TOPIC: MAMMALIAN SYSTEMS

Key Knowledge:

- Specialisation and organisation of animal cells into tissues, organs and systems with specific functions: digestive, endocrine and excretory

BODY SYSTEMS

Multicellular organisms may form complex body systems to complete emergent functions. Cells may be grouped together to form different tissues, which in turn can combine to form organs capable of carrying out specific functions. Homeostatic regulation in mammals requires multiple interconnected body systems:

- **Endocrine system:** Releases chemical messengers (hormones) to coordinate the other body systems
- **Digestive system:** Involved in the breakdown and absorption of essential nutrients (ingested as food)
- **Excretory system:** Responsible for the removal of metabolic waste products (i.e. urea) from the body

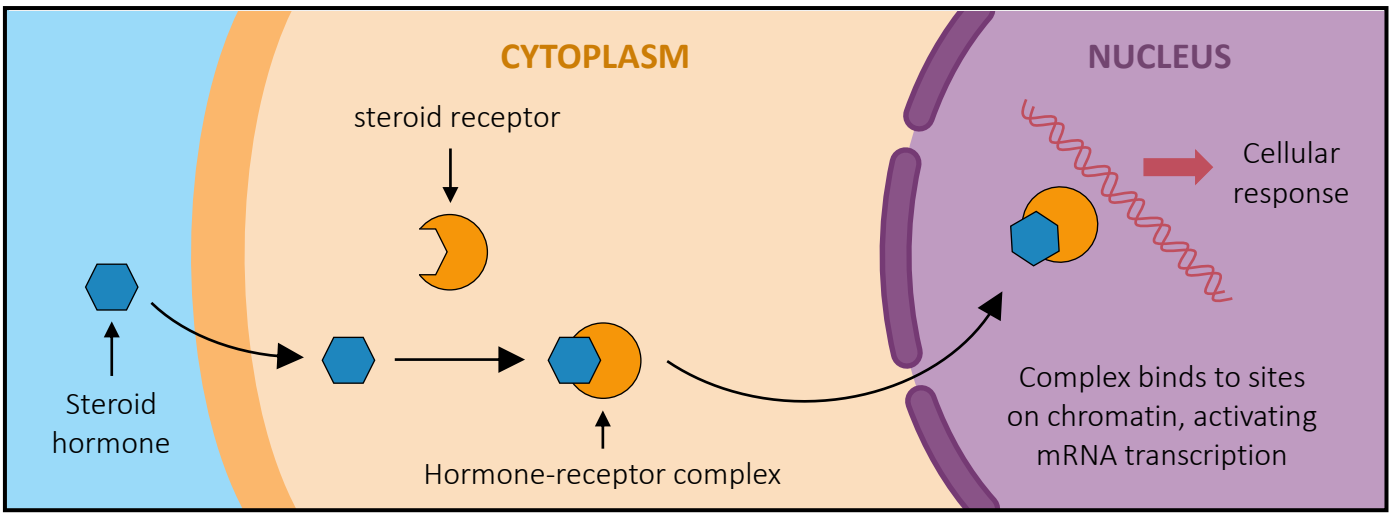
Malfunctions to any of these body systems will potentially lead to a loss of homeostasis. The inability to maintain body processes within physiological tolerance limits will lead to an abnormal condition (**disease**).

ENDOCRINE SYSTEM

Animal hormones are chemical messengers that are released by specialised (ductless) endocrine glands. They are transported via the bloodstream to act on distant target cells that possess specific receptors. These hormones can be either protein-based (hydrophilic) or lipid-based (hydrophobic). Hormonal signals may be slower acting than other types of communication (nerves) but can be more sustained in duration. When a hormonal signal is converted into an cellular signal, the initial message may undergo amplification if multiple molecules (second messengers) are activated during the process of signal transduction.

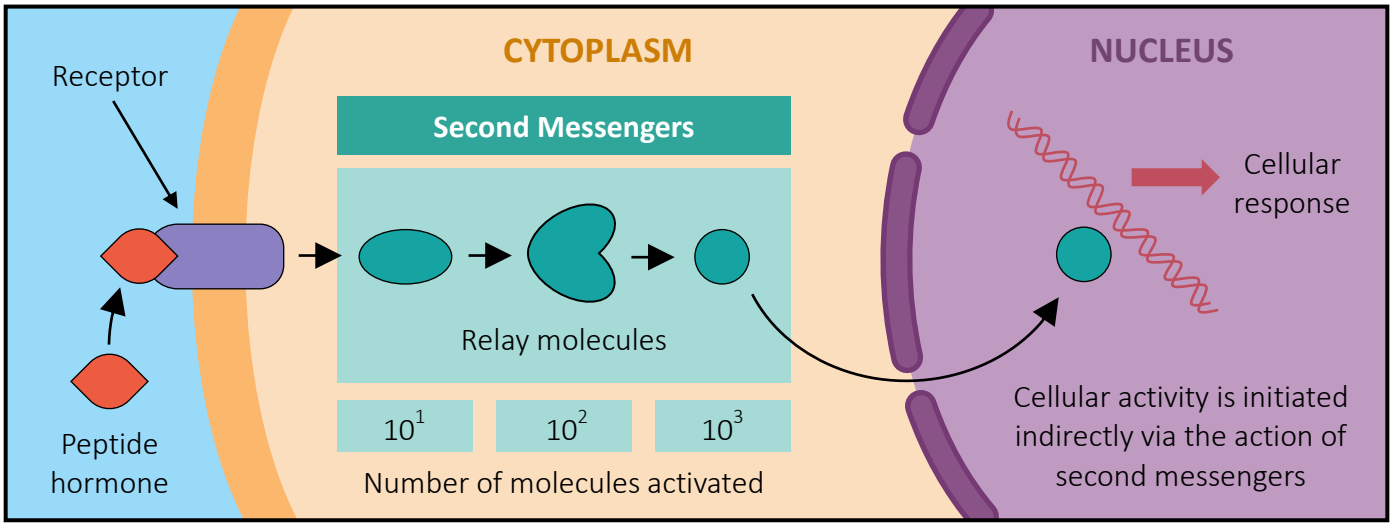
1. HYDROPHOBIC SIGNALS

Hydrophobic (water-hating) and lipophilic (fat-loving) signalling molecules can freely diffuse across the plasma membrane of a cell. They will bind to intracellular receptors in either the cytoplasm or nucleus of a target cell and form an activated complex. This complex will then directly bind to DNA, in order to act as a transcription factor for gene expression. This will then create a differential response within the target cell. Examples of hydrophobic signalling molecules include the steroid hormones produced within the gonads.



2. HYDROPHILIC SIGNALS

Hydrophilic (water-loving) and lipophobic (fat-hating) signalling molecules cannot freely cross the plasma membrane of a cell, and must instead bind to transmembrane receptors on the cell surface. The receptor will then activate a series of intracellular molecules called second messengers, potentially leading to the amplification of the initial signal. This signal transduction cascade will ultimately result in the activation of an internal response (such as a change in gene expression). Examples of hydrophobic signalling molecules include peptide hormones, such as insulin, glucagon, anti-diuretic hormone (ADH) and adrenaline.



EXCRETORY SYSTEM

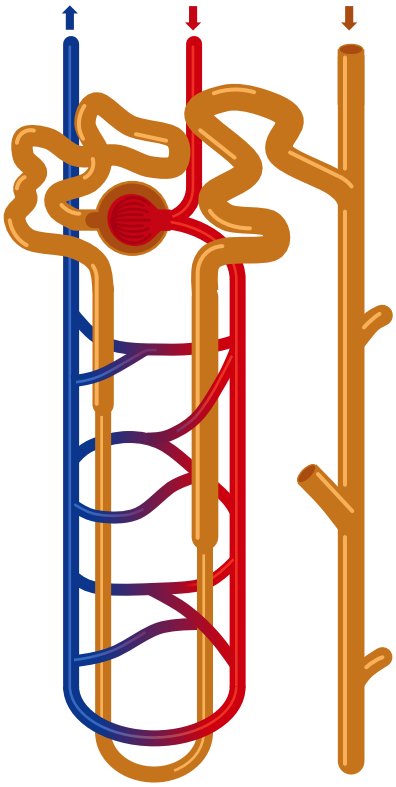
The excretory system is responsible for filtering the blood and removing The metabolic waste products (e.g. urea). The **kidney** is the organ that regulates this process and it is composed of specialised filtration cells called **nephrons**. Filtration of blood by the kidneys involves three steps:

1. **Ultrafiltration**
- Blood enters the kidney via the renal artery and is filtered in order to separate all blood cells and large proteins from the fluid (filtrate)

2. **Selective Reabsorption**
- Essential nutrients (e.g. monosaccharides, amino acids, ions) are selectively reabsorbed into the bloodstream for use by the body

3. **Osmoregulation**
- Water is reabsorbed by the kidneys according to hydration levels (the retention of water is controlled by an anti-diuretic hormone)

The resulting urine that is formed by the kidneys contains high levels of **urea** (nitrogenous waste), but should not contain any cells, protein or monosaccharides. The urine is transported to the **bladder**, where it is then stored prior to its eventual release (via the act of urination).



STRUCTURE OF A NEPHRON

Urinary analysis can be used to detect deviations from normal homeostatic processes. If specific diseases abrogate normal body functioning, certain metabolic by-products may accumulate within the bloodstream, requiring subsequent removal via the kidneys. The presence of these substances in urine indicates disease.

DIGESTIVE SYSTEM

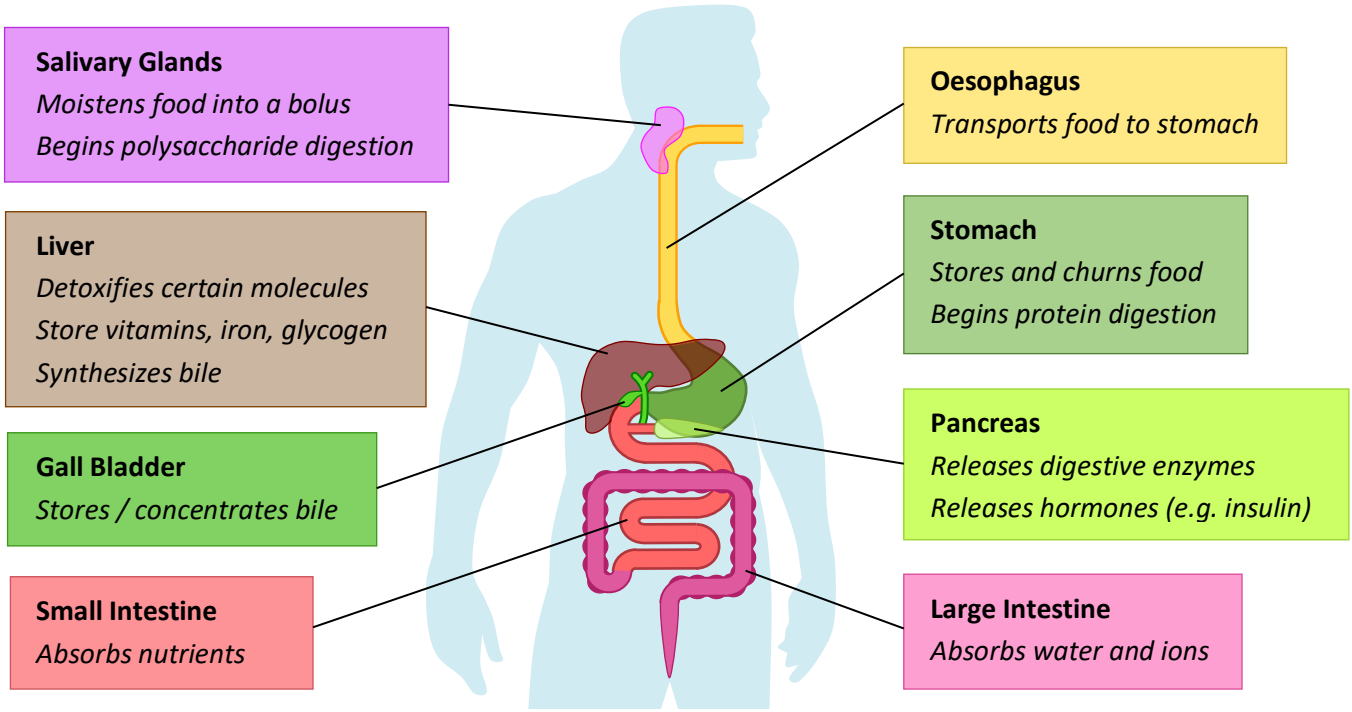
The digestive system functions to break down ingested food and then absorb and assimilate the products. There are two major groups of organs which comprise the digestive system: the alimentary canal forms a hollow tube through which food actually passes, while accessory organs will assist in the digestive process.

Alimentary Canal:

- *Oesophagus* – A hollow tube connecting the oral cavity to the stomach (and moves food via peristalsis)
- *Stomach* – A temporary storage tank that will secrete acids and enzymes to enable chemical digestion
- *Small Intestine* – A highly folded tube that functions to absorb digested nutrients into the bloodstream
- *Large Intestine* – Involved in the absorption of water and dissolved minerals (connects to the rectum)

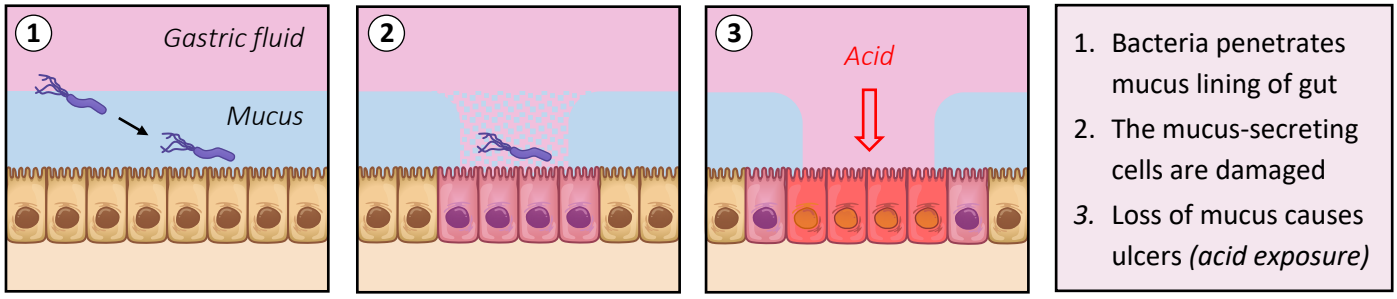
Accessory Organs:

- *Pancreas* – Produces a broad spectrum of enzymes and hormones to assist in digestion and absorption
- *Liver* – Processes and stores nutrients absorbed by the small intestine (also involved in detoxification)
- *Gall Bladder* – Secretes bile that is produced by the liver (responsible for the emulsification of lipids)



DIGESTIVE MALFUNCTION

Stomach ulcers are inflamed and damaged areas in the stomach wall, caused by exposure to gastric acids. The gastric lining typically contains a layer of mucus, which protects the stomach wall. *Helicobacter pylori* is a bacterium that survives the acid conditions of the stomach by penetrating the mucus lining. Infection with *H. pylori* results in an inflammatory response that damages the gastric lining, causing stomach ulcers.



1. Bacteria penetrates mucus lining of gut
2. The mucus-secreting cells are damaged
3. Loss of mucus causes ulcers *(acid exposure)*