Endocrine Function & Homeostasis

Session Objectives.

What you will cover
- Location of endocrine glands
- Endocrine Function
- Hormone Function
- Homeostasis

Your objectives are
- Locate endocrine glands in the body, and identify some of the hormones produced by these glands
- List the effects of the hormones produced by the endocrine glands
- Identify hormones as belonging to steroid, protein or amino acid class
- Explain the mode of action of steroid hormones
- Explain the mode of action of protein and amino acid hormones in terms of second messenger systems
- Name the stimuli for hormone production
- Describe the homeostatic [hormonal] control mechanisms for maintenance of blood glucose, plasma osmolality and body temperature with normal ranges
- Define homeostasis
- Explain the mechanisms of negative and positive feedback
- Give examples of negative and positive feedback and explain their physiological relevance
- Distinguish between autoregulation and extrinsic control

Suggested reading: Tortora, Ch 1, Ch18, Ch27 Marieb Ch 1, Ch 17, Ch 27
Endocrine Function and Homeostasis

The endocrine system consists of many small organs. These are found at various locations around the body.

**Task**
Identify the organs of the endocrine system on the image below. Use the names given below.

- Testes
- Hypothalamus
- Thyroid Gland
- Ovaries
- Kidney
- Pituitary gland
- Adrenal glands
- Parathyroid glands
- Thymus
- Pancreas
**Endocrine Communication - Hormones**
The organs and tissues you have identified as endocrine have structures in common. They have glandular epithelia. They release hormones.

**Task.**
Match the glands with the appropriate hormones from the list given on the next page.
Identify the functions of the hormones [briefly!]. Some of the glands produce more than one hormone, so you need to give functions for all the hormones you identify.

<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone(s)</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pituitary Gland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyroid Gland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parathyroid Gland</td>
<td></td>
<td></td>
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<tr>
<td>Thymus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrenal Gland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kidney</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pancreas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ovaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hormone List

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-diuretic hormone</td>
<td>Insulin</td>
</tr>
<tr>
<td>Thyroxine [T₄]</td>
<td>Parathyroid hormone</td>
</tr>
<tr>
<td>Parathyroid hormone</td>
<td>Erythropoetin [EPO]</td>
</tr>
<tr>
<td>Thymosin</td>
<td>Oxytocin</td>
</tr>
<tr>
<td>Oestrogen</td>
<td>Adrenaline [epinephrine]</td>
</tr>
<tr>
<td>Aldosterone</td>
<td>Calcitonin</td>
</tr>
<tr>
<td>Noradrenaline</td>
<td>Luteinising Hormone</td>
</tr>
</tbody>
</table>

Classifying Hormones

Hormones can be classed by their biochemical family structures. There are three main types. These are steroid hormones, peptide/protein hormones and amino acids and their derivatives [amines].

Control of Hormonal Release

Generally, hormones are not secreted all the time. They are secreted into the bloodstream in small, short duration pulses or waves. Regulation of this secretion is what homeostasis is all about. Homeostasis prevents the body wasting valuable energy resources on making and secreting hormones. Conversely, homeostasis also ensures that hormones are produced as and when they are needed.

There are three mechanisms that stimulate hormone release.

| Task
| Give a brief descriptions of the stimuli for the secretion of hormones.

<table>
<thead>
<tr>
<th>STIMULUS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humoral</td>
<td></td>
</tr>
<tr>
<td>Neural</td>
<td></td>
</tr>
<tr>
<td>Hormonal</td>
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</tr>
</tbody>
</table>
Homeostasis

Homeostasis is an essential characteristic for life. Homeostasis controls the processes required for life using special internal mechanisms. Failure to maintain homeostasis will result in illness or even death.

But what is homeostasis?

**Definition of homeostasis**
Simply put, homeostasis is the maintenance of a constant internal environment.

**What is a constant internal environment?**
We may be aware that our external environment is changing e.g. when it gets hot in a room. Our internal environment has to adapt to this to prevent our internal organs from getting too hot. We are familiar that when we are hot, our skin is hot to the touch and we may sweat. These events are evidence that our body is responding to the changing external environment to keep the internal one within safe limits.

Homeostasis diagram…

<table>
<thead>
<tr>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you think the diagram is trying to explain in terms of homeostasis [and its not that you’ll win a teddy].</td>
</tr>
</tbody>
</table>
Limits and ranges for homeostasis
Biochemicals such as glucose need to be maintained within what is termed the **normal range**. For glucose the normal range is 3.5-7.5 millimoles per litre (mmol l⁻¹). If your blood glucose levels are constantly greatly above 7.5 mmol l⁻¹ cellular damage occurs in the eyes, kidneys and nerve endings. Similarly, the osmolarity of our blood [essentially the water concentration] needs to be maintained at around 285 - 300 milliosmoles (mOsm) so that important blood constituents do not become too diluted or too concentrated, and that cells do not lose or gain too much water by osmosis.

**Task**
**Explaining homeostasis – hot water system.**
Read the following passage, and then complete the flow diagram of how you think the heating system is regulated.

Think about a simple control system to control the temperature of water being heated by a gas boiler. A sensor constantly monitors the temperature of water. When the water temperature drops below the temperature you want [that you have set with a thermostat] the sensor makes a valve open that supplies gas to the boiler. This increase in gas supply makes the boiler come on. The water is heated. The sensor detects the higher water temperature. When the water reaches the desired temperature, the sensor makes the valve supplying gas to the boiler close. The heater goes off and the water gradually cools.

NORMAL RANGE

Or think about it like this…

**Increases/more**

**Decreases/less**

Normal range
Feedback systems.

You should be getting the idea that all homeostatic mechanisms in our bodies operate by maintaining conditions within a narrow range around a particular operating point. Homeostasis is maintained by balancing inputs and outputs. Imbalances are controlled by adjustments made by regulatory centres. The relationship between an imbalance and the response to the imbalance is called feedback.

The majority of feedback systems in the body are **negative** feedback systems.

**Task**

Give a brief definition of negative feedback

Suggest one advantage of having a negative feedback system to control homeostasis

**Advantage:**

Give a brief definition of positive feedback

Give two examples of negative feedback systems and two examples of positive feedback systems.

Negative Feedback ____________________________

Negative Feedback ____________________________

Positive Feedback ____________________________

Positive Feedback ____________________________
Control of Blood Glucose.
Normal blood glucose concentrations should fall within a range of 3.5 – 7.5 mmol l\(^{-1}\). But how is this regulated? The diagram below attempts to explain this.
**Task**

Use the diagram of glucose homeostasis to answer these questions.

What would cause blood glucose levels to rise?

_____________________________________

Which pancreatic cells release
   a) insulin ____________________________
   b) glucagon __________________________

What molecule is glucose converted into by the action of insulin?

___________________

In which tissues is this storage molecule principally found?

_________________________________________

Glucagon increases the release of glucose from which organ?

__________________________

**Glucose tolerance test.**

This is a procedure that determines whether a person is able to use and store glucose normally. The test is most commonly carried out to diagnose diabetes mellitus. The glucose tolerance test may also be used during pregnancy to test for gestational diabetes. Reactive hypoglycemia may also be diagnosed using this test.

After a period of fasting, the patient's blood and urine are tested for glucose. Then, a measured quantity of glucose is given as a drink or by injections. Further blood and urine samples are taken at regular intervals for two to four hours. The results of a glucose tolerance test for two individuals are shown in a graph that follows.
A normal result shows a maximum level of glucose in the blood about an hour after the dose, followed by gradual return to the normal level during the second hour. An abnormal result reveals an unusually high rise in the blood sugar level, an extremely slow return to normal, and sugar in the urine (glycosuria). An abnormally low blood sugar level following glucose administration is indicative of reactive hypoglycemia.

**Task**

Suggest at what time that insulin levels peaked for subject 1 and for subject 2.

Subject 1 _______________ Subject 2 _______________

Explain why it is unlikely that either subject is diabetic.

**Water homeostasis - osmoregulation.**

Osmoregulation is the correct term for the homeostatic balance of water in the body. Water surrounds all cells as extracellular fluid [ECF]. ECF is monitored for compositional or volume changes. This makes sense, as the ECF can be monitored more efficiently than intracellular fluids [cytosol] can be monitored. Our body monitors the exact concentrations of ions like sodium, by checking the osmotic concentration of ECF or the precise volume of ECF. Body water content, and therefore ECF water content will alter if dietary gains or losses are made.
Task
Identify causes of water gains and water losses.

<table>
<thead>
<tr>
<th>Water gains</th>
<th>Water losses</th>
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</tbody>
</table>

Anti-diuretic hormone.
We have specialised receptors in the hypothalamus called osmoreceptors. It is these that detect changes in water concentration.

Task
In terms of the feedback flow diagrams on page 3 what role do the osmoreceptors have in the regulation of water concentration?

__________________________________________

The hypothalamus synthesises anti-diuretic hormone [ADH]. As it’s name suggests, it stops diuresis/urine production.

Task
Although ADH is made in the hypothalamus, it is released from another endocrine organ.
Identify a) the endocrine gland that secretes ADH  b) the organ in the body that ADH acts on

a) ____________________  b) ____________________________

Web Pages [accessed August 2004]

http://www.vivo.colostate.edu/hbooks/pathphys/endocrine/  Worth looking at to find Baloo’s endocrine organs

http://www.mscc.cc.tn.us/ftp/scompton/Endocrine%20System-I%20Handout.ppt