

ZOOLOGY

+2 1st Year (Class XI) · Study Notes

8 chapters · theory in simple words · key terms · exam Q&A

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How to use: read the box "In simple words" first, then the main points. Learn the key terms, then try each exam question yourself before reading the model answer. Diagrams named in the notes should be practised from your textbook.

Chapter 1. Animal Kingdom

In simple words: Animals are grouped by a few basic features of their body plan: how cells are organised, the type of symmetry, the number of germ layers, whether there is a body cavity (coelom), segmentation and the presence of a notochord. These features place every animal in a phylum.

Basis of classification

- **Levels of organisation:** cellular (sponges), tissue (coelenterates), organ (flatworms) and organ-system level (annelids onwards).
- **Symmetry:** asymmetrical (most sponges), radial (coelenterates, adult echinoderms) and bilateral (annelids, arthropods, chordates and others).
- **Germ layers:** diploblastic animals have two layers, ectoderm and endoderm (coelenterates). Triploblastic animals also have a middle mesoderm (flatworms onwards).
- **Coelom:** acoelomate (no cavity, e.g. flatworms), pseudocoelomate (cavity not fully lined by mesoderm, e.g. roundworms) and coelomate (true coelom, e.g. annelids to chordates).
- **Segmentation (metamerism):** the body is divided into repeated segments, e.g. earthworm.
- **Notochord:** a rod-like support on the back, formed from mesoderm during embryonic life. Animals with it are chordates; the others are non-chordates.

Non-chordate phyla at a glance

Porifera	Sponges. Pores (ostia), canal system, choanocytes (collar cells), spicules. Example: Sycon, Spongilla.
Coelenterata (Cnidaria)	Cnidoblasts (stinging cells), two body forms: polyp and medusa. Example: Hydra, Aurelia (jellyfish), Physalia.
Ctenophora	Comb jellies with eight rows of comb plates; bioluminescence. Example: Pleurobrachia.
Platyhelminthes	Flatworms; flame cells for excretion; many are parasites. Example: Taenia (tapeworm), Fasciola (liver fluke), Planaria.
Aschelminthes	Roundworms; pseudocoelom; sexes separate. Example: Ascaris, Wuchereria (filaria worm).
Annelida	Segmented worms; nephridia for excretion. Example: Pheretima (earthworm), Hirudinaria (leech), Nereis.
Arthropoda	Largest phylum; jointed legs, chitin exoskeleton; open circulation. Example: insects, prawn, spider, scorpion.
Mollusca	Soft body with mantle, often a shell; radula for feeding. Example: Pila (apple snail), Octopus, Sepia.
Echinodermata	Spiny skin; water vascular system with tube feet; all marine. Example: Asterias (starfish), sea urchin.
Hemichordata	Worm-like marine animals with a proboscis, collar and trunk. Example: Balanoglossus.

Phylum Chordata

- Three basic features: a **notochord**, a **dorsal hollow nerve cord** and **pharyngeal gill slits**, at least at some stage of life. The heart is ventral.

- Subphyla: Urochordata (notochord only in the larval tail, e.g. Ascidia), Cephalochordata (notochord along the whole body for life, e.g. Branchiostoma/Amphioxus) and Vertebrata.
- In vertebrates the notochord is replaced by the **vertebral column** in the adult.

Cyclostomata	Jawless; parasites on fish. Example: Petromyzon (lamprey).
Chondrichthyes	Cartilaginous fish; no air bladder. Example: Scoliodon (dogfish), sharks.
Osteichthyes	Bony fish; air bladder; gills covered by operculum. Example: Labeo (rohu), Catla.
Amphibia	Live on land and in water; moist skin; three-chambered heart. Example: frog, toad, salamander.
Reptilia	Dry scaly skin; lay shelled eggs on land. Example: lizard, snake, turtle, crocodile (four-chambered heart).
Aves	Birds; feathers, beak, hollow (pneumatic) bones, four-chambered heart. Example: crow, pigeon, ostrich.
Mammalia	Mammary glands, hair, external ears (pinnae), four-chambered heart. Example: human, whale, bat; platypus lays eggs.

Exam tip: Cold-blooded (poikilothermous) vertebrates: fish, amphibians and reptiles. Warm-blooded (homoiothermous): birds and mammals.

Exam questions

Q. What is the difference between radial and bilateral symmetry?

In radial symmetry, any plane passing through the central axis divides the body into two identical halves (e.g. Hydra). In bilateral symmetry, only one plane divides the body into identical left and right halves (e.g. earthworm, human).

Q. Name the three basic features of chordates.

Notochord, dorsal hollow nerve cord and paired pharyngeal gill slits.

Q. Why is Arthropoda called the largest phylum?

About two-thirds of all named animal species are arthropods, mainly insects.

Q. What are cnidoblasts?

Stinging cells found in coelenterates, used for defence, anchoring and capturing prey.

Chapter 2. Structural Organisation in Animals

In simple words: In complex animals, similar cells group together to form tissues. Tissues form organs, and organs work together as organ systems. There are four basic animal tissues: epithelial, connective, muscular and neural.

Epithelial tissue

- Covers body surfaces and lines cavities. Cells are packed closely with little matrix and rest on a basement membrane.
- **Simple epithelium** (one layer): squamous (walls of blood vessels, air sacs of lungs), cuboidal (kidney tubules, ducts of glands) and columnar (lining of stomach and intestine). Ciliated columnar epithelium lines the bronchioles and fallopian tubes.
- **Compound epithelium** (many layers): protects against chemical and mechanical stress, e.g. skin, lining of mouth and pharynx.
- **Glandular epithelium:** exocrine glands pour secretions through ducts (salivary glands); endocrine glands release hormones directly into blood.
- **Cell junctions:** tight junctions stop leakage, adhering junctions hold cells together, gap junctions let ions and small molecules pass between cells.

Connective tissue

- The most abundant and widely spread tissue. It links and supports other tissues.
- **Loose connective tissue:** areolar tissue (under the skin) and adipose tissue (stores fat).
- **Dense connective tissue:** tendons join muscle to bone; ligaments join bone to bone.
- **Specialised connective tissue:** cartilage, bone and blood.

Cartilage	Flexible, matrix of chondrocytes. Found in the tip of the nose, outer ear, between vertebrae.
Bone	Hard matrix rich in calcium salts and collagen; cells are osteocytes in spaces called lacunae.
Blood	Fluid connective tissue: plasma plus RBCs, WBCs and platelets.

Muscular tissue

- **Skeletal (striated) muscle:** attached to bones; voluntary; cells are long and multinucleate.
- **Smooth muscle:** walls of internal organs like the intestine and blood vessels; involuntary; spindle-shaped cells without stripes.
- **Cardiac muscle:** only in the heart; striated but involuntary; cells joined by intercalated discs so they contract together.

Neural tissue

- Made of **neurons** (the excitable cells that carry impulses) and **neuroglia** (supporting cells, which make up more than half of neural tissue).

Example animal: the frog (*Rana tigrina*)

- Amphibian; cold-blooded; shows camouflage and aestivation (summer sleep) and hibernation (winter sleep).
- Skin is moist and used for breathing on land and in water (cutaneous respiration). Lungs are used on land; tadpoles use gills.

- Heart has three chambers: two atria and one ventricle. Kidneys excrete urea (frog is ureotelic).
- Fertilisation is external, in water; development includes a tadpole larva (metamorphosis).
- Sexes are separate. The male has vocal sacs and a copulatory (nuptial) pad on the first finger of the forelimb.

Exam questions

Q. Where do you find ciliated epithelium? What is its function?

It lines the bronchioles and fallopian tubes. The cilia beat to move mucus or particles (or the egg) in a fixed direction.

Q. Distinguish between a tendon and a ligament.

A tendon joins a skeletal muscle to a bone. A ligament joins one bone to another bone.

Q. Why is cardiac muscle able to contract as one unit?

Its cells are joined by intercalated discs with gap junctions, so the impulse spreads quickly and all cells contract together.

Chapter 3. Breathing and Exchange of Gases

In simple words: Breathing brings in oxygen and removes carbon dioxide. In the lungs, oxygen moves from the air sacs (alveoli) into blood, and CO_2 moves out, by simple diffusion from high to low partial pressure.

Human respiratory system

- Path of air: nostrils → nasal chamber → pharynx → larynx (voice box) → trachea → bronchi → bronchioles → alveoli.
- The **epiglottis** covers the glottis during swallowing, so food does not enter the windpipe.
- The trachea is kept open by C-shaped rings of cartilage.
- The lungs are covered by a double **pleura** with pleural fluid that reduces friction.
- Alveoli are thin-walled, numerous and richly supplied with capillaries — ideal for diffusion.

Mechanism of breathing

- **Inspiration (active):** the diaphragm contracts and flattens; the external intercostal muscles lift the ribs and sternum. Chest volume increases, lung pressure falls below air pressure, and air rushes in.
- **Expiration (normally passive):** the diaphragm and intercostal muscles relax, chest volume decreases, pressure inside rises, and air is pushed out.
- A healthy adult breathes about 12–16 times a minute.

Respiratory volumes

Tidal volume (TV)	Air breathed in or out in a normal breath: about 500 mL.
Inspiratory reserve volume (IRV)	Extra air that can be breathed in by force: about 2500–3000 mL.
Expiratory reserve volume (ERV)	Extra air that can be breathed out by force: about 1000–1100 mL.
Residual volume (RV)	Air left in the lungs even after forced expiration: about 1100–1200 mL.
Vital capacity (VC)	$\text{ERV} + \text{TV} + \text{IRV}$: the maximum air a person can breathe out after a forced inspiration.
Total lung capacity	$\text{VC} + \text{RV}$: about 5800–6000 mL.

Transport of gases

- About **97% of O_2** is carried by haemoglobin in RBCs as oxyhaemoglobin; 3% is dissolved in plasma.
- CO_2 : about 20–25% as carbaminohaemoglobin, about 70% as **bicarbonate** in plasma, about 7% dissolved in plasma.
- The enzyme **carbonic anhydrase** in RBCs speeds up $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{HCO}_3^- + \text{H}^+$.
- The oxygen dissociation curve is **sigmoid** (S-shaped).

Regulation and disorders

- The **respiratory rhythm centre** is in the medulla oblongata; the pneumotaxic centre in the pons can adjust it.
- Asthma: spasm of bronchioles causing difficulty in breathing.
- Emphysema: alveolar walls are damaged, reducing the surface for gas exchange. Cigarette smoking is a main cause.

- Occupational disorders: long exposure to dust (stone grinding, mining) causes fibrosis of the lungs.

Exam questions

Q. What is vital capacity? Why is it important?

It is the maximum volume of air a person can breathe out after a forced inspiration ($ERV + TV + IRV$). Higher vital capacity means better lung function, as in athletes.

Q. Why is the diffusion of CO_2 across the alveolar membrane faster than O_2 ?

CO_2 is about 20–25 times more soluble than O_2 , so it diffuses much more quickly even with a smaller pressure difference.

Q. Name the enzyme that helps to carry CO_2 as bicarbonate.

Carbonic anhydrase, present mainly in red blood cells.

Chapter 4. Body Fluids and Circulation

In simple words: Blood and lymph carry food, gases, hormones and wastes around the body. The heart pumps blood through a closed system of vessels in two circuits: to the lungs and to the rest of the body.

Blood

- **Plasma** (about 55%): water with proteins — fibrinogen (clotting), globulins (defence) and albumin (osmotic balance).
- **RBCs (erythrocytes)**: about 5–5.5 million per mm^3 ; no nucleus in mammals; contain haemoglobin; live about 120 days; destroyed in the spleen.
- **WBCs (leucocytes)**: 6000–8000 per mm^3 . Neutrophils (most numerous, phagocytic), lymphocytes (immune response), monocytes, eosinophils (allergy), basophils (release histamine, heparin).
- **Platelets (thrombocytes)**: 1.5–3.5 lakh per mm^3 ; help in clotting.

Blood groups

ABO system	Based on antigens A and B on RBCs. Group O is the universal donor; group AB is the universal recipient.
Rh factor	An antigen on RBCs. Rh^- mother with Rh^+ baby may cause erythroblastosis foetalis in a later pregnancy.

Coagulation (clotting)

- Injured tissue and platelets release factors → thrombokinase → prothrombin is changed to **thrombin** → thrombin changes soluble **fibrinogen** into insoluble **fibrin** threads that trap blood cells. **Calcium ions** are needed.

Lymph

- Lymph is tissue fluid collected by lymph vessels. It has lymphocytes and carries absorbed fats (from lacteals in the intestine) back to blood.

The human heart

- Four chambers: two atria and two ventricles. The left ventricle has the thickest wall because it pumps blood to the whole body.
- Valves: **tricuspid** (right side), **bicuspid/mitral** (left side) and **semilunar** valves at the openings of the aorta and pulmonary artery. Valves allow flow in one direction only.
- The heart is **myogenic**: the beat starts in the heart muscle itself, at the **SA node** (the pacemaker), then passes to the AV node, bundle of His and Purkinje fibres.

Cardiac cycle and double circulation

- One cardiac cycle takes about 0.8 s (72 beats per minute). Stroke volume $\approx 70 \text{ mL}$; cardiac output $\approx 70 \text{ mL} \times 72 \approx 5 \text{ litres per minute}$.
- Heart sounds: "lub" (closure of tricuspid and bicuspid valves) and "dub" (closure of semilunar valves).
- **ECG**: P wave = atrial depolarisation; QRS complex = ventricular depolarisation; T wave = ventricular repolarisation.
- **Double circulation**: pulmonary circulation (right ventricle → lungs → left atrium) and systemic circulation (left ventricle → body → right atrium). Oxygenated and deoxygenated blood never mix.

Disorders

- Hypertension: blood pressure repeatedly above 140/90 mm Hg (normal 120/80).
- Coronary artery disease: arteries supplying the heart muscle get narrowed by deposits.
- Angina: chest pain when heart muscle gets too little oxygen. Heart failure: the heart cannot pump enough blood.

Exam questions

Q. Why is the SA node called the pacemaker?

It produces the largest number of action potentials per minute (70–75) on its own, starting each heartbeat and setting its rhythm.

Q. What is the role of calcium in clotting?

Calcium ions are needed for the formation of thrombin from prothrombin, which then changes fibrinogen into fibrin.

Q. Explain double circulation.

Blood passes through the heart twice in one complete round: once through the lungs (pulmonary circuit) and once through the body (systemic circuit). This keeps oxygenated and deoxygenated blood separate.

Chapter 5. Excretory Products and their Elimination

In simple words: Animals must remove nitrogen wastes made from proteins. Humans mainly excrete urea through the kidneys. Each kidney has about a million tiny filtering units called nephrons.

Types of nitrogenous waste

Ammonotelic	Excrete ammonia (very toxic, needs plenty of water). Example: bony fish, aquatic amphibians.
Ureotelic	Excrete urea (less toxic). Example: mammals, many terrestrial amphibians, marine fish.
Uricotelic	Excrete uric acid as paste or pellets (least water loss). Example: birds, reptiles, insects, land snails.

Human excretory system

- A pair of **kidneys**, a pair of **ureters**, a **urinary bladder** and the **urethra**.
- Kidney regions: outer **cortex** and inner **medulla** (with medullary pyramids).
- **Nephron**: Bowman's capsule + glomerulus (together the Malpighian body), proximal convoluted tubule (PCT), loop of Henle, distal convoluted tubule (DCT) and collecting duct.

Urine formation

- **Glomerular filtration**: blood is filtered under pressure. About 125 mL of filtrate is formed per minute (GFR), i.e. about 180 litres per day.
- **Reabsorption**: about 99% of the filtrate is reabsorbed — glucose, amino acids, Na^+ and much water, mainly in the PCT.
- **Secretion**: H^+ , K^+ and ammonia are secreted into the tubule, helping to keep the pH and ion balance of blood.
- The loop of Henle and the vasa recta set up a **counter-current mechanism** that keeps the medulla very concentrated, so concentrated urine can be produced.
- An adult passes 1–1.5 litres of urine a day.

Regulation of kidney function

- **ADH (vasopressin)** from the posterior pituitary increases water reabsorption in the DCT and collecting duct.
- **Renin–angiotensin system**: a fall in blood pressure makes the JGA release renin → angiotensin II → aldosterone from the adrenal cortex → more Na^+ and water reabsorption.
- **ANF** (from the heart) works opposite to renin–angiotensin, lowering blood pressure.

Other excretory organs and disorders

- Lungs remove CO_2 ; skin removes sweat and sebum; liver produces bile containing bilirubin.
- **Uraemia**: urea builds up in blood; treated by **haemodialysis** (artificial kidney). Kidney transplant is the final cure for kidney failure.
- Renal calculi (kidney stones); glomerulonephritis (inflammation of glomeruli).

Exam questions

Q. What is GFR? What is its normal value?

The amount of filtrate formed by the kidneys per minute: about 125 mL/min, i.e. about 180 litres per day.

Q. How does ADH help in conserving water?

When the body has less water, ADH is released. It makes the DCT and collecting duct reabsorb more water, so urine becomes concentrated and water is saved.

Q. Why are birds uricotelic?

Uric acid is nearly insoluble and can be excreted as a paste with very little water, which helps them save water and keep body weight low for flight.

Chapter 6. Locomotion and Movement

In simple words: Movement of the body depends on muscles pulling on bones at joints. A skeletal muscle contracts when its thin actin filaments slide over thick myosin filaments — the sliding filament theory.

Types of movement

- Amoeboid (WBCs, macrophages), ciliary (cilia in trachea, fallopian tubes) and muscular movement (limbs, jaws, tongue).

Structure of skeletal muscle

- A muscle is made of bundles (fascicles) of muscle fibres. Each fibre contains many **myofibrils**.
- A myofibril shows light **I-bands** (actin) and dark **A-bands** (myosin). The unit between two Z-lines is the **sarcomere** — the functional unit of contraction.
- Proteins: actin (thin filament, with tropomyosin and troponin) and myosin (thick filament, with heads that bind ATP).

Mechanism of contraction

- A nerve signal releases acetylcholine at the neuromuscular junction → action potential in the muscle fibre → Ca^{2+} is released from the sarcoplasmic reticulum.
- Ca^{2+} binds troponin and exposes binding sites on actin → myosin heads form cross bridges, use ATP and pull actin towards the centre.
- The sarcomere shortens: the I-band and H-zone shorten, but the A-band length stays the same.
- Red muscle fibres have much myoglobin and mitochondria (aerobic, slow to tire); white fibres have little myoglobin (fast, tire quickly).

Human skeleton

- 206 bones: **axial skeleton** (80 bones: skull, vertebral column, sternum, ribs) and **appendicular skeleton** (126 bones: limbs and girdles).
- Vertebral column: 26 vertebrae (cervical 7, thoracic 12, lumbar 5, sacral 1 fused, coccygeal 1 fused).
- Ribs: 12 pairs — true ribs (1–7), false ribs (8–10) and floating ribs (11–12).

Joints

Fibrous joints	No movement. Example: sutures of the skull.
Cartilaginous joints	Limited movement. Example: joints between vertebrae.
Synovial joints	Free movement; fluid-filled cavity. Types: ball and socket (shoulder, hip), hinge (knee, elbow), pivot (atlas–axis), gliding (carpals), saddle (thumb).

Disorders

- Myasthenia gravis: autoimmune disorder of the neuromuscular junction causing muscle weakness.
- Muscular dystrophy: gradual degeneration of skeletal muscle, often genetic.
- Tetany: rapid spasms due to low Ca^{2+} in body fluids.
- Arthritis: inflammation of joints. Osteoporosis: bones become brittle (low oestrogen, low calcium). Gout: uric acid crystals in joints.

Exam questions

Q. What is a sarcomere?

The part of a myofibril between two successive Z-lines. It is the functional unit of muscle contraction.

Q. What happens to the A-band and I-band during muscle contraction?

The A-band keeps the same length, while the I-band (and the H-zone) shortens as actin slides over myosin.

Q. Give one example each of a ball-and-socket joint and a hinge joint.

Ball and socket: shoulder joint (humerus and pectoral girdle). Hinge: knee joint.

Chapter 7. Neural Control and Coordination

In simple words: The nervous system receives information, processes it and sends commands, very quickly. Messages travel as electrical impulses along neurons and pass to the next cell across synapses using chemicals.

Neuron

- Parts: **cell body** (cyton), **dendrites** (carry impulses towards the cell body) and **axon** (carries impulses away). Myelinated axons have nodes of Ranvier and conduct faster (saltatory conduction).

Generation and conduction of the impulse

- At rest, the outside of the axon membrane is positive and the inside negative (**resting potential**, about -70 mV). The Na^+/K^+ pump keeps more Na^+ outside and more K^+ inside.
- On stimulation, Na^+ rushes in $\rightarrow$ the inside becomes positive (**depolarisation**, action potential). Then K^+ moves out and the membrane is **repolarised**.
- The impulse moves along the axon as a wave of depolarisation.

Synapse

- **Electrical synapse:** current flows directly between cells; very fast; rare.
- **Chemical synapse:** the impulse releases a **neurotransmitter** (e.g. acetylcholine) into the synaptic cleft; it binds receptors on the next neuron. Transmission is one-way.

Human nervous system

- **CNS:** brain and spinal cord. **PNS:** cranial nerves (12 pairs) and spinal nerves (31 pairs).
- **Autonomic nervous system:** sympathetic (prepares for "fight or flight") and parasympathetic (rest and digest).

Cerebrum	Largest part; thinking, memory, intelligence, voluntary actions, senses. Two hemispheres joined by the corpus callosum.
Thalamus	Major relay centre for sensory and motor signals.
Hypothalamus	Controls body temperature, hunger, thirst; makes hormones that control the pituitary.
Cerebellum	Balance, posture and coordination of movements.
Medulla oblongata	Controls breathing, heartbeat, blood pressure, swallowing, vomiting.
Pons	Relay between parts of the brain; helps regulate breathing.

Reflex action

- A quick, automatic response to a stimulus, without conscious thought, e.g. pulling the hand away from a hot object, knee jerk.
- **Reflex arc:** receptor $\rightarrow$ sensory (afferent) neuron $\rightarrow$ spinal cord (interneuron) $\rightarrow$ motor (efferent) neuron $\rightarrow$ effector (muscle).

The eye and the ear

- Eye: cornea, iris, pupil, lens, retina. The retina has **rods** (dim light, contain rhodopsin) and **cones** (colour, bright light). The **fovea** has only cones and gives the sharpest vision. The **blind spot** has no receptors.

- Ear: outer ear (pinna, canal), middle ear (malleus, incus, stapes — the smallest bone), inner ear (cochlea for hearing; vestibular apparatus with semicircular canals for balance). The **organ of Corti** in the cochlea contains hair cells that act as sound receptors.

Exam questions

Q. What is the resting potential?

The electrical potential difference across the membrane of a resting neuron, about -70 mV, with the inside negative compared with the outside.

Q. Why is conduction faster in myelinated fibres?

The impulse jumps from one node of Ranvier to the next (saltatory conduction), instead of travelling along every part of the membrane.

Q. Name the parts of a reflex arc.

Receptor, sensory neuron, interneuron in the spinal cord, motor neuron and effector.

Chapter 8. Chemical Coordination and Integration

In simple words: Hormones are chemical messengers made by endocrine (ductless) glands. They travel in blood and act on target organs, controlling growth, metabolism, reproduction and balance in the body. Their effect is slower but longer-lasting than nerve impulses.

Main human endocrine glands

Hypothalamus	Releasing and inhibiting hormones that control the pituitary; also makes ADH and oxytocin.
Pituitary (anterior)	GH (growth), TSH, ACTH, FSH, LH, prolactin (milk production). It is called the master gland.
Pituitary (posterior)	Stores and releases ADH (vasopressin) and oxytocin (uterine contraction, milk ejection).
Pineal gland	Melatonin: day–night (sleep) rhythm.
Thyroid	Thyroxine (T_4) and T_3 : basal metabolic rate; calcitonin lowers blood calcium.
Parathyroid	Parathormone (PTH): raises blood calcium.
Thymus	Thymosins: maturation of T-lymphocytes; large in children, shrinks in adults.
Adrenal cortex	Cortisol (glucocorticoid), aldosterone (mineralocorticoid, Na^+ and water balance), sex hormones.
Adrenal medulla	Adrenaline and noradrenaline: "fight or flight" emergency hormones.
Pancreas (islets of Langerhans)	Insulin from β -cells lowers blood glucose; glucagon from α -cells raises it.
Testis	Testosterone: male sex characters, sperm production.
Ovary	Oestrogen (female sex characters) and progesterone (supports pregnancy).

Hormonal disorders

- **Gigantism:** too much GH in childhood. **Dwarfism:** too little GH in childhood. **Acromegaly:** too much GH in adults.
- **Diabetes insipidus:** too little ADH — large volumes of dilute urine.
- **Goitre:** enlarged thyroid, often due to lack of iodine. **Cretinism:** too little thyroxine in children (stunted growth, mental retardation). **Graves' disease:** too much thyroxine (exophthalmic goitre).
- **Diabetes mellitus:** too little insulin or insulin not working — high blood sugar, sugar in urine.
- **Addison's disease:** too little cortisol and aldosterone.

Mechanism of action

- Protein and peptide hormones (e.g. insulin, adrenaline) bind receptors on the cell membrane and act through a **second messenger** such as cAMP.
- Steroid hormones (e.g. cortisol, testosterone) and iodothyronines (thyroxine) pass through the membrane and bind receptors inside the cell, changing gene expression.

Exam questions

Q. Why is the pituitary called the master gland?

Its hormones (TSH, ACTH, FSH, LH, GH) control the working of many other endocrine glands, such as the thyroid, adrenal cortex and gonads.

Q. Which two hormones control blood sugar? How?

Insulin lowers blood glucose by helping cells take it up and store it as glycogen. Glucagon raises blood glucose by breaking down glycogen in the liver.

Q. What is the role of parathormone?

It raises the calcium level of blood by releasing calcium from bones and increasing its reabsorption in the kidneys.

Exam tip: Common mistake: ADH and oxytocin are made in the hypothalamus but stored and released by the posterior pituitary.