F 6 Bio - Ch 25: Homeostasis

Name:

By bathing cells in a fluid, the tissue fluid, whose composition remains constant, the chemical reactions within these cells can take place at a predictable rate. Not only are the cells able to survive but they can also function efficiently.

Homeostasis is a term used to describe all the mechanisms by which a constant environment is maintained.

25.1 Principles of Homeostasis

Cybernetics is the science of control systems, i.e. self-regulating systems which operate by means of feed-back mechanisms.

The essential components of a control system are:

1. Reference point
2. Detector
3. Controller
4. Effector
5. Feedback loop

Negative feedback: the corrective measure which acts in a direction opposite to the change

Positive feedback: a reaction/measure acting in the same direction as the change

25.2 Temperature Control

Thermoregulation: the regulation of body temperature

In living organisms, heat may be gained in 2 ways:

1. __________________________
2. __________________________

Heat may be lost in 4 main ways:

1. __________________________
2. __________________________
3. __________________________
4. __________________________

25.2.1 Ectothermy and Endothermy

Ectotherms: animals which obtain __________________________

Poikilotherms: animals whose body temperature varies with the environment

Ectotherms attempt to regulate their temperatures within broad limits by behavioural means.

Endotherms: animals which maintain their body temperatures irrespective of the environmental temperature.

Homoiotherms: animals whose body temperature remains the same, e.g. birds & mammals

The higher the body temperature the higher the metabolic rate of the animal.

Birds have a higher body temperature than mammals (40-44°C) because of the energy demands of flight and more heat loss due to a greater temperature gradient with the surrounding.

Advantage: much more environmental independence

25.2.2 Structure of the Skin

The skin plays the most important role in thermoregulation. Mammalian skin has two main layers: epidermis and dermis
**Epidermis** - consists of 3 layers of cells:

The *cornified layer* is composed of dead cells which are easily peeled off & replaced by cells of the lower layer,  
*Function:*  

The *granular layer* is made of living cells which approach the surface & become cornified layer

The **Malpighian layer** contains melanin, a pigment which protects the body from ultra-violet radiation; cells also undergo cell division to form new cells for repairing

**Dermis**  
- the true skin which is thicker than the epidermis; 
contains connective tissues containing: 
**blood vessels** carries blood which delivers oxygen & food to the living cells in the skin; also helps in temperature regulation

**sweat gland** secretes sweat through a sweat duct open to the outside 
**hair follicle** contains a hair with a nerve, a capillary, **erector muscle** and a **sebaceous gland** attached to it; erector muscle contracts & makes the hair erect; sebaceous gland secretes an oily layer which forms a waterproof layer & prevents the entry of germs

**nerves** are responsible for receiving external stimuli 
subcutaneous **adipose tissue** acts as food reserve & insulator of heat

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**25.2.3 Maintain A Constant Body Temperature in Warm Environments**

These adaptations may be anatomical, physiological or behavioural:

1. Vasodilation  
2. Sweating  
3. Panting and licking  
4. Insulation  
5. Large surface area to volume ratio  
6. Variation in body temperature, e.g. camels (34-41°C) - reduce temp gradient - reduce sweating  
7. Behavioural mechanisms, e.g. summer hibernation (aestivation), nocturnal
25.2.4 Maintain A Constant Body Temperature in Cold Environments

They include:
1. Vasconstriction
2. Shivering
3. Insulation, e.g. fat, fur or feathers
4. Small surface area to volume ratio
5. Variations between superficial and core temperature - with counter-current heat exchange system to reduce heat lost by extremities (limbs) of animals
6. Increased metabolic rate
7. Behavioural mechanisms, e.g. diurnal, grouping together, reproductive behaviour
8. Hibernation, e.g. squirrel spending brown adipose tissue

25.2.5 Role of the Hypothalamus in the Control of Body Temperature

There are two centres: heat gain and a heat loss centres. It monitors the temperature of blood passing through it with nerves coming from receptors in the skin about external temperature changes. Any reduction in blood temperature will bring about changes which conserve heat. A rise in blood temperature has the opposite effect.

25.3 Control of Blood Sugar

The liver plays a key role in glucose homeostasis:

i) glycogenolysis: breakdown of glycogen

ii) gluconeogenesis: converting proteins into glucose

iii) glycogenesis: converting glucose into glycogen

Summary of body temperature control by the hypothalamus
Pancreas:
- islets of Langerhans with two types of cells:
  - α-cells produce glucagon for converting glycogen into glucose
  - β-cells produce insulin for converting glucose into glycogen

If the glycogen supply in liver becomes exhausted and is detected by the hypothalamus
- → pituitary
- → secretes adrenocorticotropic hormone
- → adrenal glands
- → glucocorticoid hormones
- → liver converts amino acids & glycerol into glucose

In times of stress, adrenal gland secretes adrenaline which causes the breakdown of glycogen in the liver and so helps to raise the blood sugar level.

25.4 Control of Respiratory Gases - not required in syllabus
25.5 Control of Blood Pressure - not required in syllabus
25.6 Cellular Homeostasis - not required in syllabus

25.7 The Liver - an organ for digestion and homeostasis
25.7.1 The Structure of the Liver
- Blood is drained into the liver by 2 vessels:
  - Blood is drained away from the liver by
  - Branches of the hepatic artery & hepatic portal vein combine within the liver to form common venules which lead into a series of channels called sinusoids.
  - Sinusoids are lined with liver cells (hepatocytes) and drains into a branch of the hepatic vein called the central vein.
  - Between the hepatocytes are fine tubes called canaliculi in which bile is secreted. The canaliculi combine to form bile ducts which drain into the gall bladder.
  - The functional unit of the liver is the acinus. In the sinusoids materials are exchanged between the hepatocytes and blood.

Structures of hepatocytes for exchange of materials with high metabolic rate:
- microvilli, large nucleus,
- many mitochondria, lysosomes and glycogen granules.

The canaliculi are also lined with microvilli to remove bile from the hepatocytes by active transport.
- Sinusoids are lined with endothelial cells with specialized Kupffer cells of the reticulo-endothelial system.
for ingesting any foreign materials and damaged, worn out RBCs. **Bilirubin** is produced as a by-product & excreted in the bile.

### Structure of the mammalian liver

#### 25.7.2 Functions of The Liver

The liver has about 500 individual functions. They are grouped as below:

1. **Carbohydrate metabolism** - action of insulin & glucagon by inlets of Langerhans
2. **Lipid metabolism** - lipids are broken down or transported to storage areas
   - excess carbohydrates → lipid
   - regulate cholesterol level; atherosclerosis & gall stones
3. **Protein metabolism** - deamination
   - transamination to synthesize non-essential amino acids
4. **Synthesis of plasma proteins**, e.g. clotting factors: prothrombin & fibrinogen
5. **Production of bile**: bilirubin + bile salts + NaCl + HCO₃⁻
6. **Storage of vitamins**, especially fat soluble vitamins A, D, E, K
7. **Storage of minerals**, e.g. Fe, K, Cu & Zn
8. **Formation & breakdown of RBCs** - foetal liver produces RBCs
   - adult liver breaks down aged RBCs
9. **Storage of blood** - about 1500 cm³ of blood can be stored
10. **Hormone breakdown**, e.g. testosterone, insulin etc
11. **Detoxification** - Kupffer cells ingest foreign materials
    - hepatocytes convert toxic chemicals into harmless forms
12. **Production of heat** - when body temperature falls
    - triggered by the hypothalamus, is in response to adrenaline, thyroxine & nervous stimulus