Regulatory Mechanisms in Animals

Why are they doing?

Learning Intentions

- Understand that animals respond to changes in their external and internal environment

- Understand how animals maintain equilibrium and respond to changes in environmental conditions(homeostasis)

- Give examples of some factors that are under homeostatic control.

Animals need to respond to changes in their external and internal environment.

What are some responses?

Temperature

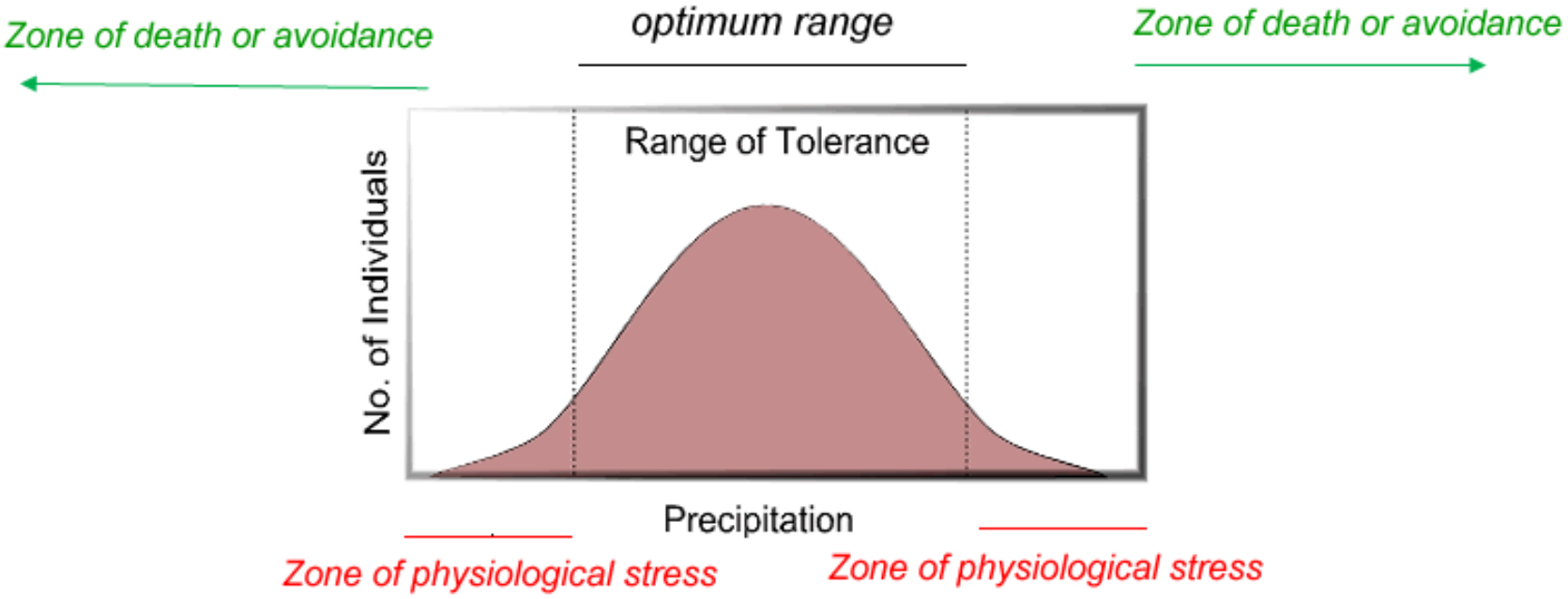
Water and solute

Glucose etc

Oxygen, CO_2

These responses ensure that various internal factors stay within ***tolerance limits.***

Tolerance range – the range a population thrives in an optimal range of abiotic factors. Beyond this range, one finds less and less numbers of these organisms. Often the range is shown for each factor, see diagram below.



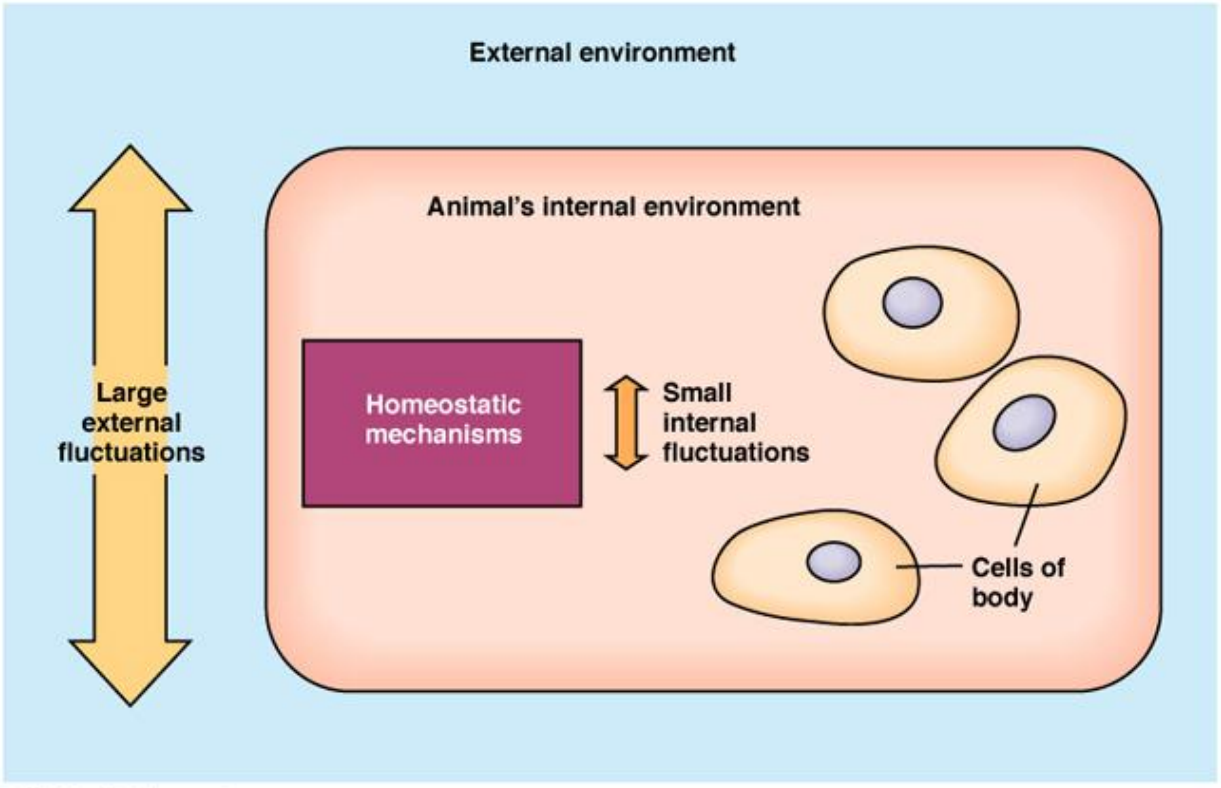
Biozone, page 243, Habitat

Limiting Factor – one factor that affects the population and limits its growth. Can be too much or too little. E.g. The limiting factor for a plant population near a chemical factory may be the soil pH.

Homeostasis

Homeostasis is the maintenance of a constant internal environment..

That is the tissue fluid around the cells needs to remain in a relatively constant state.



What factors are under homeostatic control?

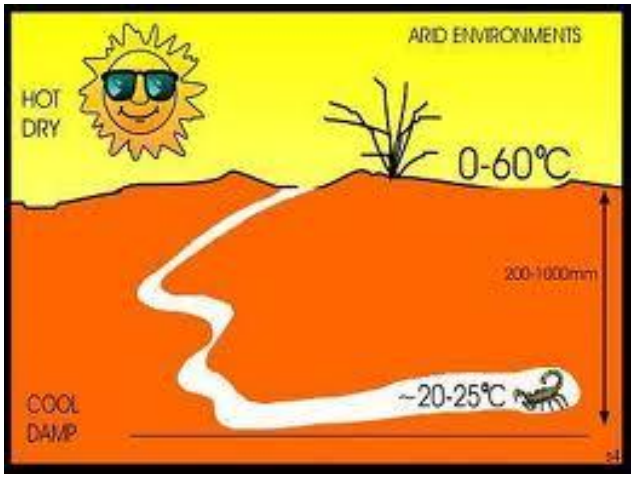
- Body Temperature (Thermoregulation)
- Water level in blood (Water balance)
- Blood glucose concentration
- Oxygen and carbon dioxide concentration in blood
- Concentrations of ions ie sodium, chloride, calcium....

Animals have physiological, behavioural and structural adaptations to ensure their core temperature remains within their upper and lower tolerance limits.

Examples…….

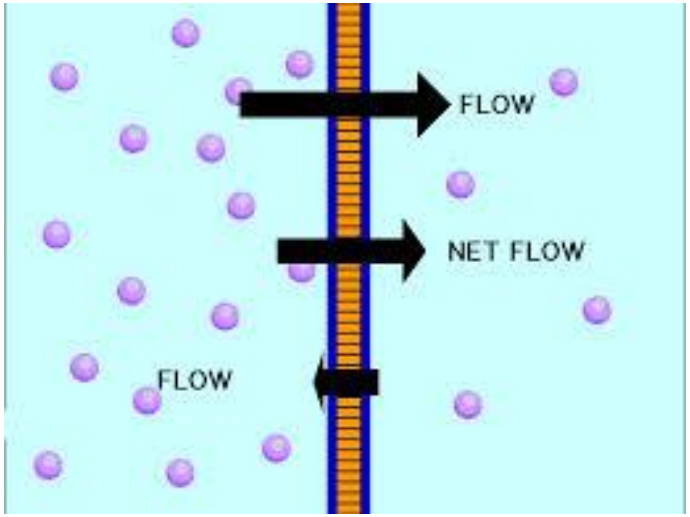
1. Thermoregulation

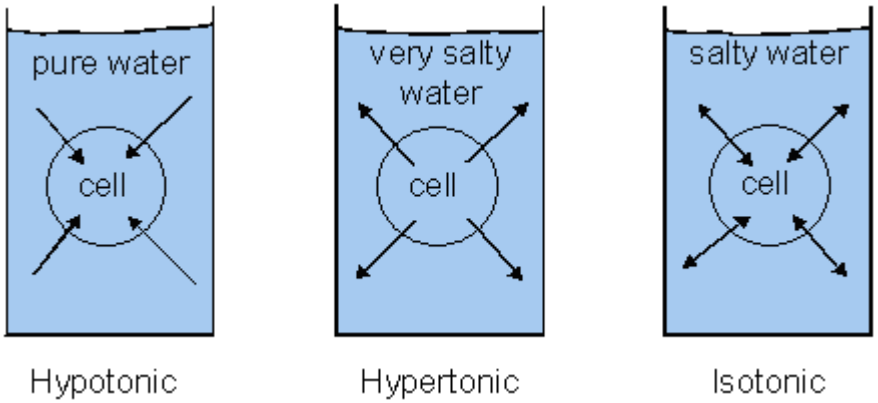
2. Water balance



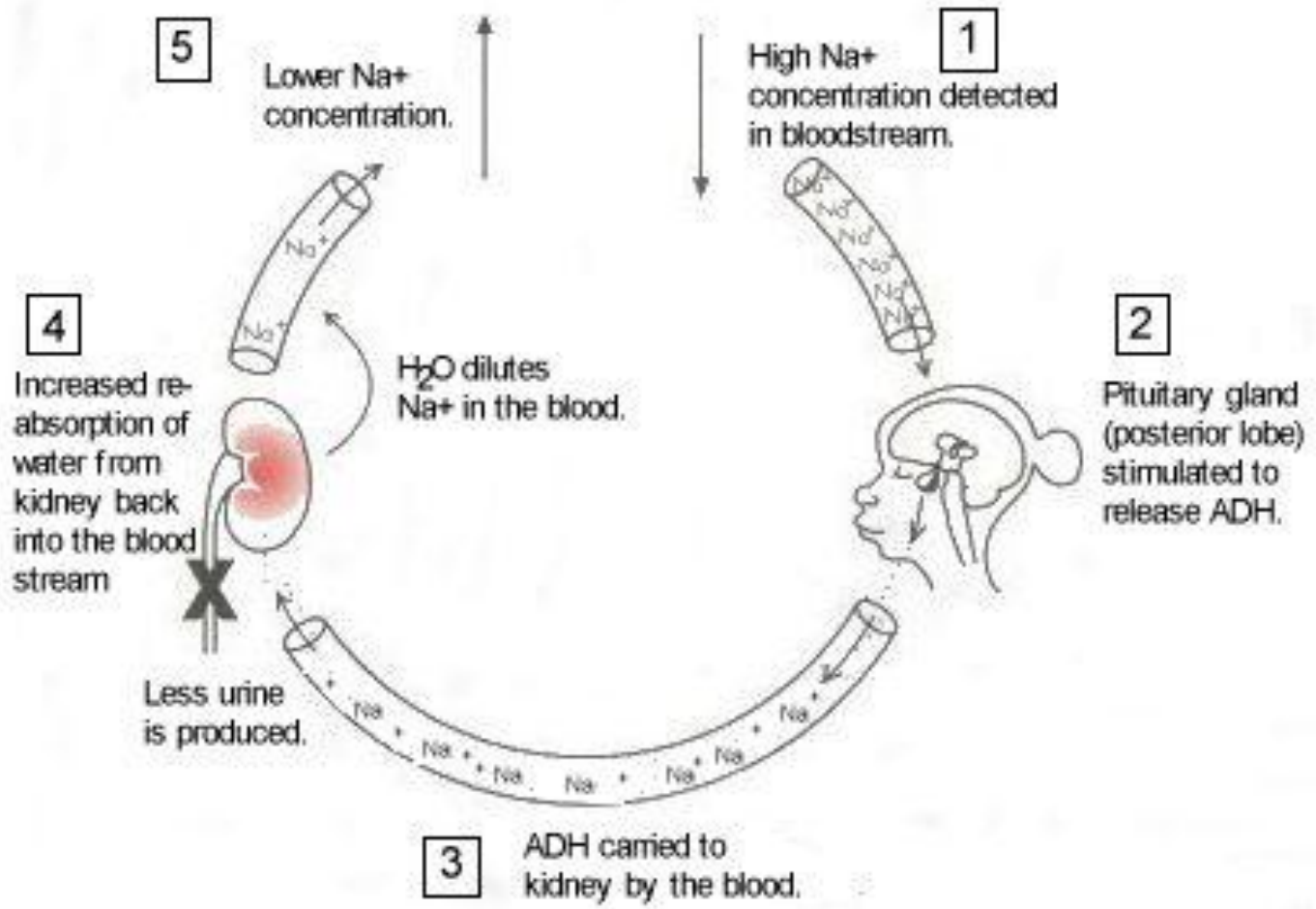
Osmoregulation

- This is the homeostatic control of water.
- A change in water concentration(osmotic pressure) occurs (water concentration in cytoplasm increases or decreases).
- Osmoreceptors detect water concentration change. These are situated on the hypothalamus next to the circulatory system.
- The hypothalamus sends chemical messages to the pituitary gland next to it. The pituitary gland secretes anti-diuretic hormone (ADH), which targets the kidney responsible for maintaining water levels. (feedback mechanism)





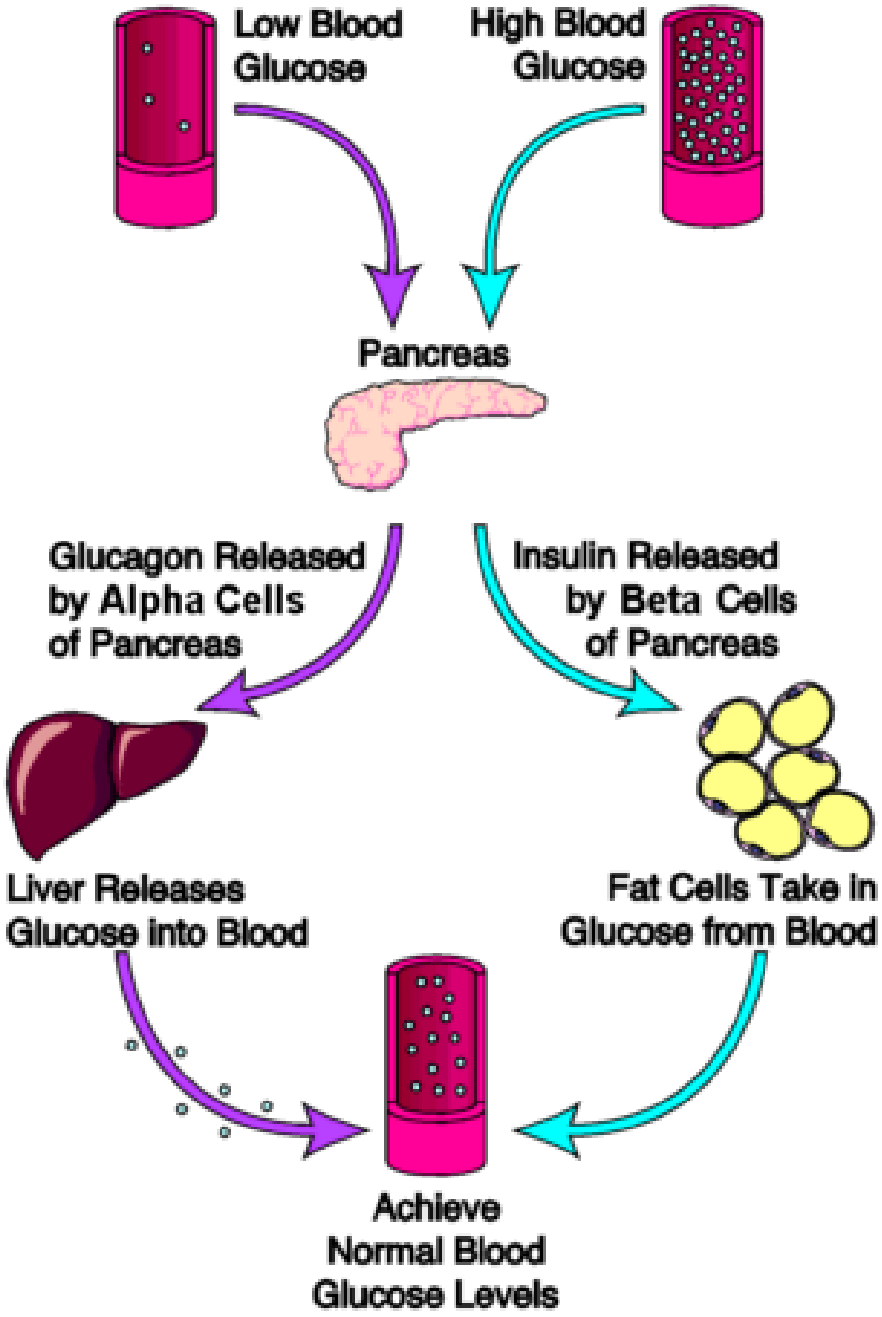
Concentrations of ions ie sodium, chloride, calcium....



Evolutionary Adaptations in Water Regulation

- Ways in which both animals and plants can be better adapted to cope with extreme environments (desert or wetlands).

- These changes can be behavioural, structural or physiological, and in some way promote water regulation.



3. Blood Glucose

Blood Glucose Regulation

The receptors of the pancreas are responsible for monitoring glucose levels in the blood, since it is important in every cell for respiration.

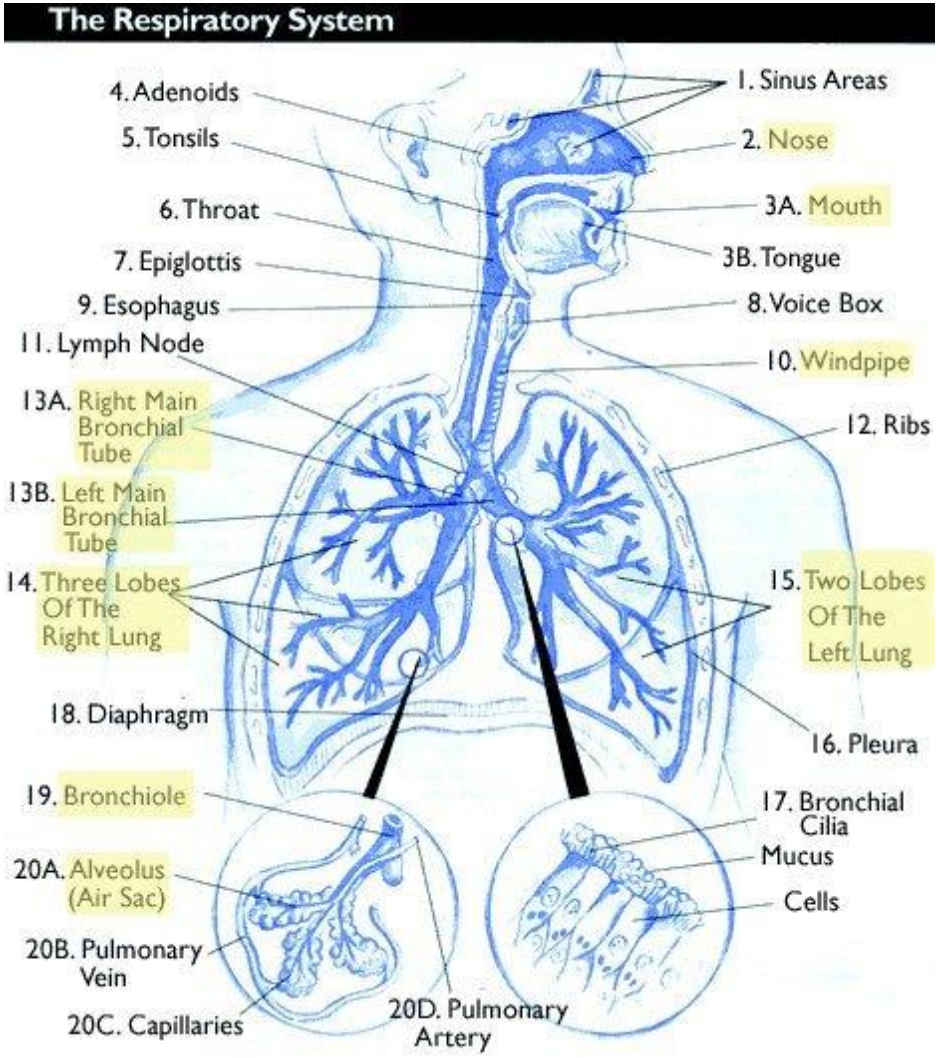
Two types of cells release two different hormones from the pancreas, insulin (promotes conversion of glucose into glycogen for storage in liver) and glucagon (promotes conversion of glycogen stored in liver to glucose) for controlling the concentration of glucose in the blood.

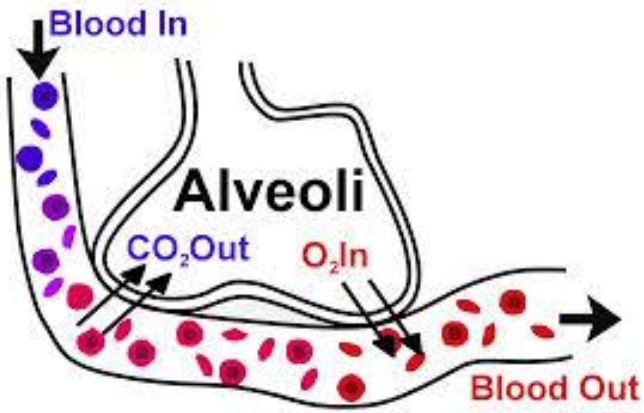
Diabetes

Diabetes is a where the sufferer does not have the ability to produce sufficient insulin, meaning that glucose cannot be converted into glycogen.

Anyone who has this condition usually has to take injections of insulin after meals and snacks to maintain their storage of glucose needed in emergencies.

4. Oxygen and carbon dioxide concentration in blood





Oxygen and carbon dioxide concentration in blood

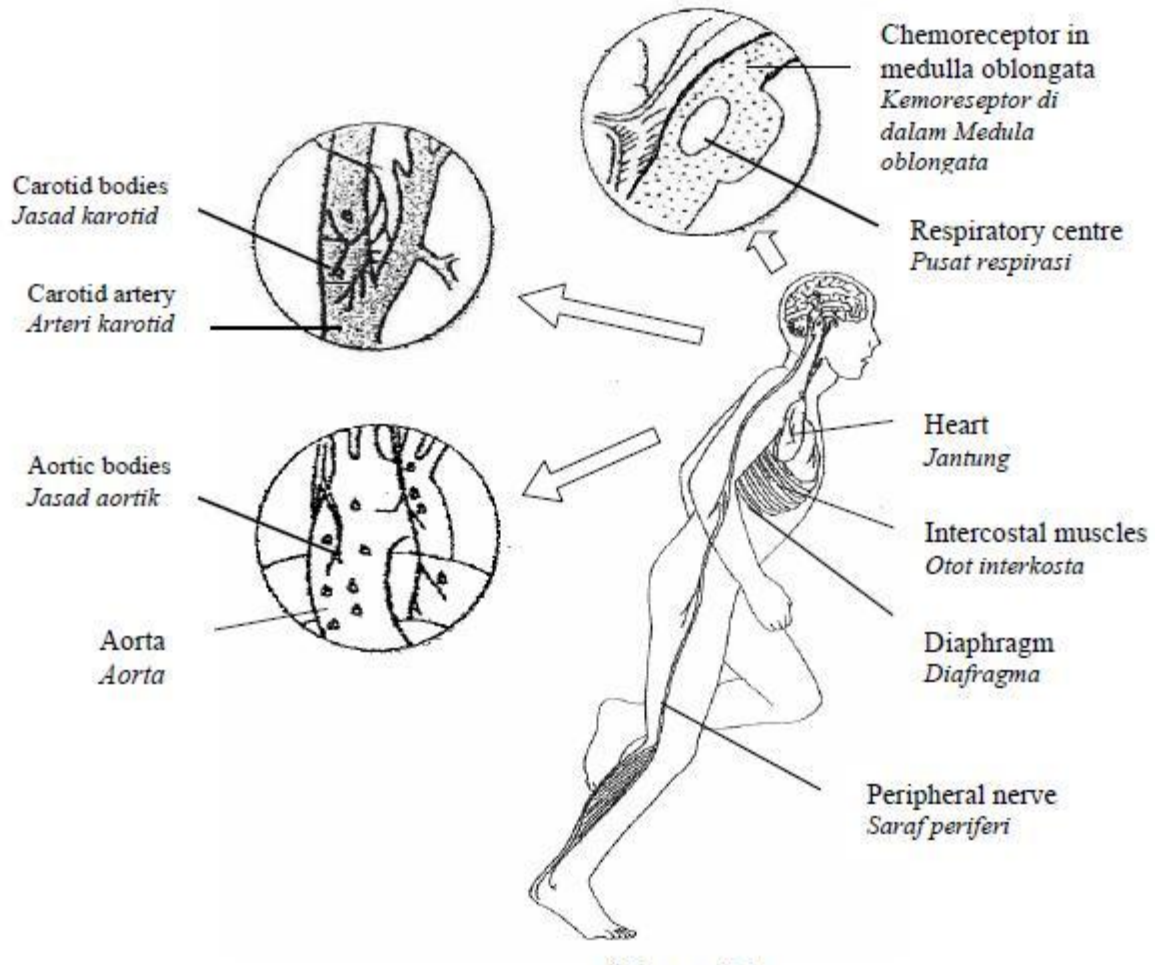
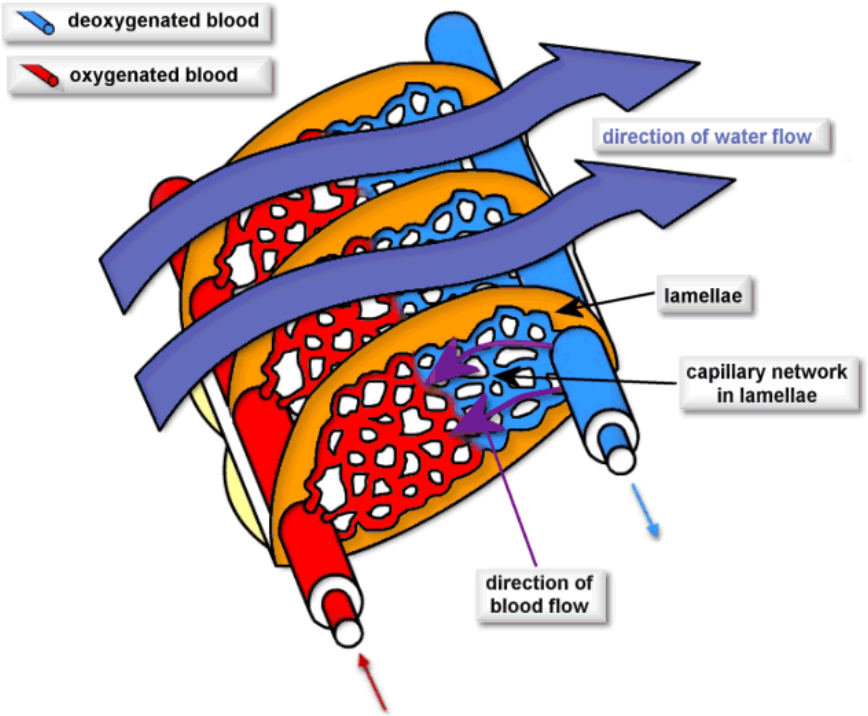
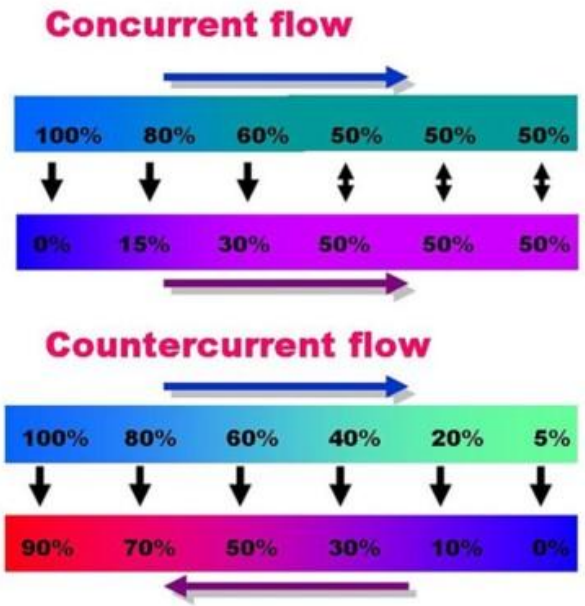


Diagram 6.1
Rajah 6.1

Countercurrent gas exchange in fish





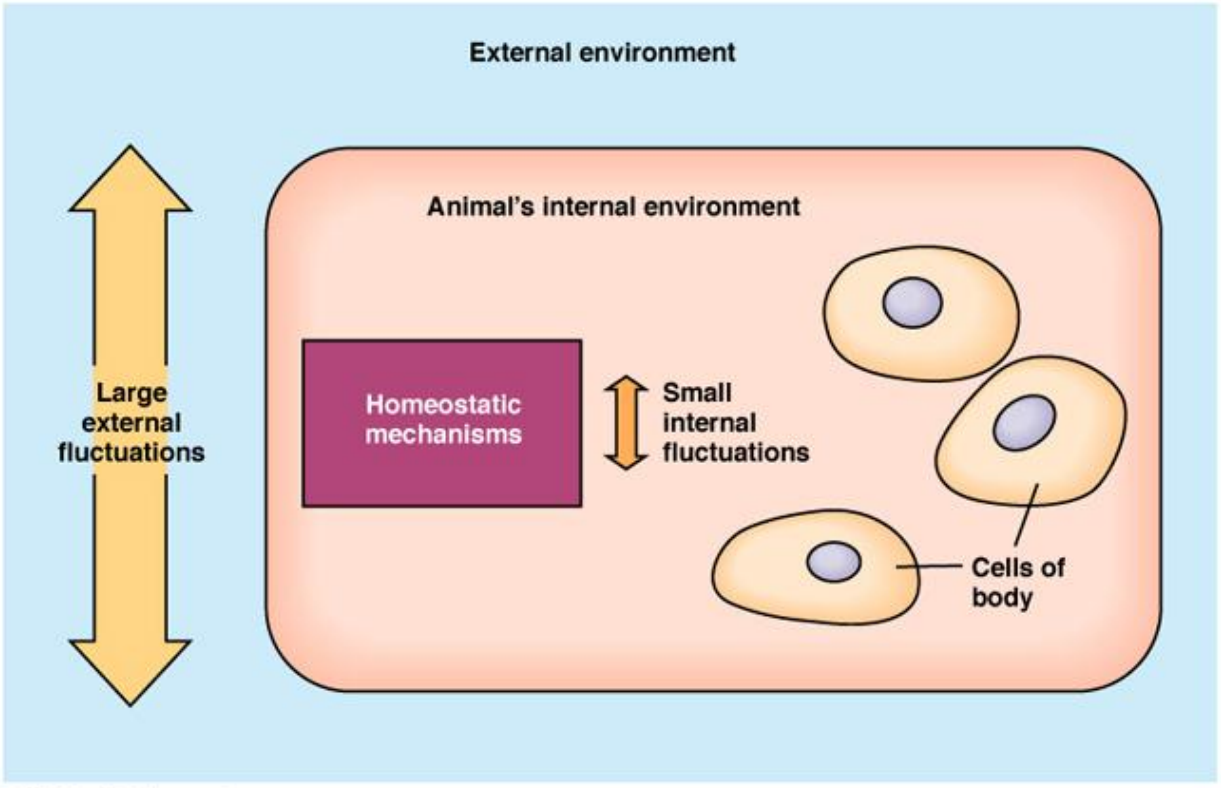
Systems reach equilibrium and no further exchange takes place.

Systems do not reach equilibrium and exchange takes place along entire length. More of the exchanged substance is transferred than in previous example.

Homeostasis

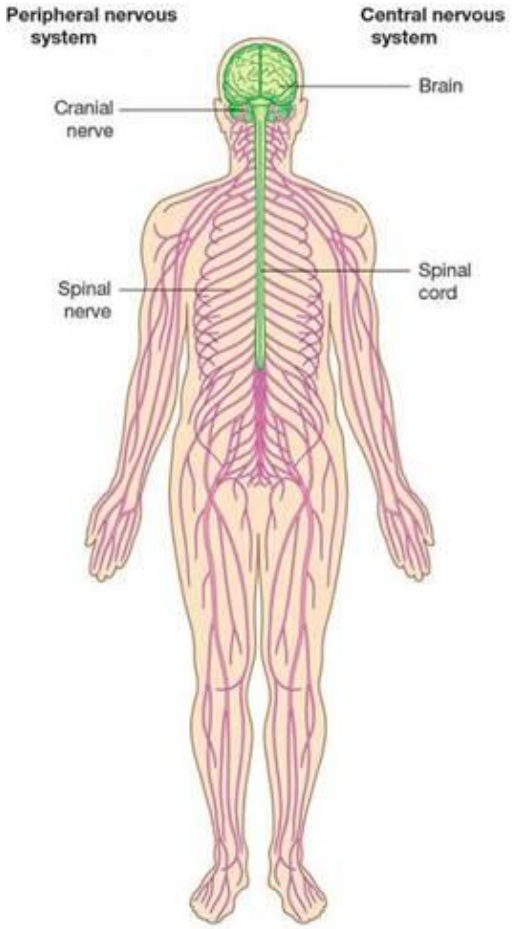
Homeostasis is the maintenance of a constant internal environment..

That is the tissue fluid around the cells needs to remain in a relatively constant state.



Homeostasis is maintained by:

- The Endocrine System
- The nervous system



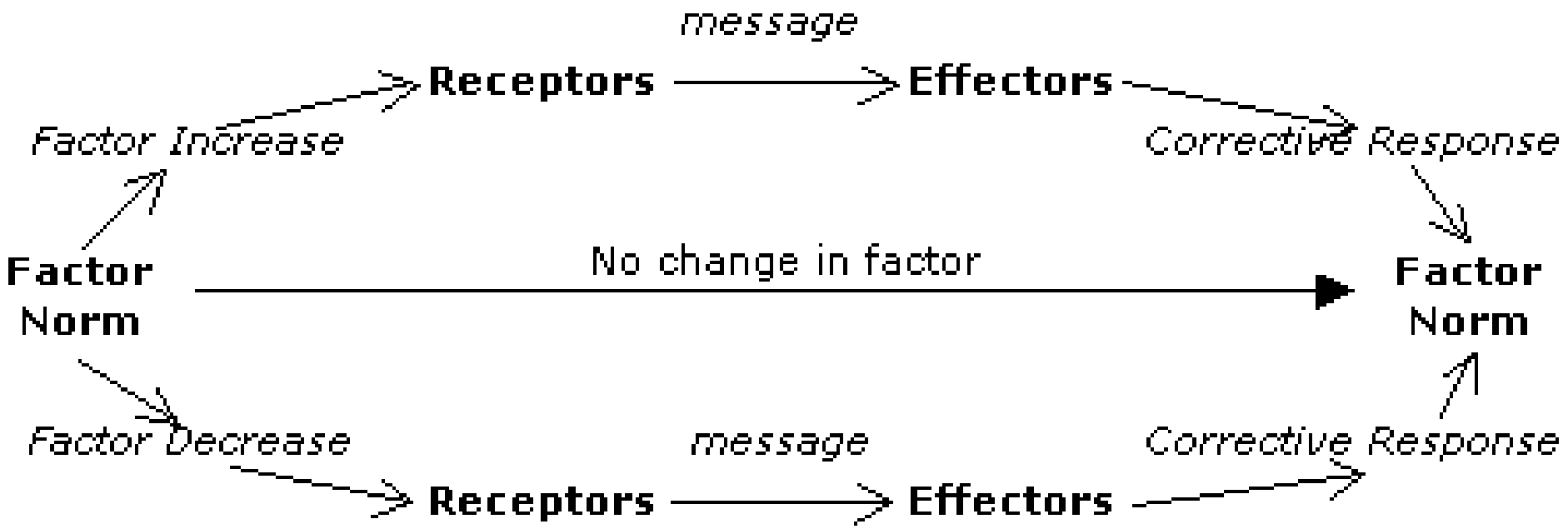
Negative Feedback Control

In animals such as ourselves, the internal environment of our bodies must have certain conditions within tolerable limits to continue the healthy functioning of us.

This is done by a process called negative feedback control, where various receptors and effectors bring about a reaction to ensure that such conditions remain favourable.

This occurrence is known as physiological ***homeostasis****, translating in layman's terms to the* ***physical equilibrium****. It is essentially a corrective mechanism.*

The principle of negative feedback control is illustrated by the diagram below:



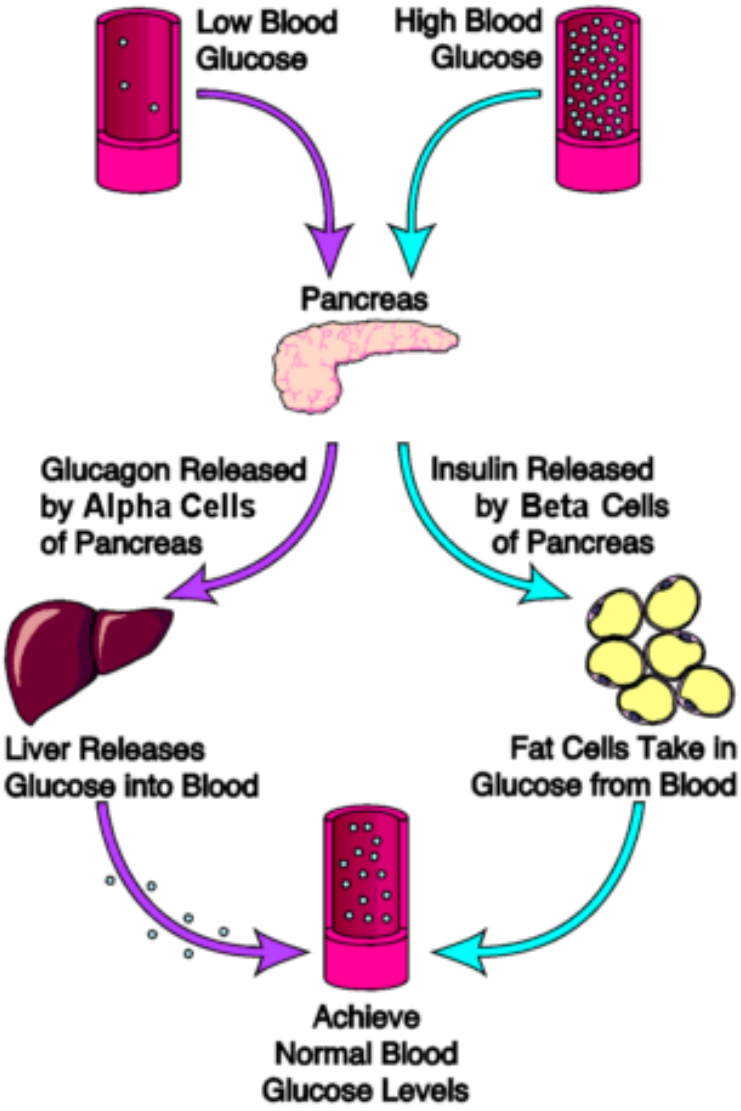
Example 1 - Blood Glucose Regulation

Blood Glucose Regulation

The receptors of the pancreas are responsible for monitoring glucose levels in the blood, since it is important in every cell for respiration.

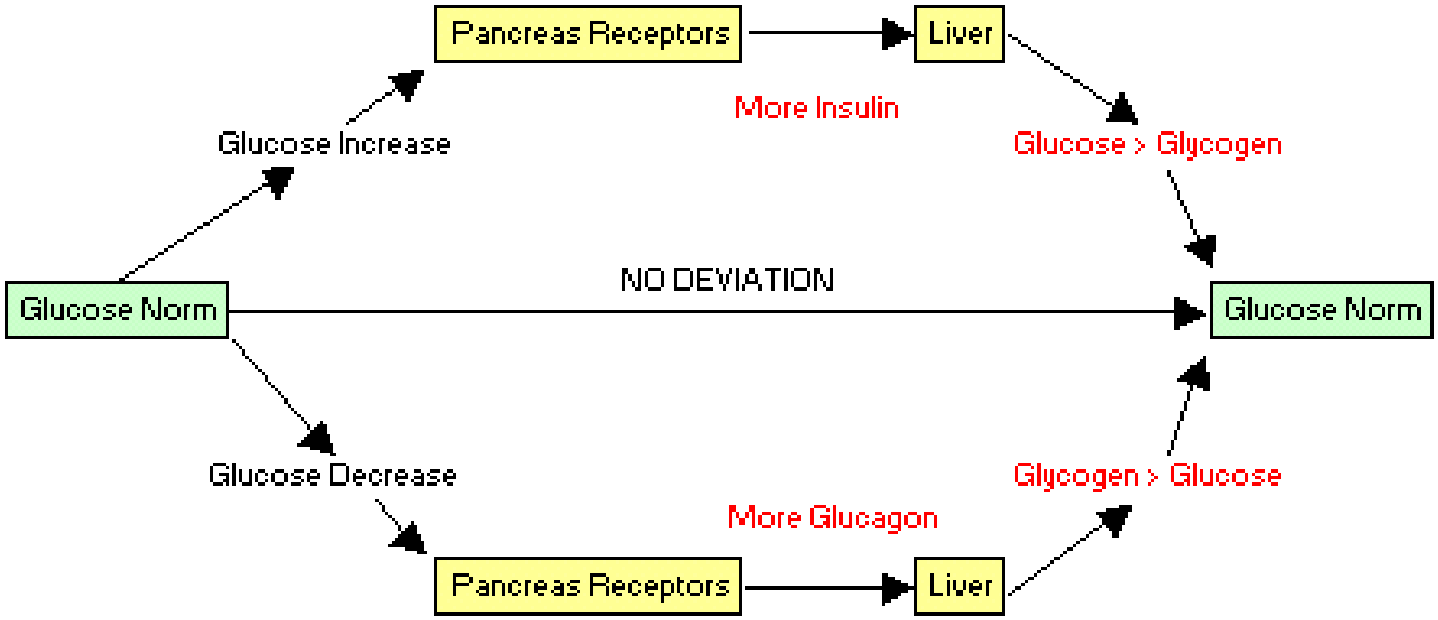
Two types of cells release two different hormones from the pancreas, insulin (promotes conversion of glucose into glycogen for storage in liver) and glucagon (promotes conversion of glycogen stored in liver to glucose) for controlling the concentration of glucose in the blood.

These hormones target the liver, depending on the glucose concentration.



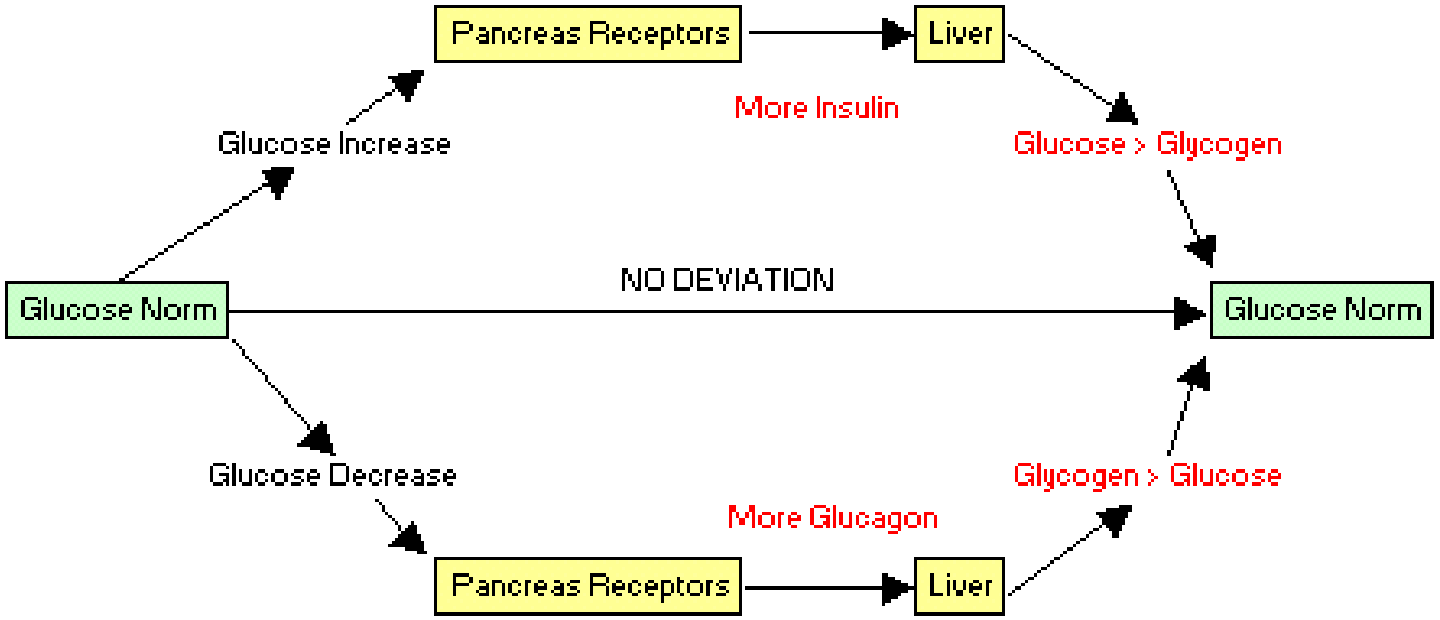
Corrective response by the pancreas is:

- when glucose levels increases to secrete less glucagon and more insulin
- When glucose levels decreases is to secrete less insulin and more glucagon by the pancreas



The negative feedback process is as follows:

- The level of glucose in the bloodstream drops.(Factor decreases)
- The person requires glucose in cells to meet the demands of respiration. (Corrective response)
- The body detects this with a particular receptor designed for this function.
- These receptors release hormones (glucagon) , chemical messages that initiate the start of the feedback mechanism
- The hormones travel to their target tissue (liver) and initiate a corrective response
- In this case, the corrective response is the secretion of more glucose into the bloodstream



Example 2 - Negative feedback scenario of osmoregulation in fish

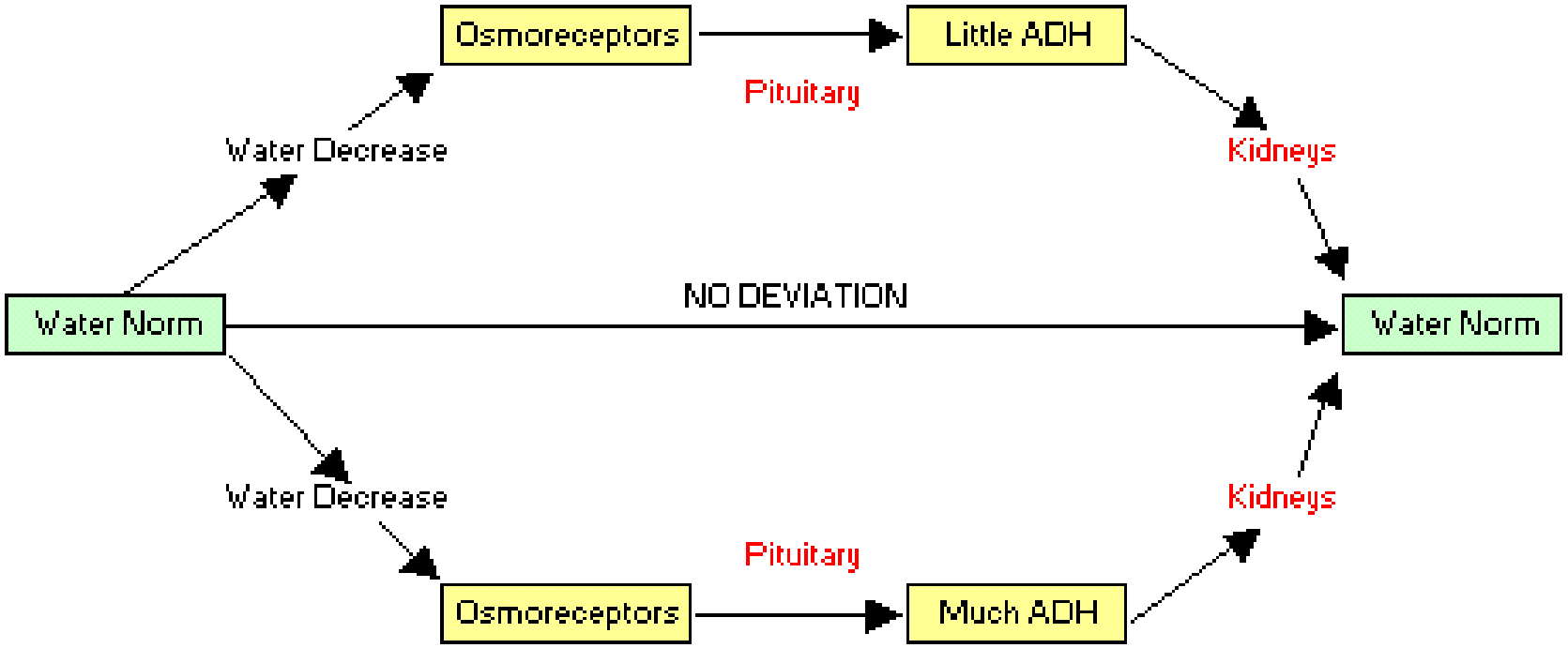
The homeostatic control of water is as follows:

- A change in water concentration occurs. (factor increase or decrease)
- Osmoreceptors detect water concentration change. These are situated on the hypothalamus next to the circulatory system.
- The hypothalamus sends chemical messages to the pituitary gland next to it. The pituitary gland secretes anti-diuretic hormone (ADH), which targets the kidney responsible for maintaining water levels. (feedback mechanism)

- When the hormone reaches its target tissue, it alters the tubules of the kidney to become more / less permeable to water (corrective response)
  - If more water is required in the blood stream, high concentrations of ADH make the tubules more permeable. (corrective response1)

OR

  - If less water is required in the blood stream, low concentrations of ADH make the tubules less permeable. (corrective response2)



Other examples where negative feedback occurs

- Flight and Fight Response
- Temperature Control

Advantages of Homeostasis

- Homeostasis has survival value because it means an animal can adapt to a changing environment e.g. You can deal with the temperature difference you face when you step out your front door.

- The body will attempt to maintain a norm, (the desired level of a factor to achieve homeostasis) for example constant body temperature of 37 degree celsius.

  - however, it can only work within tolerable limits.

  - extreme conditions can disable the negative feedback mechanism

  - In these instances, death can result, unless medical treatment is executed to bring about the natural occurrence of these feedback mechanisms.