

Metabolism module

Introduction to Hormones

Communication is the key

- Multi-cellular organisms stay together **because** cells communicate
 - **When they come into contact (autocrine)**
 - Cell surface chemicals
 - **When they are close (paracrine)**
 - Local diffusion of chemical messengers
 - **When they are far apart (endocrine)**
 - **Chemical messengers in the blood stream (Hormones)**
 - **Electrical transmission (Nerves)**

Chemical communication

- A chemical messenger must be produced by one cell
- And detected by another
 - Target cell
 - Receptors
- **Receptors are (insulin as example)**
 - Specific for particular messengers
 - Linked to metabolic processes in the cell
 - Directly or indirectly
- **Receptors always involved even when transmission is mostly electrical (see Figure again)**

So: Local and long distance

- Cells in contact
 - Direct interaction
 - **Immune system**
- Cells nearby
 - Local diffusion of messengers
 - **Paracrine**
- Distant cells
 - Chemicals in the blood stream
 - **Endocrine** via **hormones**
 - Rapid electrical transmission
 - **nerves**

Hormone

- Chemical signal produced by endocrine glands that travel in the bloodstream to affect other tissues

Where? - Endocrine glands

- **Head & neck**
 - **Pineal body (Melatonin)**
 - Hypothalamus (Releasing H & release inhibitory)
 - Pituitary gland – anterior and posterior parts
 - **Thyroid glands**
 - Parathyroid glands (4 in No.)

Where? - Endocrine glands

- **Abdomen**

- Adrenal glands – cortex and medulla
- Pancreas
- Kidneys
- Gut

Where? - Endocrine glands

- **Pelvis**
 - **Gonads**
 - Ovaries
 - Testes
 - **Placenta (pregnancy)**

What? – classes of hormones

- **Polypeptide hormones**
 - Around 20
- **Glycoprotein hormones**
 - Four
- **Amino acid derivatives**
 - 3 major
- **Steroid hormones**
 - Around 10

Polypeptide hormones

- **Largest group**
- Nearly all single chain peptides **vary** in chain **length**
 - **Growth hormone** - 191 amino acids
 - **Insulin** - 51 amino acids in two chains
 - **TRH** – 3 amino acids

Glycoprotein hormones

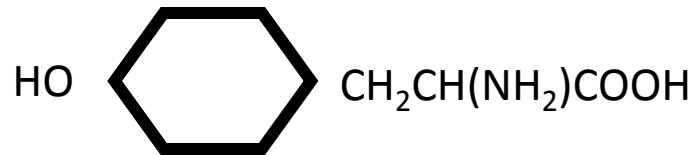
- **All** have two polypeptide chains with carbohydrate side chains
 - α and β chains (α is similar while β is vary)
- **Related families**
 - Thyroid stimulating hormone (TSH)
 - Follicle stimulating hormone (FSH)
 - Luteinising hormone (LH)
 - Human chorionic gonadotrophin (HCG)

Polypeptide and glycoprotein hormones

- **Synthesised as larger precursor molecules**
 - Pro-hormones
- **Stored in vesicles before release**
- **Cleaved to active hormone**
- **Example : perproinsulin → proinsulin → insulin**

Amino acid derivatives

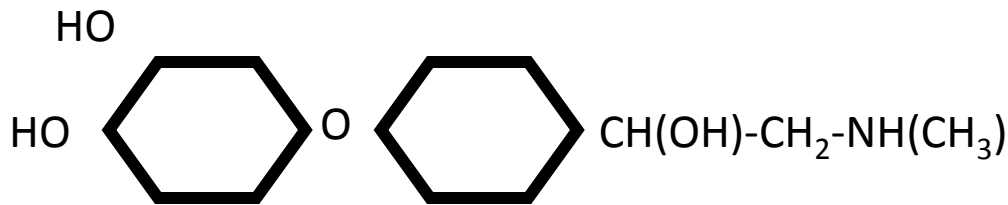
- All from **tyrosine**



- **Thyroid hormones**
 - Tetra-iodothyronine (T4)
 - Tri-iodothyronine (T3)
- **Catecholamines (Ex: Adrenaline & noradrenaline)**

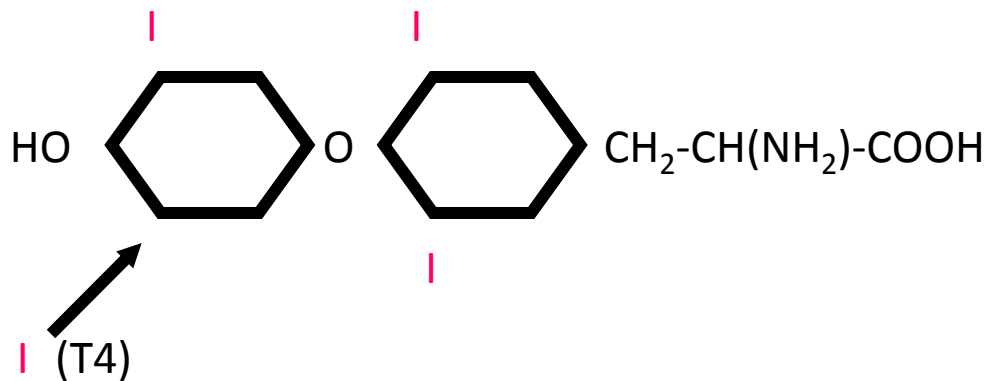
Adrenaline

- Stored in vesicles in adrenal medulla
- Hydrophilic molecule
- Does not easily cross cell membranes



Thyroid hormones

- Stored extra- cellularly in follicles in thyroid gland
- As colloid
- Hydrophobic
- Readily cross cell membranes (has cytoplasmic and nuclear receptors)



Steroid hormones

- Derived from cholesterol

Steroids

- **Classed by:**
 - Number of carbon atoms
 - C27, C21, C19 or C18
 - Number of double bonds
 - Different side chains

Classes of steroid hormones

- C27
 - Calciferols – e.g. vitamin D
- C21
 - Corticosteroids – adrenal cortex
 - Glucocorticoids (cortisol)
 - Mineralocorticoids (eg aldosterone)
 - Progestins – eg progesterone from ovaries
- C19
 - Androgens – eg testosterone from testes
- C18
 - Oestrogens – eg oestradiol from ovaries

Steroids

- **Not** stored by cells
- Synthesised on **demand** from cholesterol esters
- **Hydrophobic**
- **Readily cross cell membranes**

Travelling in the blood

- **Few hormones soluble enough to travel in simple solution**
 - **Peptides**
 - **Adrenaline**
- **Most should bind to (usually) proteins**
 - **Often specific**
 - Steroids
 - Thyroid hormones

Controlling secretion

- The endocrine cells are stimulated chemically to release hormones
- Produces **negative feedback** control
- Tends to **keep hormone concentration** in blood at controlled level

Negative feedback

- **Just Example is HPT axis**
- TRH secretion stimulated when blood thyroxine levels fall
- TRH acts on anterior pituitary to stimulate TSH secretion
- TSH acts on **thyroid gland** to make **thyroxine** levels rise
- **High thyroxine** reduces TSH secretion again
- Overall acts to keep blood thyroxine levels constant
 - **Many hormones controlled in similar ways**

Critical role of anterior pituitary

- Many hormones controlled by other hormones ('trophic' hormones)
- Secreted by anterior pituitary gland
- Allows brain to influence the endocrine system

Hormone action

- Always bind to receptors
- If hormone can cross membrane (eg steroids) receptors located inside cells
- Receptor hormone complex can move
- Binding linked directly to metabolic changes
 - Often expression of genes

Hormone action

- If hormone **cannot** cross membrane
- Binds to receptor **on** cell surface
- Activates **second messenger pathway**
- **Second messenger (inside the cell)** exerts metabolic effects
 - **Often modifying action of enzymes**

Inactivation

- Steroids and amino-acid derivatives
 - Small changes in structure
 - Recycled or excreted
- Peptides
 - Degraded to amino acids
- Inactivation may occur in target tissues, but also in other tissues, especially the liver