ANAT20006 Principles of Human Structure – Detailed Notes

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2.2 Lecture 6: Nervous system 1

Anatomical orientation

- The nervous system of vertebrates has a central division and a peripheral division.
- The **central nervous system (CNS)** is the brain and spinal cord. The **peripheral nervous system (PNS)** is the nerves connecting the CNS to the body (the periphery), including clusters of neurons (ganglia) at specific places along the nerves.
- The CNS is elongated. In quadrupeds the rostro-caudal neuraxis is essentially horizontal, so "up" and "down" are dorsal and ventral. In humans the neuraxis is vertical but bends forward at the rostral (brain) end.
- The central sulcus separates the frontal lobe from the parietal lobe; the folds of the cerebellum are called folia.

The meninges and CSF

- Three layers protect the brain: the dura mater (outer, tough), the arachnoid mater and the pia mater (inner, on the brain surface). The subarachnoid space (between the arachnoid and pia) contains CSF.
- The dura can bleed, causing multiple problems even though it is protective (for example bleeding into the subdural space).
- The arachnoid protrudes into the dural venous sinuses as arachnoid granulations.
- **CSF** fills the brain ventricles and surrounds the brain and spinal cord. It is a clear fluid with little protein and few cells.
- It is produced continuously by the choroid plexus (specialised vascular tissue) and reabsorbed by the arachnoid granulations, so that production is balanced with drainage and pressure does not build up.
- **Hydrocephalus** is excess CSF accumulating in the ventricles because of blocked flow or poor reabsorption (for example absent or defective arachnoid granulations). It is treated by a catheter (shunt) draining CSF from the ventricles into the peritoneal cavity, usually for life.

Lobes and cortex

- The four lobes of the brain are frontal, parietal, temporal and occipital. A hidden fifth lobe, the insula, lies deep to the lateral fissure and is part of the limbic system.
- Most primary cortices are located around the deepest sulci and fissures:

Landmark	Cortex
Central sulcus	Separates frontal from parietal lobe
Postcentral gyrus	Primary somatosensory cortex (major sensory control)
Precentral gyrus	Primary motor cortex (major motor control)
Lateral fissure	Surrounded by the primary auditory and gustatory cortices
Calcarine sulcus	Surrounded by the primary visual cortex

- The corpus callosum connects the two hemispheres (cutting it can cause split-brain behaviour).

Cranial nerves

- They mostly arise from the brainstem, except the olfactory and optic nerves. The 12 cranial nerves and their functions should be memorised; some are mixed, and some are purely sensory or purely motor.

Nerve	Attachment	Function
I Olfactory	Cerebral hemisphere	Sensory: nose (smell)
II Optic	Cerebral hemisphere	Sensory: eye (vision)
III Oculomotor	Midbrain	Motor: all eye muscles except those supplied by IV and VI
IV Trochlear	Midbrain	Motor: superior oblique muscle
V Trigeminal	Pons	Sensory: face, teeth, sinuses. Motor: muscles of mastication
VI Abducens	Pons	Motor: external (lateral rectus) eye muscle
VII Facial	Pons	Motor: muscles of the face. Intermediate nerve: motor to the submandibular and sublingual glands; sensory from the anterior part of the tongue and soft palate
VIII Vestibulocochlear	Pons	Sensory: inner ear (hearing and balance)
IX Glossopharyngeal	Medulla	Motor: pharyngeal musculature. Sensory: posterior part of the tongue, tonsil, pharynx
X Vagus	Medulla	Motor: heart, lungs, bronchi, gastrointestinal tract. Sensory: heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear
XI Accessory	Medulla	Motor: sternocleidomastoid and trapezius muscles
XII Hypoglossal	Medulla	Motor: muscles of the tongue

Somatic versus autonomic nervous system

- Efferent neurons can be either somatic or autonomic.
- The **somatic nervous system** is part of the PNS and includes muscle reflex movements and voluntary movements.
- The **autonomic nervous system (ANS)** is an effector system in the CNS and PNS that mediates unconscious homeostatic control of organ and body physiology. It has two main divisions: thoracolumbar (sympathetic) outflow and craniosacral (parasympathetic) outflow.
- Each autonomic pathway has a pre-ganglionic and a post-ganglionic neuron, and their relative lengths are reversed between the divisions:

	Sympathetic	Parasympathetic
Outflow	Thoracolumbar	Craniosacral
Pre-ganglionic neuron	Short	Long
Post-ganglionic neuron	Long	Short (ganglion in or near the organ)
Typical effects	Dilates pupils; inhibits salivation; increases heart rate; relaxes airways; inhibits stomach, gall bladder and intestinal activity; secretes adrenaline and noradrenaline (adrenal medulla); relaxes the bladder	Constricts pupils; stimulates salivation; slows heart rate; constricts airways; stimulates stomach, gall bladder and intestinal activity; contracts the bladder

Sympathetic outflow (efferent neuron)

- The sympathetic nervous system is part of the ANS, which is part of the PNS. It consists of an integration site: the ganglia of the sympathetic chain running along the spinal column.
- It carries information from the brain to target involuntary functions such as cardiac muscle.
- The pre-ganglionic neuron leaves from the lateral horn (not the ventral horn), enters the mixed spinal nerve, passes into the sympathetic chain and synapses with the post-ganglionic neuron, which then carries the signal to the organ.

Parasympathetic sacral nerves

- Organisation is simpler in the nerves at the bottom of the spine: sacral pre-ganglionic axons leave in the pelvic splanchnic nerves and synapse with post-ganglionic neurons close to or within the target organ.
- Sympathetic outflow is more complicated than parasympathetic outflow, which usually has the post-ganglionic neuron located directly in the organ or muscle.

Connective tissue organisation of skeletal muscle

- The **endomysium** encloses the smallest muscle cells (fibres). Bundles of fibres form a **fascicle**, surrounded by the **perimysium**. The whole muscle is enclosed in the **epimysium**.
- The epimysium is continuous with the **deep fascia** (present in most limbs), which blends with the periosteum of the bone.
- The deep fascia separates groups of muscles into "fascial compartments" divided by intermuscular septa.
- It connects deeply into joints, forming bands that hold tendons in place, the **retinacula**. All the muscles responsible for moving the fingers and toes are enclosed in deep fascia.

Other connective tissues

- **Tendons:** found in the limbs. The **origin** is the stable, proximal attachment; the **insertion** is the distal attachment that moves. Muscle contraction pulls the insertion toward the origin.
- **Aponeurosis:** a flat sheet of tendon (providing stability).
- **Raphe:** joins left and right parts, forming a seam.
- **Fascial sheath:** flexible connective tissue enclosing a neurovascular bundle.
- **Synovial tendon sheaths:** connective tissue containing synovial fluid encircling a tendon.
- **Tenosynovitis:** infection or inflammation of a synovial sheath. It occurs where there are synovial tendon sheaths, and causes pain and swelling; the tendons themselves can be infected as well.

Muscle classification by shape

Shape	Features
Fusiform	Spindle-shaped belly with a tendinous insertion on a small point of bone; high control and tension from one specific point
Parallel	Fibres run parallel to the long axis; connective tissue stabilises and holds things down (for example the tendinous intersections that make a "six pack" in rectus abdominis)
Convergent	Wide muscle converging on a narrow point; powerful action at one point
Unipennate	Feather-shaped; fibres pull on the tendon from one side (strong contraction)
Bipennate	Fibres attach to the tendon from both sides
Multipennate	Fibres attach to the tendon from many directions (for example the deltoid); the strongest type of contraction
Circular	Ring-shaped muscle (for example around the eye socket)

Upper limb movements

Joint	Type	Movements
Shoulder girdle	Sternoclavicular, acromioclavicular and scapulothoracic	Protraction and retraction (moving the shoulders forward or backward), elevation and depression, rotation
Shoulder (glenohumeral)	Ball and socket	Flexion/extension, abduction/adduction, medial/lateral rotation, circumduction (moving in a circle)
Elbow	Hinge	Flexion and extension
Proximal and distal radioulnar	Pivot	Pronation and supination
Wrist	Condyloid	Two planes: flexion/extension and abduction/adduction (radial and ulnar deviation)
Fingers	Metacarpophalangeal and interphalangeal	Flexion/extension and abduction/adduction (with respect to the midline of the hand, which is the middle finger)
Thumb	Saddle	Flexion/extension (in the plane of the palm), abduction/adduction (at right angles to the palm) and opposition

Muscles of the shoulder girdle

- These muscles attach to and act on the upper limb, connecting the shoulder, limb and chest together. Know their relative positions.
    - **Trapezius:** elevates, retracts and rotates the scapula.
    - **Deltoid:** the main abductor of the arm (multipennate).
    - **Pectoralis major:** adducts and medially rotates the arm.
    - **Latissimus dorsi** and **teres major:** extend, adduct and medially rotate the arm.
- **Rotator cuff muscles:** they attach to the scapula, blend with the capsule of the shoulder joint and pull the humeral head toward the glenoid, compressing it into the socket.

Muscle	Position	Action
Supraspinatus	Above (supraspinous fossa)	Abducts the arm (initiates abduction)
Infraspinatus	Behind (infraspinous fossa)	Laterally (externally) rotates the humerus
Teres minor	Behind	Laterally rotates and stabilises the humerus in the glenoid
Subscapularis	Comes around anteriorly (front of the scapula)	Medially (internally) rotates the humerus

Nerve	Roots	Motor supply	Cutaneous supply	Injury
Musculocutaneous (anterior compartment of arm)	C5, 6, 7	All muscles of the anterior compartment of the arm (elbow flexors)	Lateral aspect of the forearm (it becomes cutaneous in the forearm)	Well protected and rarely injured
Median (anterior compartment of forearm)	C5 to T1	Most anterior compartment forearm muscles; passes through the carpal tunnel and supplies most of the thumb muscles	Lateral 3.5 digits on the palmar side and the nail beds	Compression in the carpal tunnel, which contains nine tendons (carpal tunnel syndrome): numbness of the 3.5 digits
Ulnar	C8, T1	No muscles in the arm; a few in the forearm; most of the intrinsic muscles of the hand	Medial 1.5 digits (palmar and dorsal)	At the medial epicondyle (the “funny bone”), and at the wrist where it passes over the flexor retinaculum (for example pressure from bicycle handlebars). Ulnar claw: the ring and little fingers lose their intrinsic muscle tone and are hyperextended at the knuckles and flexed at the finger joints
Axillary (posterior compartment)	C5, 6	Deltoid (and teres minor)	Skin over the shoulder	Shoulder dislocation; fracture of the surgical neck of the humerus
Radial (posterior compartment of arm and forearm)	C5 to T1	Extensor muscles of the elbow, wrist and fingers	Posterior skin of the arm and forearm and the back of the hand	Humeral shaft fracture, because the nerve runs down the shaft in the radial groove (between the medial and lateral heads of triceps) and is very close to the bone: loss of innervation to everything below, causing wrist drop. Also compression