carotid artery

- Carotid sheath lies deep to lower scm
- Pulse felt by pressing lateral to trachea, against anterior tubercle (carotid tubercle of Chassaignac) of C6
- Bifurcates at C4 (upper edge of thyroid cartilage); carotid body at bifurcation contains chemoreceptors, supplied by glossopharyngeal and vagus nerves; carotid body tumours form lump at anterior border scm

External carotid artery - passes through parotid gland

- Branches: anteriorly - superior thyroid, lingual, facial; posteriorly - occipital, posterior auricular (often arises within parotid gland); medially: ascending pharyngeal artery

Internal carotid artery

- Carotid sinus at commencement, contains baroreceptors supplied by glossopharyngeal and vagus nerves
- Internal carotid artery initially lies laterally to external, then passes deeper; approached surgically by incision down anterior border scm (safeguarding hypoglossal nerve)

Describe and identify the venous drainage of the head and neck:

Internal jugular vein

- Arises from jugular bulb, posterior to internal carotid artery; passes lateral to artery, into carotid sheath; inferior root of ansa curls around it; omohyoid crosses it low down; lies behind gap in scm heads; joins subclavian behind clavicle
- Tributaries – inferior petrosal sinus just below skull, then pharyngeal, lingual, facial, superior and middle thyroid veins (inferior thyroid veins drain into brachiocephalic veins)
- Surface marking from between heads of scm to lobe of ear

- Superficial temporal and maxillary vein (draining pterygoid venous plexus) join to form retromandibular vein – splits to drain into facial vein, and to join posterior auricular vein to form external jugular vein - runs down across scm; drains into subclavian

Describe the lymphatic drainage of the head and neck:

- Superficial cervical nodes: submental ; submandibular nodes; parotid (preauricular) nodes; buccal node; mastoid (retroauricular) nodes; occipital nodes; anterior cervical nodes – infrahyoid, prelaryngeal, pretracheal; paratracheal and retropharyngeal nodes
- Deep cervical nodes, lying along internal jugular vein, receive lymph from all other nodes; drain to jugular lymphatic duct; include the jugulodigastric node - receives lymph from the tonsils, and jugulo-omoyoid node - receives lymph from the tongue
- Lymphoid tissue in pharynx: palatine tonsil, pharyngeal tonsil, lingual tonsil
- [label to back of tongue]

Anatomy of the Head

1. Superficial anatomy of the head

You should be able to:

Describe and identify the muscles of facial expression:

- Constrictors or dilators of orifices
- Orbicularis oculi closes eye – palpebral part opposed by levator palpebrae superioris; orbital part by frontal belly of occipitofrontalis
- Transverse part of nasalis compresses nostrils; alar part dilates
- Orbicularis oris (formed mainly by fibres from buccinator – crossing over at modiolus) acts as sphincter; opposed by other muscles radiating out from mouth – levators and depressors of the lips, zygomaticus muscles, risorius
- Muscles originate from 2nd pharyngeal arch – therefore supplied by facial nerve; facial nerve provides posterior auricular nerve to auricularis posterior and posterior belly occipitofrontalis, then nerves to stylohyoid and posterior belly digastric; then 5 branches in parotid gland

Describe and identify the parotid gland

- Parotid gland (mainly serous) extends from zygomatic arch to over anterior border of scm; accessory parotid may lie above parotid duct
- Enveloped by investing layer of deep fascia ('parotid capsule')
- Superfical muscular aponeurotic system (SMAS): aponeurosis over parotid connected to superfiical muscles: frontalis, platysma, risorius
- Secretomotor fibres from Cn IX… otic ganglion under skull, hitchhike with auriculotemporal nerve to gland
- External carotid artery; retromandibular vein and 5 branches of facial nerve lie within parotid gland
- Most common tumour: pleomorphic adenoma (mixed parotid tumour)

Describe the branches of the trigeminal nerve:

- Opthalmic division: frontal (supraorbital, supratrochlear); infratrochlear… external nasal nerve
- Maxillary division: zygomaticotemporal, zygomaticofacial, infraorbital
- Mandibular dvision: anterior trunk – muscular branches to muscles of mastication, and buccal nerve; posterior trunk - auriculotemporal, inferior alveolar… mental nerve, lingual

Describe and identify the facial artery and vein:

- Facial artery crosses inferior border of mandible, gives labial branches, becomes angular artery near eye… supratrochlear artery
- Facial vein – straighter than artery – connects with pterygoid venous plexus via deep facial vein – passing between buccinator and masseter (NB pterygoid venous plexus has intracranial connections, via ophthalmic and other emissary veins which connect to cavernous sinus)

2. Infratemporal and pterygopalatine fossae

Describe and identify the boundaries and contents of the infratemporal fossa:

- Lies between pharynx and ramus of mandible
- Contains deep part of parotid gland; pterygoid muscles, pterygoid venous plexus; mandibular nerve, otic ganglion, maxillary artery

Describe and identify important branches of the maxillary artery:

- From 1st part – inferior alveolar artery, middle and accessory meningeal arteries; branches to ear
- From 2nd part (deep to lateral pterygoid) – muscular branches to muscles of mastication, and buccal artery
- From 3rd part: sphenopalatine (main artery of nose), infraorbital artery, branches to upper teeth, palate and pharynx

Describe and identify the boundaries and contents of the ptergopalatine fossa:

- Opens laterally as pterygomaxillary fissure
- Contains maxillary vessels and nerve
- Contains pterygopalatine ('hayfever') ganglion – receives parasympathetic fibres from facial nerve via greater petrosal nerve… nerve of pterygoid canal… and branches from maxillary nerve; provides secretomotor and sensory branches to nose, palate, nasopharynx and lacrimal gland

3. Oral and nasal cavities and orbit

Describe and identify the boundaries and contents of the oral cavity, including the tongue:

- SSKE on hard palate and oral part of tongue; SSNKE on soft palate and pharyngeal part of tongue
- Intrinsic and extrinsic tongue muscles
- Innervation of tongue: hypoglossal nerve supplies muscles; lingual nerve supplies anterior two thirds (including parasympathetic fibres from facial nerve via chorda tympani); glossopharyngeal supplies posterior third (sensory and parasympathetic)
- Tip of tongue drains to submental nodes, rest of anterior part to submandibular nodes; jugulodigastric nodes drain posterior part; all lymph from tongue ultimately passes through jugulo-omohyoid nodes

Describe the anatomy of the hard and soft palates

- Hard palate formed by maxillae and palatine bones
- Soft palate formed by 5 paired muscles: tensor palate, levator palate, palatoglossus, palatopharyngeus, musculus uvulae
- All muscles of soft palate supplied by pharyngeal plexus except tensor palati – from n to medial pterygoid (Cn V)

Describe the anatomy of the nasal cavity

- Boundaries – bones contributing
- Paranasal sinuses and drainage: sphenoid sinus into sphenethmoid recess; posterior ethmoid cells into superior meatus; middle ethmoid cells onto bulla ethmodalis in middle meatus; infundibulum draining anterior ethmoid cells and frontal sinus drains into hiatus semilunaris in middle meatus; maxillary sinus also opens into hiatus semilunaris; nasolacrimal duct into inferior meatus
- Septum: vomer, perpendicular plate of ethmoid and septal cartilage; main artery: sphenopalatine artery (from maxillary artery); anastomoses with ascending branch of greater palatine and septal branch of superior labial to form Kieselbach's plexus on anterior, inferior septum (Little's area)

Describe the anatomy of the orbit and eye

- Orbit covered by orbital septum, thickened as tarsal plates either side of palpebral fissure, anchored by medial and lateral palpebral ligaments
- Lacrimal gland – large serous gland; 12 ducts run into superior fornix of conjunctiva
- Nasolacrimal duct forms from canaliculi and sac at inner canthus; 2cm long
- Rectus muscles angled - oblique muscles required to correct line of gaze during elevation and depression of globe; recti arise from common tendinous ring at back of orbit; superior oblique and levator palpebrae superioris arise above ring
- Nerves of the orbit: Infraorbital nerve enters orbit through inferior orbital fissure, enters infraorbital canal; frontal nerve (CnV1) divides into supraorbital and supratrochlear nn; superior division Cn III supplies superior rectus and levator palpebrae; inferior division supplies inferior and medial recti, inferior oblique and parasympathetic fibres to ciliary ganglion; nasociliary n (CnV2) gives sensory branches to ciliary ganglion, and ethmoidal branches; short ciliary nerves from ciliary ganglion to eyeball - supply sensory, parasympathetic (from Cn V2) and sympathetic (from internal carotid plexus); trochlear and aducent nerves

Neuroanatomy

In the Dissection Room:

1. Brainstem, cranial nerves and spinal cord

You should be able to:

Identify and describe the parts of the brainstem and cerebellum:

Midbrain
- Tectum - includes superior and inferior colliculi
- Tegmentum – forms cerebral peduncle with basis pedunculi (substantia nigra + crus cerebri)
- Crus cerebri derives from internal capsule of cerebral hemisphere: corticospinal and corticobulbar motor fibres

Pons
- Transverse pontine fibres anteriorly, overlying corticospinal tract - pass into contralateral middle cerebellar peduncle
- Pontine nuclei receive corticopontine fibres – important in control of movement
- Cerebellar peduncles posteriorly
- Floor of fourth ventricle

Medulla
- Olive and pyramids anteriorly
- Olive contains inferior olivary nucleus – connects with cerebellum – involved in control of movement
- Gracile and cuneate tubercles and fascicles posteriorly

Cerebellum
- 2 hemispheres joined by the vermis (superior vermis is a ridge, inferior a groove)
- Approximately transverse folia
- Some deep fissures – anterior separates anterior from posterior lobe; posterolateral fissure separates flocconodular lobe (nodule medially, flocculus laterally)
- White matter contains 4 pairs of cerebellar nuclei: fastigial, globose, emboliform and dentate (only dentate visible in section with naked eye)

Identify the cranial nerves on the brain or brainstem, and describe their functions:

I Olfactory nerve
- Olfactory nerves enter cranial cavity through cribriform plate, synapse with second order neurones in olfactory bulb; olfactory tract runs back close to optic chiasma
- Lateral olfactory stria terminates in primary olfactory cortex of the uncus
- Unique sensory system: only 2 neurones, does not project to thalamus

II Optic nerve
- Axons of retinal ganglion cells form optic nerve
- Optic chiasma lies rostral to tuber cinereum of hypothalamus
- Axons from nasal retinae decussate
- Optic tracts diverge around cerebral peduncle; terminate in LGN of thalamus (apart from some fibres which pass to superior colliculus – involved in pupillary light reflex)
- Fibres representing upper visual field swing out laterally into temporal lobe (Meyer's loop)

III Oculomotor nerve
- Fibres from oculomotor & Edinger-Westphal nuclei in periaqueductal grey of midbrain; passes between posterior cerebral and superior cerebellar arteries, along wall of cavernous sinus, through IOF into orbit
- Supplies extraocular mm
- Pre-ganglionic parasympathetic fibres synapse in ciliary ganglion; postganglionic fibres pass to globe in short ciliary nerve – supply constrictor pupillae and ciliary muscle

IV Trochlear nerve
- Somatic motor neurones arise in periaqueductal grey; axons run dorsally, cross over and emerge caudal to the inferior colliculus; runs between posterior cerebral and superior cerebellar arteries, lies in lateral wall of cavernous sinus, enters orbit through SOF
- Supplies superior oblique muscle

VI Abducens nerve
- Somatic motor neurones arise in pons; fibres emerge between pons and medullary pyramid; passes through cavernous sinus, SOF, to supply lateral rectus

V Trigeminal nerve
- Small motor and large sensory root emerge from pons
- Sensory cell bodies lie in trigeminal ganglion; trigeminal sensory nucleus extends for length of brainstem; second order neurones decussate to form trigeminothalamic tract
- Connections to cerebellum and facial nucleus (eg: corneal reflex)

VII Facial nerve
- Emerges near pontomedullary junction – medial motor root and lateral sensory and parasympathetic root (nervus intermedius – from superior salivatory nucleus)
- Sensory cell bodies in geniculate ganglion within facial canal
- Taste fibres terminate in nucleus solitarius of medulla
- Motor fibres to stapedius, stylohyoid & posterior belly of digastric, mm facial expression
- Bell's palsy – inflammatory lesion of facial nerve within canal
- Ramsay Hunt syndrome – Bell's palsy, rash in EAM and oropharynx (Herpes zoster)

VIII Vestibulocochlear nerve

Vestibular nerve
- Dendrites of vestibular neurones contact hair cells in the vestibular membranous labyrinth, project to vestibular nuclei in rostral medulla
- Connections of vestibular nuclei: descending pathways (medial and lateral vestibulospinal tracts) influence motor control of posture and balance; ascending pathways connect with oculomotor, trochlear and abducens nuclei, to control eye movements; connections with flocconodular lobe of cerebellum to control balance; projections via VP thalamic nucleus to sensory cortex

Cochlear nerve
- Dendrites of cochlear nerve contact hair cells in the Organ of Corti
- Cochlear nerve fibres end in dorsal and ventral cochlear nuclei
- Ascending auditory pathway to thalamus and cerebral cortex – various connections along the way, including connections with trigeminal and facial motor nuclei (reflex contraction of tensor tympani and stapedius in response to loud noise)

IX Glossopharyngeal nerve
- Small rootlets attach to medulla, lateral to the olive
- Carries sensation from: pharynx, posterior tongue, middle ear, taste buds in posterior tongue and pharynx, chemoreceptors in carotid body and baroreceptors in carotid sinus
- General sensory fibres end in trigeminal nucleus; special sensory fibres end in nucleus solitarius
- Small motor component, from nucleus ambiguus, for stylopharyngeus
- Preganglionic parasympathetic fibres from inferior salivatory nucleus of medulla; synapse in otic ganglion; supply parotid

X Vagus nerve
- General sensation from pharynx, larynx, oesophagus, external auditory meatus (to trigeminal nucleus)
- Supplies aortic chemoreceptors & baroreceptors
- Visceral sensation from thorax and abdomen (end in nucleus solitarius)
- Motor fibres from nucleus ambiguus (most caudal in cranial accessory nerve), to pharynx & larynx (controlling swallowing)
- Parasympathetic fibres from dorsal motor nucleus of vagus in the floor of ventricle IV

XI Accessory nerve
- Purely motor
- Cranial root from nucleus ambiguus (joins vagus at jugular foramen)
- Spinal root from ventral horn at levels C1-5 – to scm and trapezius

XII Hypoglossal nerve
- Purely motor
- From hypoglossal nucleus in floor of ventricle IV
- Rootlets emerge between pyramid and olive
- Hypoglossal nucleus recieves corticobulbar fibres, reflex connections with nucleus solitarius and trigeminal nucleus (swallowing, chewing)

Describe and identify the spinal cord:

- About 45cm long (European males), with enlargements corresponding with supply to limbs (brachial and lumbosacral plexuses)
- Spinal cord occupies entire length of vertebral canal until third month of fetal life; terminates L1/2 (T12 to L2/3) in adults; rises slightly in vertebral flexion; Rule of thumb: cervical segments 1 spinous process higher; thoracic 2; lumbar 3-4
- Lumbar and sacral nerve roots form cauda equina
- Filum terminale internum - upper 15cm within subarachnoid space, continuous with pia above; filum terminale externum – fuses with dura and descends to 1st coccygeal vertebra
- 3 longitudinal arteries supply the spinal cord:
    - Anterior spinal artery – branches from vertebral arteries on medulla
    - Paired posterior spinal arteries – from vertebral or PICA - reinforced by radicular arteries from segmental vessels, including the great radicular artery (of Adamkiewicz) from anywhere between T8 and L3
- Anterior and posterior spinal veins, and anterolateral and posterolateral veins along nerve root drain into… internal vertebral (epidural) venous plexus…. external vertebral venous plexus… lumbar veins and azygous system.

2. Brain

You should be able to:

Identify and describe the anatomy of the cerebral hemispheres:

- Cerebral hemispheres divided by great longitudinal fissure – occupied by falx cerebri, ending at corpus callosum (solid body)
- Frontal, parietal, temporal and occipital lobes
- Cerebral cortex folded into gyri and sulci

Parietal, temporal, occipital loves receive sensory information:

- Somatosensory in parietal lobe (somatotopic organisation in postcentral gyrus), visual in occipital (primary visual cortex around calcarine sulcus), hearing in temporal lobe (in transverse temporal gyri – tonotopical organisation); adjacent areas to primary sensory cortex are associative
- Areas of association cortex in parietal, temporal and frontal lobes on left involved with language expression and comprehension – left is ‘dominant’ for language and mathematical ability; right involved more in spatial perception and musical proficiency; cerebral dominance established in infanthood

Frontal lobe includes:

- Precentral gyrus – primary motor cortex (somatotopic organisation – motor homunculus; premotor cortex involved in programming movement, posture control
- Middle frontal gyrus – frontal eye field; inferior frontal gyrus – motor speech area (Broca’s area) – involved with expression/articulation
- Prefrontal cortex (anterior to premotor areas) – rich connections with cortex of other lobes; higher cognitive functions here: intellect, decision making, planning, prediction.

Identify important structures forming the white matter of the cerebral hemispheres:

- Projection fibres – afferent and efferent fibres between subcortical structures (basal ganglia, thalamus and brainstem) to cortex form internal capsule and corona radiata
- Commissural fibres – link the hemispheres: corpus callsoum is the main commissural tract
- (Association fibres – connect between areas of cortex)

Identify parts of the brain involved in the limbic system

- Lies on the medial edge or limbus of brain
- Input from cortex and output to hypothalamus and thalamus – involved with stereotyped responses and affective association – and memory
- Includes: amygdala, cingulate gyrus, hippocampal formation (hippocampus, parahippocampal gyrus and dentate gyrus), fimbria and fornix, mammillary bodies of the hypothalamus - connect to anterior nuclei of thalamus and brainstem; connections with nucleus accumbens – 'pleasure centre'
- *Alcohol abuse can lead to capillary haemorrhages in limbic system – confusion & coma (Wernicke's encephalopathy); partial recovery my occur, with retrograde or anterograde amnesia*
- *Temporal lobe epilepsy can affect amygdala and hippocampus – complex experiences of mood, smell and memory*

Identify and describe the basal ganglia:

- Corpus striatum is largest, comprises: caudate nucleus, putamen, globus pallidus
- Also include substantia nigra (and amygdala – functionally part of limbic system)
- Initiation of movement from cerebral cortex involves corticospinal/bulbar pathways, but also connections to basal ganglia – which feed back to facilitate appropriate movements and inhibit inappropriate movements – different pathways
- Disorders of basal ganglia may produce akinesia (Parkinson's disease) or unwanted movements (chorea - Huntingdon's disease) depending on pathway affected

Describe and identify the thalamus:

- largest part of the diencephalons; forms wall of 3rd ventricle; egg-shaped structure; thalami usually joined at massa intermedia
- Involved with sensory, motor and cognitive functions; has extensive connections with cerebral cortex
- Includes anterior nuclei; medial and lateral nuclei; pulvinar, lateral and medial geniculate nuclei posteriorly

Describe and identify the pineal gland:

- Pineal gland & habenular nuclei (in stalk of pineal gland – together form epithalamus) involved in sleep-wake cycles, nutrition, pain, reproduction and reward
- Pineal gland makes melatonin

Describe and identify the hypothalamus

- forms floor of 3rd ventricle
- Connects with limbic system
- Integrates ANS and endocrine systems (through pituitary gland)

Identify and describe the meninges:

- Dura mater – 2 layers, fused together except where separated to form dural venous sinuses; falx cerebri, tentorium cerebelli
- Thin (potential) subdural space between dura and arachnoid mater; CSF in subarachnoid space
- Pia adheres to surface of brain

Identify the ventricles of the brain, and describe the circulation of CSF:

- Lateral ventricles: corpus callosum roofs anterior horn; head of caudate nucleus forms lateral wall; medial wall – septum pellucidum (translucent septum); posterior horn projects into occipital lobe; inferior horn runs into temporal lobe, with hippocampus in its floor, and the tail of the caudate nucleus in its roof
- Lateral ventricles and 3rd ventricle connected via interventricular foramen (of Monro)
- 3rd & 4th ventricles connected via cerebral aqueduct through midbrain; cerebellar peduncles flank 4th ventricle
- CSF produced by choroid plexus – mainly in lateral ventricles; escapes into subarachnoid space from 4th ventricle - through lateral apertures (foramen of Luschka) and median aperture (foramen of Magendie), into cisterna magna; flows superiorly - reabsorbed via arachnoid villi, mainly into superior sagittal sinus
- *Raised CSF pressure produces hydrocephalus, papilloedema*

Identify and describe the blood vessels of the brain

- Arterial supply: internal carotid arteries, basilar artery, vertebral arteries, Circle of Willis, cerebellar arteries, cerebral arteries
- Venous drainage: all intracranial veins are valveless; cerebral veins drain into dural venous sinuses; straight and superior sagittal sinuses join at confluence, blood flows laterally in transverse sinus…sigmoid sinus…through jugular foramen into internal jugular vein

Additional notes

You may find the following notes useful in guiding further reading. They relate more to theory or to structures that are not likely to be seen in the dissection room.

Spinal cord

Internal architecture of the spinal cord:

- Posterior/dorsal median sulcus shallower than anterior median fissure; posterior median septum of neuroglia extends almost to central canal
- Dorsal rootlets of spinal nerves leave at posterolateral sulcus - 31 pairs of spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal); dorsal horn – afferent neurons terminate; ascending pathways to brain originate
- Ventral horn – motor neurons to skeletal muscle; anterior and lateral funiculi of cord divided by emergence of ventral rootlets
- Lateral/intermediolateral horn in thoracic and upper lumbar segments – cell bodies of preganglionic sympathetic neurones
- Denticulate ligaments – lateral extensions of pia, attaching to arachnoid and dura mater
- Arachnoid and dura form sheaths around dorsal and ventral roots, then fuse with epineurium
- Characteristics of regions of spinal cord:
    - Cervical – oval, large amount of white matter, chunky ventral horn
    - Thoracic – round, large amount of white matter, thin dorsal horns
    - Lumbar – round, large ventral and dorsal horns
    - Sacral – round, grey matter predominates

Organisation of the grey matter of the spinal cord:

- Rexed's laminae – based on cytoarchitecture of grey matter
- Laminae I-III: substantia gelatinosa - nociceptive fibres terminate - interactions with other neurones modify transmission of information; high levels of enkephalin (endogenous opioid); opiates work here too
- Lamina VII: forms the thoracic nucleus at levels C8-L3 (receives input from muscle spindles, Golgi tendon organs, touch and pressure receptors); also contains autonomic preganglionic neurones

Organisation of the white matter of the spinal cord:

Ascending tracts of the spinal cord

General sensation (touch, pressure, pain, temperature and proprioception) carried in spinal nerves and CnV; chain of 3 neurones between the periphery and the cortex:

- primary afferent neurone – stays ipsilateral; cell body in DRG
- secondary afferent neurone – cell body in spinal cord/brainstem; axon decussates and ascends to thalamus
- tertiary afferent neurone - projects to the cortex

Dorsal columns
- Convey fine (discriminative) touch & proprioception
- Fasciculus gracilis contains fibres (primary afferent neurones) entering (ipsilaterally) at lower thoracic to sacral levels
- Fasciculus cuneatus contains fibres entering through upper thoracic and cervical dorsal roots
- Primary afferents ascend uninterrupted in dorsal columns, terminate in dorsal column (gracile and cuneate) nuclei in medulla
- Secondary afferents form medial lemniscus, ascending through brainstem, to ventral posterior (VP) nucleus of thalamus

Anterolateral system:

Spinothalamic tract
- Carries ('fast') pain and temperature information, coarse touch and pressure (intermingled)
- Primary spinal afferents in this pathway terminate near level of entry; secondary afferents decussate within a few levels, through ventral white commissure, then ascend in spinothalamic tract

Spinocerebellar tracts
- Carry proprioceptive information
- Informs the cerebellar control of posture and coordination
- Dorsal spinocerebellar tract forms inferior cerebellar peduncle; ventral forms superior peduncle

Spinoretiular tract
- Reticular formation includes locus coeruleus and raphe nuclei of brainstem – regulates ANS

Spinal cord lesion: loss of ipsilateral fine touch/ proprioception; contralateral pain & temperature

Descending tracts of the spinal cord

Corticobulbar and corticospinal pathways
- Control voluntary, skilled movements
- Chain of 2 neurons: UMN (cell bodies in cortex): corticobulbar fibres descend and synapse with LMN in cranial nerve nuclei; corticospinal fibres descend and synapse with LMN in spinal cord

Corticospinal pathway
- Corticospinal fibres from primary motor cortex, through corona radiata and internal capsule, crus cerebri of midbrain, through the pons, to form the pyramids of the medulla
- 75-90% decussate in the lower medulla, into the contralateral lateral corticospinal tract
- 10-25% stay ipsilateral, in ventral corticospinal tract, decussate near termination
- Voluntary, skilled movements
- *UMN lesions cause pyramidal weakness (esp extension of UL, flexion of lower); spasticity & clasp-knife response; hyper-reflexia; extensor plantar response – Babinski +; LMN lesions: brainstem lesion: contralateral paralysis; spinal cord lesion: ipsilateral paralysis*

Extrapyramidal pathways

Rubrospinal tract
- from red nucleus of midbrain
- Controls tone of flexor muscles

Tectospinal tract
- from superior colliculus of midbrain (receives visual input), mostly terminating in cervical segments of the spinal cord
- Reflex responses to visual stimuli

Vestibulospinal tracts
- from medial and lateral vestibular nuclei in brainstem
- control extensor muscles involved in posture
- NB medial longitudinal fasciculus is another name for medial vestibulospinal tract

Reticulospinal tracts
- Basal ganglia have projections to cortex (via thalamus) and to reticular formation in brainstem
- Reticulospinal tract controls reflexes, muscle tone, breathing and circulatory functions

Cerebellum

Cerebellar connections
- Grey matter of cerebellum has outer molecular layer, inner granular layer, intermediate layer: Purkinje cell layer
- Spino-, vestibulo-, and pontocerebellar fibres connect to cerebellar cortex (as climbing fibres) and to cerebellar nuclei
- Cerebellar efferents connect nuclei to reticular and vestibular nuclei of the medulla and pons, red nucleus, and VL nucleus of thalamus

Functional subdivisions of the cerebellum
- Archicerebellum: Flocconodular lobe and fastigial nuclei – concerned wth balance
- Palaeocerebellum: Vermis, globose and emboliform nuclei - concerned with muscle tone and posture
- Neocerebellum (largest part): cerebellar hemisphere and dentate nucleus; concerned with coordination of movement

NB. Unilateral cerebellar lesions cause ipsilateral symptoms; Charcot's triad (nystagmus, dysarthria, intention tremor) in MS

Parts of the diencephalon:

Thalamus – largest part

Specific nuclei
- Lateral geniculate nucleus - receives optic tract, projects to primary visual cortex
- Medial geniculate nucleus – input from inferior colliculus, projects to primary auditory cortex
- Ventral posterior - receives termination of all sensory pathways from spinal cord and brainstem
- Ventral lateral nucleus - afferents from basal ganglia and cerebellum; efferents to primary motor cortex
- Ventral anterior nucleus - afferents from basal ganglia; efferents to premotor cortex (controlling movement)

Nonspecific nuclei:
- anterior, medial and dorsal tier of lateral nuclei
- less well-defined connections with association cortex, limbic system; involved with mood and emotions and activating the cortex – waking

Epithalamus
- Pineal gland & habenular nuclei

Subthalamus
- small nucleus below thalamus
- Connects to globus pallidus and substantia nigra – important in control of movement

Hypothalamus
- Hypothalamus is involved with homeostasis
- Neural (eg: baroreceptor, chemoreceptor) and circulatory (eg: temperature, osmolality, blood glucose) inputs
- Neural output via ANS and limbic system; circulatory via anterior pituitary (adenohypophysis) - releasing factors synthesised in hypothalamus pass to anterior pituitary in portal system to control release of hormones
- Lateral hypothalamus important in food and water intake = physiological feeding centre; lateral hypothalamic lesions cause aphagia and adipsia
- Hormones of the hypothalamus
    - Supraoptic nucleus reacts to increased osmolality of blood and produces vasopressin (ADH)
    - Paraventricular nucleus stimulated by suckling - produces oxytocin
    - Adenohypophysis produces ACTH, LH, FSH, TSH, GH, prolactin