Unit 3A

Human Form & Function

Cells, metabolism & regulation

Disruption of homeostasis
Study Guide

Read:
- Our Human Species (3rd edtn)
  Chapter 12, section 9.3; Chapter 15, section 4.5
  Chapter 5, section 6
  Chapter 13, section 13

Complete:
- Human Biological Science Workbook
  Topic 8 – Disruption of Homeostasis
What happens if homeostasis fails?

If homeostasis cannot be maintained within tolerance limits, our body cannot function properly – consequently, we are likely to get sick and may even die.
Example 1

Disruption resulting from hormonal imbalance
Diabetes

• Diabetes is a disease characterised by abnormally high levels of blood glucose.
• Diabetes results from the body being unable to maintain the blood sugar level in homeostatic balance.
Terminology

- **Insulin** – hormone that lowers blood glucose
- **Glucagon** – hormone that raises blood glucose
- **Glucose** – simple carbohydrate (basic carbohydrate building block)
- **Glycogen** – complex carbohydrate (stored in liver & muscles)
- **Glycogenesis** – formation of glycogen from glucose
- **Glycogenolysis** – break down of glycogen to glucose
- **Gluconeogenesis** – formation of glucose from breakdown of lipids or protein
- **Lipogenesis** – formation of fats from carbohydrate
- **Glycaemia** – blood glucose level
Normal regulation of high blood glucose levels

- **Stimulus** - Blood glucose above threshold (>90mg/dl)
- **Receptor** - Beta-cells in Islets of Langerhans (Pancreas)
- **Transmission** - Beta cells secrete hormone insulin
- **Effectors** - Skeletal muscles and liver
- **Response**
  - Skeletal muscles – increased uptake of glucose
  - Liver – glucose converted to glycogen
Glycogenesis

**Stimulus**
- High blood glucose

**Feedback**
- Reduced level of blood glucose

**Stimulus**
- Beta cells (pancreas)

**Response**
- Glycogenesis
- Increased glucose uptake
- Lipogenesis

**Receptor**
- Liver
- Somatic cells

**Effector**
- Beta cells Secrete insulin
Normal regulation of low blood glucose levels

- **Stimulus**: Blood glucose below threshold (<90mg/dl)
- **Receptor**: Alpha-cells in Islets of Langerhans (Pancreas)
- **Transmission**: Alpha-cells secrete hormone glucagon
- **Effector**: Skeletal muscles, liver and fat
- **Response**: Liver & Skeletal muscles – glycogen converted to glucose
  Fat – increases fat mobility
Glycogenolysis

Low blood glucose

Stimulus → Receptor

Feedback

Increased level of blood glucose

Response

Effector

• Glycogolysis

• Liver

Alpha cells (pancreas)

Alpha cells Secrete glucagon

Liver

Glycogenolysis
There are several different types of diabetes. The most common are:

- Diabetes mellitus – Type 1
- Diabetes mellitus – Type 2

Neither form of diabetes can be cured; however, both types can be managed through diet, exercise and the use of insulin.
Diabetes mellitus – Type 1

- Also known as early onset diabetes because it often occurs in young people under the age of 30.
- Occurs because the pancreas stops making insulin.
- Treated with daily injections of insulin.
- Life-threatening if untreated.

An islet of Langerhans
Diabetes mellitus – Type 2

• Also known as late onset diabetes because it typically occurs in older people under the age of 30.
• Type 2 is the most common form of diabetes (85-90%).
• Occurs because the body cells become less responsive to insulin.
• Treated by dietary control, exercise and insulin injections.
• Life-threatening if untreated.
Symptoms of diabetes

Hyperglycaemia

• Being excessively thirsty
• Passing more urine
• Feeling tired and lethargic
• Always feeling hungry
• Having cuts that heal slowly
• Itching, skin infections
• Blurred vision
• Weight change (Type 1 – weight loss, Type 2 – weight gain)
Problems that arise if homeostasis is not restored

High levels of blood sugar can damage blood vessels. This can lead to:

• Blindness
• Kidney failure
• Cardiovascular disease
• Loss of sensation
• Ulcers and gangrene sometimes requiring amputation of the toes or foot.
Ketoacidosis

- People with type 1 diabetes cannot use glucose as an energy source so their body burns fat and proteins instead.
- Toxic compounds called ketones are a by-product (smell like nail polish remover on the breath).
- If ketones accumulate in the body a life-threatening condition known as ketoacidosis can result.
If ketoacidosis remains untreated it results in total homeostatic disruption, followed by coma and death.

A man with diabetes using an electronic reader to measure the level of sugar in his blood.
Example 2

Disruption resulting from behaviour
If body temperature is not maintained in the thermoneutral zone homeostasis is disrupted resulting in heat stress, and possibly death.
• The average oral temperature ranges from 36.1 °C to 37.8 °C – the average is 36.8 °C, though this can vary by as much as one degree over 24 hours.
The thermoneutral zone (TNZ) is the temperature range bounded by the lower critical temperature (the point at which shivering starts) and the upper critical temperature (the point at which sweating starts).

- The average TNZ is around 36 °C to 38 °C.
Hyperthermia

- Failure of the body’s homeostatic mechanisms to control body temperature within the thermoneutral zone results in hyperthermia (abnormally high body temperature).

- Failure to lower the temperature results in heat stroke and, ultimately, death.
Heat exhaustion

- At temperatures between 38 °C and 40 °C people sweat, become flushed and feel increasingly uncomfortable. Their heart rate increases and they may experience nausea, headache and may feel dizzy, become confused or faint.
- Heat exhaustion is treated by resting in a cool area and drinking water.
Heat stroke

- At temperatures above 41 °C people experience heat stroke.
- The heart rate becomes very fast, sweating stops and the skin becomes dry and hot.
- Beyond this point it is difficult for the body to maintain homeostatic balance and the temperature rises rapidly.
- Above 42 °C people are likely to lapse into a coma and will die if their temperature rises above 43 °C - 44 °C.
Example 3

Disruption resulting from disease
Renal failure

When the kidneys stop working homeostatic disruption is so widespread that the person will die unless they receive urgent medical assistance.
Causes of Renal failure

There are many causes for kidney failure – these can be classified as:

- **acute** (sudden) resulting from causes such as toxic drugs, a blockage or injury.
- **chronic** (gradual) resulting from problems such as diabetes, cancer, high blood pressure or polycystic kidney disease.
Consequences of renal failure

• In both acute and chronic renal failure, urine production is disrupted and water, salts and metabolic wastes are retained in the body.

• This causes widespread homeostatic problems which affect almost every system of the body.

• The most common cause of death is cardiovascular disease.
Treatment

In many instances there is no cure for renal failure.

Many people with renal failure have to undergo regular haemodialysis treatment to purify their blood (conventionally three times a week).

Sometimes a kidney transplant is an option.
**Haemodialysis**

- During haemodialysis, blood is removed from an artery, toxic substances, metabolic wastes and excess fluid are removed, and the blood is then returned to the body.
People with renal failure can receive a kidney transplant if a matching donor kidney is available.

The transplanted kidney is lower in the pelvis and attached to the common iliac artery and vein.