The Endocrine System

The endocrine system is responsible for chemical coordination and regulates activities that take place inside the body. The endocrine glands produce hormones. Hormones are chemical messengers. All endocrine glands are ductless which means that the hormones are secreted directly into the blood. Each gland has a rich supply of blood to transport the hormones to the target organs. Hormones generally consist of proteins and fats, but some (like the sex hormones) consist of fats only. Hormones control the activities of a target organ, but do not themselves perform the activity. Hormones work together as a system where they either stimulate or inhibit organs. Processes are regulated to ensure normal growth, development and functioning of all the systems in a coordinated manner.

- ADH – Antidiuretic hormone
- Growth Hormone (GH)
- Thyroid stimulating hormone (TSH)
- Follicle stimulating hormone (FSH)
- Lutenizing hormone (LH)
- Prolactin

- Thyroxine
- Adrenalin and Aldosterone
- Insulin and Glucagon
- Oestrogen and Progesterone
- Testosterone
### Hypothalamus

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Function</th>
<th>Effect of under- and oversecretion</th>
</tr>
</thead>
</table>
| Antidiuretic hormone (ADH)    | Regulates osmoregulation in the kidneys (in the distil convoluted tubules and the collecting tubules) | **Oversecretion:** water retention and swelling (oedema)  
**Undersecretion:** dehydration |

### Pituitary Gland

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Function</th>
<th>Effect of under- and oversecretion</th>
</tr>
</thead>
</table>
| Growth hormone (somatotrophin) | For growth, repair and replacement of cells                              | **Oversecretion:**  
Children – gigantism  
Adults – acromegaly  
**Undersecretion:**  
Children – pituitary dwarf  
Adults – premature senility |
| Follicle stimulating hormone (FSH) | **In males:** stimulates spermatogenesis  
**In females:** stimulates the development of the follicle for process of ovulation |                                                                                   |
| Luteinising hormone (LH)      | **In males:** stimulates the synthesis of the hormone testosterone by the Leydig cells in the testes  
**In females:** LH stimulates the release of the secondary oocyte from the Graafian follicle and then the development into the corpus luteum |                                                                                   |
| Thyroid-stimulating hormone (TSH) | Stimulates the production of thyroxin by the thyroid gland               | **Oversecretion:** goitre  
**Undersecretion:** lack of production of thyroxin – thyroid gland is under stimulated |
**Thyroid Gland**

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Gland</th>
<th>Location</th>
<th>Dwarfism</th>
<th>Effect of under- and oversecretion</th>
</tr>
</thead>
</table>
| Thyroxin | Thyroid | Below the larynx in the neck region | • Regulates the basal metabolic rate of the cells in the body  
• Affects growth and functioning of the heart and the nervous system  
• Stimulates growth and differentiation of tissue in a foetus and in children  
• Regulates the body temperature when stimulated by the hypothalamus | **Oversecretion:** goitre/hyperthyroidism  
**Undersecretion:** hypothyroidism  
Children – cretinism  
Adults – myxoedema |

**Needs Iodine**
### Adrenal glands

<table>
<thead>
<tr>
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<th>Function</th>
<th>Effect of under- and oversecretion</th>
</tr>
</thead>
</table>
| **Aldosterone**              | Helps the uptake of sodium ions in the loop of Henle in the kidneys. Maintains salt balance | **Oversecretion:** oedema (water retention)  
**Undersecretion:** Addison’s disease |
| **Adrenalin** (fight-and-flight hormone) | Prepares the body to deal with emergencies by stimulating:  
- Increase in heartbeat rate  
- Increase in breathing rate  
- Increase in blood pressure  
- Increase in muscle tone  
- Increase in blood sugar levels  
- Decrease in blood supply to the skin and digestive system  
- Dilation of the pupils |
### Pancreas

<table>
<thead>
<tr>
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<th>Gland</th>
<th>Location</th>
<th>Function</th>
<th>Effect of under- and oversecretion</th>
</tr>
</thead>
</table>
| Insulin | Islets of Langerhans – beta cells | Endocrine cells of the pancreas | • Controls blood sugar by causing the conversion of glucose into glycogen  
• Inhibits the functioning of glucagon | **Oversecretion:** obesity, headache, dizziness, weakness, emotional instability. In severe cases convulsions, coma and death  
**Undersecretion:** diabetes |
| Glucagon | Islets of Langerhans – alpha cells | Endocrine cells of the pancreas | Controls the increase in the blood sugar level by causing the conversion of glycogen to glucose |  |

### Testes

<table>
<thead>
<tr>
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<th>Location</th>
<th>Function</th>
<th>Effect of under- and oversecretion</th>
</tr>
</thead>
</table>
| Testosterone | Leydig cells in the testes of males located in the scrotum at the bottom of the pelvis | • Testosterone is responsible for the secondary sexual characteristics in males like a deeper voice, pubic hair, hair on face  
• Necessary for the normal development of sperm  
• Activates genes in the cells of Sertoli to promote the differentiation of the spermatogonia | **Oversecretion:** aggression. In females, it results in secondary sexual characteristics similar to that in males  
**Undersecretion:** lack of secondary sexual characteristics and lack of healthy sperm production. Low libido in males |
Ovaries

<table>
<thead>
<tr>
<th>Hormone</th>
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</tr>
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</table>
| **Oestrogen** | • Oestrogen promotes the development of the secondary sexual characteristics in females like breasts, the thickening of the endometrium (uterus) and the female body shape  
• Necessary for the process of ovulation  
• Oestrogen inhibits the secretion of FSH by the anterior pituitary gland so that only one follicle is produced during ovulation  
• High oestrogen levels will trigger the secretion of luteinising hormone (LH) | **Oversecretion:** may cause cancer  
**Undersecretion:** menstruation cycle is affected, ovulation may be prevented leading to infertility, onset of menopause may occur |
| **Progesterone** | • Progesterone prepares the endometrium of the uterus for implantation once fertilisation of the egg cell has occurred  
• Necessary for the production of the mucus plug to prevent sperm or other substances from entering the uterus during pregnancy  
• Decrease in progesterone levels causes menstruation  
• Progesterone improves memory and cognitive ability | **Undersecretion:** during pregnancy, will cause a spontaneous miscarriage |

**Homeostasis**
Homeostasis is the **maintenance of a relatively constant internal environment** by automatic control mechanisms. Cells will function normally, regardless of the external environment. The nervous system **controls** all the other systems in the body either directly or indirectly.

Homeostasis of the endocrine system occurs through the **negative feedback mechanism.** Feedback systems are important because they ensure that all the systems are interrelated and work together. When there is an increase from normal, a corrective mechanism will cause it to decrease and vice versa. This ensures that a **balance** is maintained within the body.

You must be able to describe the negative feedback mechanism involving:
• the regulation of thyroxin  
• the regulation of blood sugar levels
**NEGATIVE FEEDBACK CONTROL – REGULATION OF THYROXIN IN THE BLOOD**

- Increased thyroxin inhibits the pituitary gland.
- Thyroid is stimulated to release more thyroxin. This results in an increased cell metabolism.
- Pituitary gland
  - More TSH
  - Less TSH
- Thyroid gland

This is an important concept!

- Decreased thyroxin stimulates the pituitary gland.
- Thyroid is less stimulated – less thyroxin is released. This will result in a decreased cell metabolism.

Be able to link back to thyroid disorders. (Look at the over and under secretion column of the thyroid gland)

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**NEGATIVE FEEDBACK CONTROL – BLOOD SUGAR LEVELS**

- Blood sugar level
  - Eating/drinking sugary drinks inc. alcohol
  - Glucose taken into cells and used or stored as glycogen

- Optimal blood sugar level
  - Exercise/just not eating for a while
  - Glycogen turned back into glucose in the liver and released into the bloodstream

- High blood sugar – Insulin released

- Low blood sugar – Glucagon released

Be able to link back to insulin disorders.
Section B: Practice Questions

Question 1
Study the diagram below and answer the questions that follow.

1.1. Label the parts numbered 1 and 4. (2)

1.2. Write down only the NUMBER of the gland that:
   (a) Produces the hormone glucagon
   (b) Produces a hormone that controls the growth of long bones
   (c) Produces an iodine-containing hormone
   (d) Produces a hormone that is involved in the re-absorption of some salts by the kidneys (4)

1.3. State TWO similarities between hormones and nerves with regard to their functions. (2)

1.4. State ONE functional difference between hormones and motor nerves. (2)

Question 2
The blood glucose level is regulated by hormones. The human body attempts to maintain a glucose concentration of approximately 1 mg per mℓ of blood. The graph below shows the fluctuations in an individual's blood glucose level over a five-hour period.

2.1. From the information above and your knowledge of hormones, name the hormone released at:
   a. B
   b. D (2)

2.2. The individual ate a meal at point D. Explain the pattern of the graph for the next two hours. (4)
Question 3

The diagram below represents a model that shows the origin and fate of blood glucose in the human body. In this model blood glucose is represented as a tank of fluid.

![Diagram of blood glucose flow](image)

3.1 What is the main source of glucose? (1)
3.2 Name an organ in the human body represented in the model by the reservoir tank B. (1)
3.3 Name the carbohydrate stored in the reservoir tank B. (1)
3.4 In the human body, insulin and glucagon regulate the concentration of blood glucose. Where in the body are they produced? (1)
3.5 In the table below, place a tick (✓) in the appropriate box that matches the description of the effect of the hormones.

<table>
<thead>
<tr>
<th>Effect of hormone</th>
<th>Insulin</th>
<th>Glucagon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduces the amount of storage carbohydrate in reservoir tank B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduces the level of glucose in tank A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increases the uptake of glucose by body cells C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3)

Question 4
An experiment was carried out to investigate the effect of thyroxin from the thyroid gland of white laboratory rats of the same mass and age. Three groups were chosen, each with three rats in the group. The rats were treated as follows:

Group A: rats were fed on a normal diet plus thyroid extract
Group B: rats were fed on a normal diet alone
Group C: rats were fed on a normal diet plus drinking water that contained a weak solution of thiouracil, which is an inhibitor of thyroxin production
The oxygen consumption of each rat was measured while it was at rest. The results are shown in the table below. Oxygen consumption increases with increased metabolic rate in cells.

<table>
<thead>
<tr>
<th>Oxygen consumption (cm³ / g body mass / hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
</tr>
<tr>
<td>2.86</td>
</tr>
<tr>
<td>2.93</td>
</tr>
<tr>
<td>2.74</td>
</tr>
</tbody>
</table>

4. 1 Account for the differences in oxygen consumption between groups A, B and C. (6)
4. 2 If the rats in each group were force fed the same amount of food, which group would you expect to have the largest increase in mass? Give reasons for your answer. (2)
4. 3 Which group of rats is likely to be producing the lowest amount of TSH? Give a reason for your answer. (2)

Question 5
Describe the negative feedback mechanism involving TSH and thyroxin and describe the consequences if this mechanism does NOT function well. (20)

Section C: Solutions

Question 1
1. 1 – pituitary gland✓ 4 – adrenal gland✓ (2)
1. 2. a. 3✓ b. 1✓ c. 2✓ d. 4✓ (4)
1. 3. They respond to internal and/or external stimuli✓ They protect organisms✓ (2)
1. 4. Hormones: Responses are slow processes✓ may affect multiple sites
   Nerves: Responses are quick reactions✓ affect localised sites (2)

Question 2
2. 1. (a) Insulin✓
   (b) Glucagon✓ (2)
2. 2. In the first hour✓ after eating the glucose level increased✓
   The hormone insulin✓ was then secreted to convert the excess glucose to glycogen✓ which resulted in the glucose level dropping✓ in the second hour✓ (Any FOUR) (4)

Question 3
3. 1 carbohydrates✓
3. 2 pancreas✓
3. 3 glycogen✓
3. 4 Islets of Langehans✓
3.5

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<td></td>
</tr>
<tr>
<td>Increases the uptake of glucose by body cells C</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Question 4

4.1  A – High thyroxin levels – pushes metabolic rate up – therefore high Oxygen consumption.

4.2  B – normal thyroxin levels - normal metabolic rate – normal Oxygen consumption

4.3  C – low thyroxin levels due to thiouracil – low metabolic rate – low Oxygen consumption. (6)

4.2  Group C – low metabolism – would not "burn" up food - excess stored as fat. (2)

4.3  Group A – as thyroxin levels are very high due to supplement therefore the thyroid gland does not have to be stimulated/ negative feedback of thyroxin (2)
Question 5

The pituitary gland is sensitive to the concentration of the hormone, thyroxin, in the blood.

When the thyroxin concentration in the blood decreases below the normal level:
- The pituitary is stimulated to secrete more TSH.
- TSH stimulates the thyroid gland to secrete more thyroxin.
- Thus increasing the level of thyroxin in the blood.

When the thyroxin concentration in the blood increases above the normal level:
- The pituitary is not stimulated to secrete TSH.
- There is less stimulation of the thyroid gland to secrete thyroxin.
- Thus decreasing the level of thyroxin in the blood.

Consequences of mechanism not working

The concentration of thyroxin will not be regulated.

When the thyroxin level increases beyond normal limits it causes

Hyperthyroidism

Hyperthyroidism causes an increase in rate of metabolism resulting in:
- Weight loss
- Irritable/anxiety
- Hyperactive
- Increase in heart rate
- Tiredness

Thyroid gland swells/goitre
Eyeballs protrude

When the thyroxin level decreases beyond normal limits it causes

Hypothyroidism

Hypothyroidism causes a decrease in rate of metabolism resulting in:
- Weight gain
- Decrease in heart rate
- Slow growth of hair and fingernails

Content: 17 points