Homeostasis is the maintenance of constant internal conditions within the body.

Examples of conditions, which need to be maintained:
- body temperature
- oxygen concentration
- carbon dioxide concentration
- pH
- osmotic concentration

Question: So, why do we need to maintain a constant internal environment?
Answer: To provide the optimum conditions for the working of biochemical reactions (controlled by enzymes)

Question: How is this achieved?
Answer: A process called "**negative feedback**"

Question: What is **negative feedback**?
Answer: A change, detected by a sensor, which stimulates another change, to restore the normal.

Example: **Body Temperature**

- Normal body temperature ≈ 36.8°C
- Change above normal
  - Body temperature increases (e.g. exercise/hot bath)
  - Sensor (e.g. hypothalamus in brain) detects the change and initiates the corrective action
  - Heat loss is increased:
    1. sweat
    2. vasodilation
    3. hairs are flat

- Change below normal
  - Body temperature decreases (e.g. cold bath/exposure to cold)
  - Heat production is increased:
    1. shivering
    2. vasoconstriction
    3. hairs erect
    4. glycogen → glucose

**Vasoconstriction** Decrease in blood supply to surface capillaries Therefore reduced surface area exposed to the atmosphere Therefore less heat loss

**Vasodilation** Increase in blood supply to surface capillaries Capillaries become more prominent Therefore greater surface area exposed to the atmosphere Therefore greater heat loss by radiation
**Sweat** “latent heat of vaporisation”

- produced by coiled tube called **sweat gland** (see section on skin)
- sweat cells absorb fluids from surrounding cells
- sweat cells then release the fluid onto the surface
- fluid contains:
  - water
  - sodium chloride
  - urea
  - lactic acid
- the fluid is secreted onto the surface of the skin when the body temperature rises above the normal
- heat from the body is then used to evaporate the fluid
- therefore, the body **temperature goes down**
- the **control centre** for the sweat is the **hypothalamus**

**Hypothermia**

This is when the body temperature falls below normal and continues to fall. When the body temperature falls to 32°C, the person becomes confused:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.8</td>
<td>normal</td>
</tr>
<tr>
<td>32</td>
<td>confused</td>
</tr>
<tr>
<td>28</td>
<td>breathing slows</td>
</tr>
<tr>
<td>27</td>
<td>unconscious</td>
</tr>
<tr>
<td>25</td>
<td>heart stops, breathing stops</td>
</tr>
</tbody>
</table>

Because water conducts heat faster than air, it is easier to get hypothermia in the water / in wet weather.

**Hairs**

Upright / erect

- trap layer of stationary air next to surface of skin to **provide insulation**
- the hair is made erect by the contraction of the erector muscles
- this can be seen by goose-bumps (this is where the muscles are)

Relaxed

- no stationary air trapped
- more skin exposed
- **increase in heat loss**

**Adipose tissue**

- fat
- provides insulation
- prevents both heat loss and heat gain

**Control of heat loss**

Temperature receptors in the brain monitor the **temperature of the blood**. They then send impulses to the correct places to increase or decrease heat loss.

Temperature receptors in the skin send nerve impulses to the brain telling it about the surface temperature.

Body temperature is kept constant to maintain the optimum temperature for enzyme action.
Endocrine system – chemical coordination in the body

Consists of a number of endocrine glands, which:
- are ductless (no ducts / openings)
- manufacture MFRE (chemical messengers or hormones)
- these hormones are directly released into the blood stream
- have lots of blood capillaries around it

Hormones are:
- chemical substances / messengers
- which are produced in an endocrine/ductless gland
- and are released directly into the bloodstream
- and have an effect only on particular cells (e.g. insulin – liver only)

Characteristics of hormones:
- are soluble in water
- are proteins or steroids
- are eventually broken down or destroyed by the liver
- are excreted by the kidney
- are specific in their action
- excess or too little can cause disease

pituitary gland:
secretes:
- GH (growth hormone)
- LH
- FSH
- ADH
(see later notes)

hypothalamus:
controls output of pituitary hormones

thyroid gland:
releases thyroxine

thymus gland:
has a role in the development of immunity and formation of T cells

adrenal gland:
adrenaline (from medulla)

pancreas:
secretes:
- insulin
- glucagon

testes:
secretes:
- testosterone

ovary:
secretes:
- progesterone
- oestrogen

pituitary gland:
secretes:
- GH (growth hormone)
- LH
- FSH
- ADH
(see later notes)
The pituitary gland
This is attached to the base of the forebrain in the region of the hypothalamus (which is therefore the connection between the nervous and endocrine system). It is referred to as the “master of the endocrine orchestra!” Through its secretions it controls the activity of all other endocrine glands.

The pituitary gland secretes:

1. FSH (follicle stimulating hormone): stimulates growth of Graafian follicle in ovary
   stimulates production of sperm in testes

2. LH (lutinising hormone) stimulates ovulation
   stimulates formation of corpus luteum
   stimulates production of progesterone

3. ADH (anti-diuretic hormone) activates reabsorption of water in kidney

4. via secretions, controls activity of other endocrine glands by negative feedback

Example: Thyroxine

- If thyroxine level is low, the brain sends a nerve impulse to the pituitary gland
- The pituitary gland then secretes T.S.H. which is a thyroid stimulating hormone

**Brain**

*thyroxine in bloodstream*

**Pituitary**

**Thyroid**
**Testes:**

Pituitary produces:

1. FSH for development of sperm
2. LH for production of testosterone in the testes

Testes produce **testosterone**

This promotes the production of secondary sexual characteristics in males at puberty. These include:
- pubic hair (armpit, facial, body)
- more powerful muscles
- increase in red blood cells
- increase in penis size
- deepening of voice

**Ovaries:**

Pituitary produces:

1. FSH stimulates development of Graafian follicle* in ovary
   stimulates production of oestrogen
2. LH stimulates ovulation
   formation of corpus luteum
   production of progesterone (from corpus luteum)

Ovaries produce **oestrogen** and **progesterone**:

**Oestrogen:**

1. Development of secondary sexual characteristics.
   These include:
   - development of mammary glands (breasts)
   - pubic / armpit hair
   - lack of body hair
   - high pitched voice
   - widening of hips
2. Repair of uterus lining

**Progesterone:**

1. Maintains uterus lining after ovulation and during pregnancy

* the Graafian follicle is responsible for the production of oestrogen.
**Adrenal gland**
- lies just above the kidney in the lower back
- close connections with the nervous system
- release the hormone adrenaline
- normally the output of this hormone is low
- at times of stress, competition, danger etc. the output rises dramatically

**Adrenaline** – known as the *flight, fright, fight* hormone:

1. increases heart rate
2. increases heart output (amount of blood with each pump)
3. therefore increases the rate of blood flow between lungs/brain and muscle cells
4. increases breathing rate
5. increases depth of breathing
6. increases diameter of bronchioles
7. therefore, increases uptake of oxygen by the blood
8. increases conversion of glycogen in the liver to glucose in the blood
9. causes constriction of blood vessels to the skin and diverts blood to the muscles
10. therefore: an increase of glucose in the blood going to the brain and muscles
11. therefore, increased respiration in muscle cells: increased energy/ATP production
12. it is therefore possible to run faster / longer
13. increases awareness
14. causes erection of hairs
15. increases dilation of pupil

**Pancreas**
- this is the organ that produces digestive juices
- which are released into the duodenum via the pancreatic duct
- produces amylase, lipase, protease and sodium bicarbonate

**Paul Langerhans 1896**

Paul Langerhans found a patch of cells in the pancreas which were highly vascularised.

3 pairs of dogs:

Pancreas removed: flies found “feeding”
- therefore urine rich in glucose

Pancreatic duct tied: no glucose in the urine

Pancreas (no treatment): no glucose in the urine

The pancreas has a patch of highly vascularised (ducted) cells called the “**islets of Langerhans**” The islets of Langerhans are responsible for the secretion of hormones which are involved in controlling the level of glucose in the blood.
The pancreas produces two hormones:

1. **Insulin** - produced if there is a high glucose level in the blood.
   - it converts glucose (in the blood) to glycogen (in the liver)
   - this therefore, maintains the glucose level in the blood (at \( \approx 90\text{mg per }100\text{cm}^3 \))
   - failure to produce insulin causes **diabetes**

2. **Glucagon** - makes glycogen (in liver) convert to glucose (in blood)
   - produced when glucose in blood falls below 90mg per 100cm\(^3\)

### Diabetes
- this is when there is an excess amount of glucose in the blood
- this happens when the glucose is not converted into glycogen
- glucose is therefore excreted in the urine
- there is therefore, no build up of a store of glucose

### Normal

- Kidney reabsorbs all glucose (filtered from blood)
- Therefore, no glucose in urine

<table>
<thead>
<tr>
<th>Endocrine System</th>
<th>Nervous System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature: chemical</td>
<td>electrical (+ chemical at synapse)</td>
</tr>
<tr>
<td>Speed: slow</td>
<td>rapid</td>
</tr>
<tr>
<td>Duration: long lasting</td>
<td>short lived</td>
</tr>
<tr>
<td>Accuracy: wide spread</td>
<td>specific</td>
</tr>
<tr>
<td>Speed of response: slow</td>
<td>immediate</td>
</tr>
<tr>
<td>Route: in blood</td>
<td>along nerves</td>
</tr>
</tbody>
</table>