Section 12.1 – Principle of homeostasis

The maintenance of a constant internal environment

By maintaining a relatively constant environment (of the tissue fluid) for their cells, organisms can limit the external changed these cells experience thereby giving the organisms a degree of independence.

<u>What is homeostasis?</u>

Maintaining the volume, chemical make up and other factors of blood and tissue fluid within restricted limits
There are continuous fluctuations; however, they occur around a set point
Homeostasis is the ability to return to that set point thus maintaining equilibrium

<u>The importance of homeostasis</u>

Enzymes and other proteins are sensitive to changes in pH and temperature
Water potential of blood and tissue fluid should be kept constant to ensure cells do not burst or shrink due to a net movement of water (osmosis)
Maintaining a constant blood glucose concentration ensures that the water potential of the blood remains the same
Independence of the external environment – a wider geographical range and therefore a greater chance of finding food shelter, etc
Mammals – homeostasis allows them to tolerate a wide range of conditions

<u>Control mechanisms</u>

The set point is monitored by:

1.) **Receptor**
2.) **Controller** - brain analyses and records information from a number of different sources and decides on the best course of action
3.) **Effector –** brings about the change to return to set point
4.) **Feedback loop –** informing the receptor of the changes in the system brought about by the effector

Section 12.2 - Thermoregulation

Mechanisms of heat loss and gain

Production of heat – Metabolism of food during respiration
Gain of heat from the environment – Conduction, convection (surrounding air/fluid), Radiation (electromagnetic waves particularly infrared)

Mechanisms for losing heat

Evaporation of water
Conduction – to ground/solid
Convection - convection (to surrounding air/fluid),
Radiation

Endotherms - derive most heat energy from metabolic activities
Ectotherms – obtain most heat from the external environment

Regulation of body temperature in Ectotherms

Body temp fluctuates with the environment
Controlled by exposure to the sun
Shelter to the sun/burrows at night/obtains heat from the ground and very little from respiration.
Can sometimes change colour to alter heat that is radiated

Regulation of body temperature in Endotherms

Most heat gained through internal metabolic activities
Temperature range - 35 – 44 ^{o}C – Compromise between higher temperature where enzymes work more rapidly and the amount of energy needed (hence food) to maintain that temperature

Conserving and gaining heat in response to a cold environment

Long term adaptations:
Small SA:V ration
Therefore mammals and birds in cold environments are relatively large
Smaller extremities (e.g. ears) thick fur, feathers or fat reserves to insulate the body

Rapid changes:
Vasoconstriction – reducing the diameter of arteries/arterioles
Shivering – in voluntary rapid movements and contractions that produce he energy from respiration
Raising hair – enables a thick layer of still air to build up which acts as a good insulator.
Behavioural mechanisms – bathing in the sun
Decreased sweating

Loss of heat in response to a warm environment

Long term adaptations:
Large SA:V ratio so smaller animals are found in warmer climates
Larger extremities
Light coloured fur to reflect heat

Vasodilation – Arterioles increase in diameter, more blood reaches capillaries, more heat is therefore radiated away
Increased sweating – Heat energy is required to evaporate sweat (water). Energy for this comes from the body. Therefore, removes heat energy to evaporate water
Lower body hair – Hair erector muscles relax. Hairs flatten, reduces the insulating layer of air, so more heat can be lost to the environment
Behavioural mechanisms – seeking shade, burrows, etc

Control of body temperature

Mechanisms to control body temperature are coordinated by the hypothalamus in the brain
The hypothalamus has a thermoregulatory centre divided into two parts:
A heat gain centre which is activated by a fall in body temperature
And a heat loss centre which is activated by an increase in temperature
The hypothalamus measures the temperature of blood passing through it
Thermoreceptors in the skin also measure the temperature
Impulses sent to the hypothalamus are sent via the autonomic nervous system
The core temperature in the blood is more important that the temperature stimulating skin Thermoreceptors

Section 12.3/12/4 – Hormones and the regulations of blood glucose/Diabetes and its control

Hormones are produced by glands (endocrine glands) which secrete the hormones into the blood
The hormones are carried in the blood plasma to the target cells to which they act.
The target cells have complementary receptors on the cell surface membrane
Hormones are affective in small quantities set have widespread and long-lasting affects
Some hormones work via the secondary messenger model:

1.) The hormone (the first messenger) binds to receptors on the cell surface membrane, forming a hormone-receptor complex
2.) The hormone-receptor complex activates an enzyme inside the cell that produces a secondary messenger chemical
3.) The secondary messenger acts within the cell produces and a series of changes

Both glucagon and adrenaline work by the secondary messenger model

Adrenaline as a secondary messenger

1.) The hormone adrenaline forms a hormone-receptor complex and therefore activates an enzyme inside the cell membrane
2.) The activated enzyme the converts ATP to cyclic AMP which acts as the secondary messenger
3.) Cyclic AMP then activates several other enzymes that can convert glycogen to glucose

The group of hormone producing cells in the pancreas are known as the islets of langerhans
Alpha cells a **larger** and produce **glucagon**
Beta cells and **smaller** and produce **insulin**

<u>Blood glucose and variations in its level</u>

Blood glucose comes from three main sources:
Directly from the diet – resulting from the breakdown of carbohydrate
From the breakdown of glycogen (Glycogenolysis) – Glycogen is stored in the liver and in muscle cells
From gluconeogenises – production of new glucose from sources other than carbohydrate and glycogen. E.g. protein/amino acids and glycerol

<u>Insulin and beta cells in the pancreas</u>

Beta cells in the pancreas can detect an increase in glucose concentration in the blood and therefore release insulin
When bound to receptors on the plasma membrane of cells, insulin brings about:

- A change in the tertiary structure of the glucose transport protein channels, causing them to change shape so as to allow more glucose into the cell

- Increasing the number of carrier molecules in the cell surface membrane
- Activating enzymes involved in converting glucose to fat/glycogen

By changing the shape of glucose transport proteins and causing an increase in the amount of glucose entering cells, the rate of respiration increases

Glucagon and alpha cells

When alpha cells detect a fall in blood glucose concentration that release glucagon
Alpha cells increase blood glucose concentration by:

- Activating an enzyme that converts glycogen to glucose
- And by increasing the conversion of amino acids/glycerol to glucose

Adrenaline can inactivate enzymes that convert glucose to glycogen

Types of diabetes

***Type 1 (insulin dependent)* –** Often due to an autoimmune response where the body attacks beta cells. The result is that the sufferer cannot produce insulin
***Type 2 (insulin independent)* –** Glycoprotein receptors on cells lose their responsiveness to insulin.

Control of diabetes

***Type 1* –** Controlled by insulin injections. Insulin cannot be taken orally since stomach enzymes will break down insulin. The dose of insulin must match the amount of glucose in the blood to avoid hypoglycaemia leading to unconsciousness
***Type 2* –** Controlled by regular intake of carbohydrate and matching this to exercise. Some drugs can be used to stimulate insulin production or too slow down the rate of glucose absorption in the intestine

Symptoms of diabetes

- High blood glucose level
- Presence of glucose in the urine
- Increased thirst/hunger
- Excessive urination
- Tiredness
- Weight loss
- Blurred vision