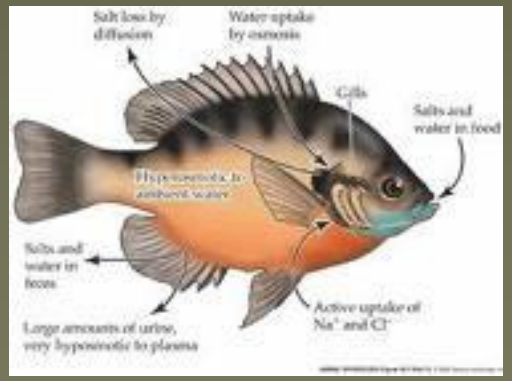
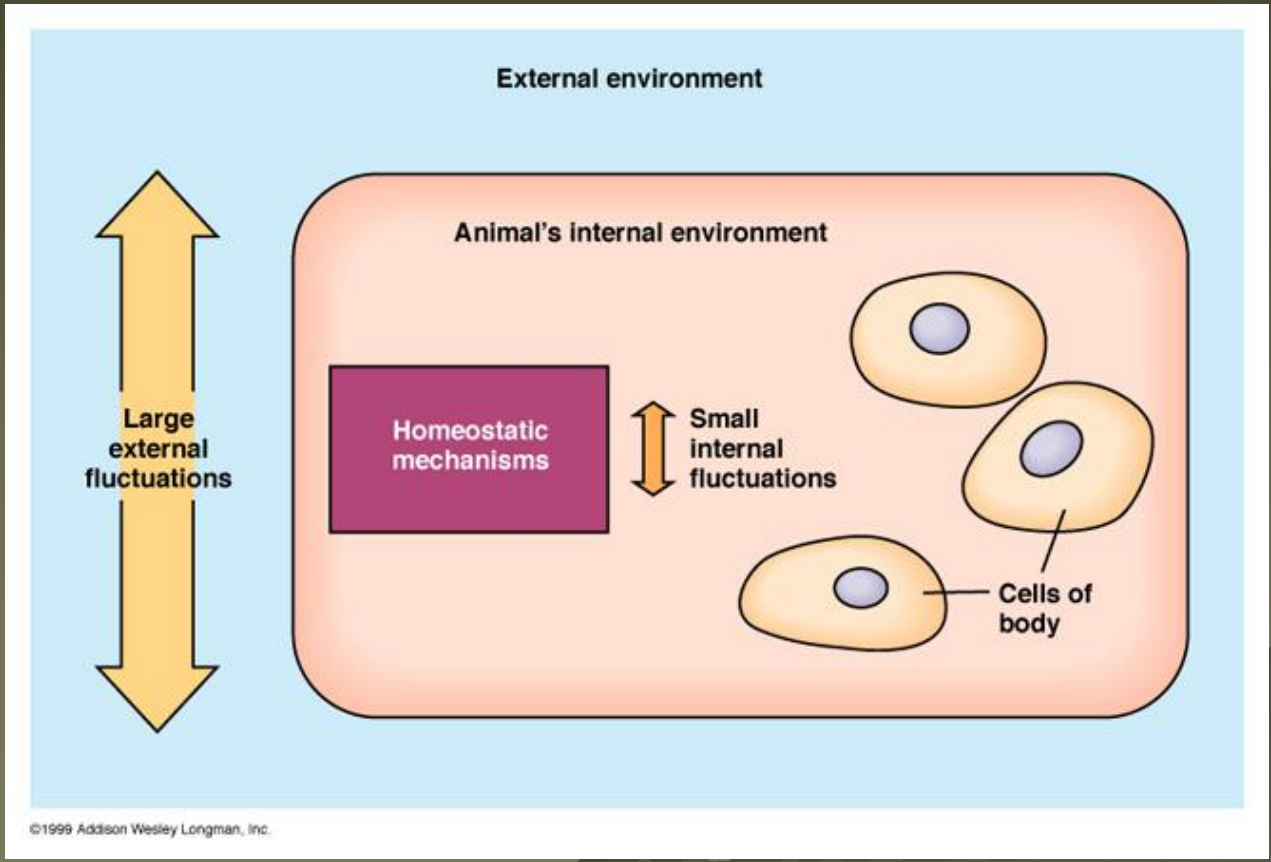
Homeostasis and negative feedback control



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.



Advantages of Homeostasis

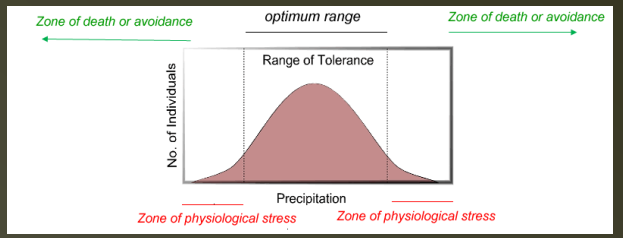
- Homeostasis has survival value because it means an animal can adapt to a changing environment e.g. You can deal with the temperature difference you face when you step out your front door.

- 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 cesius.

- **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**.**

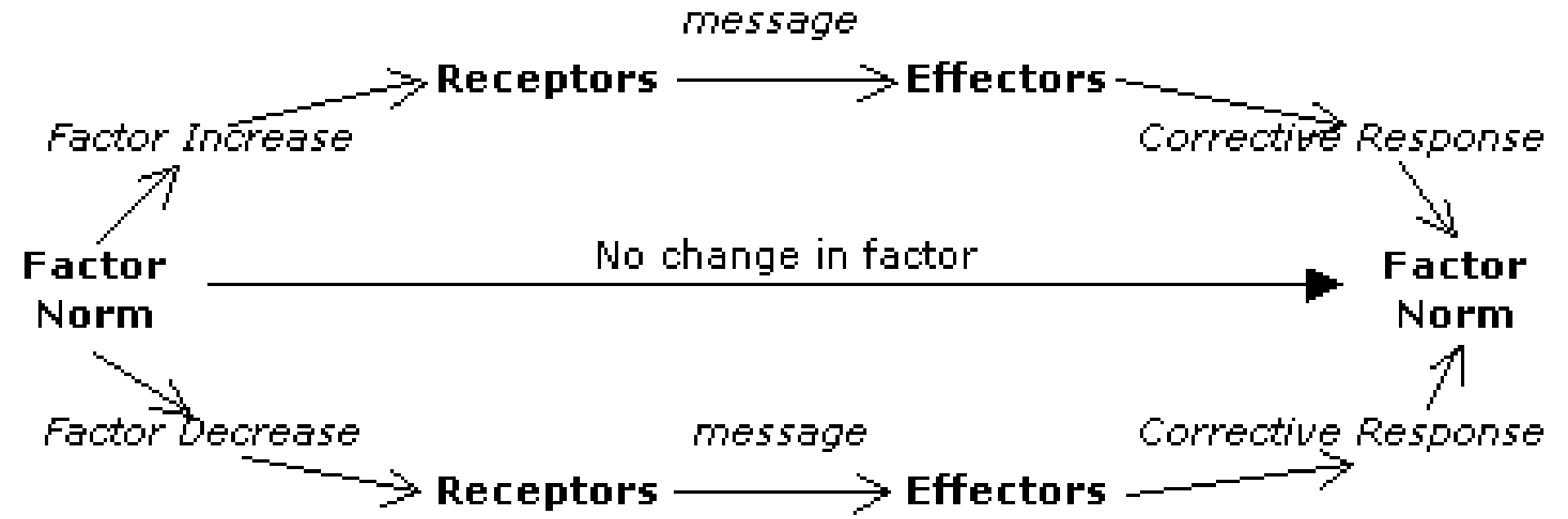


Negative Feedback Control

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.

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



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

Example 1 - 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:

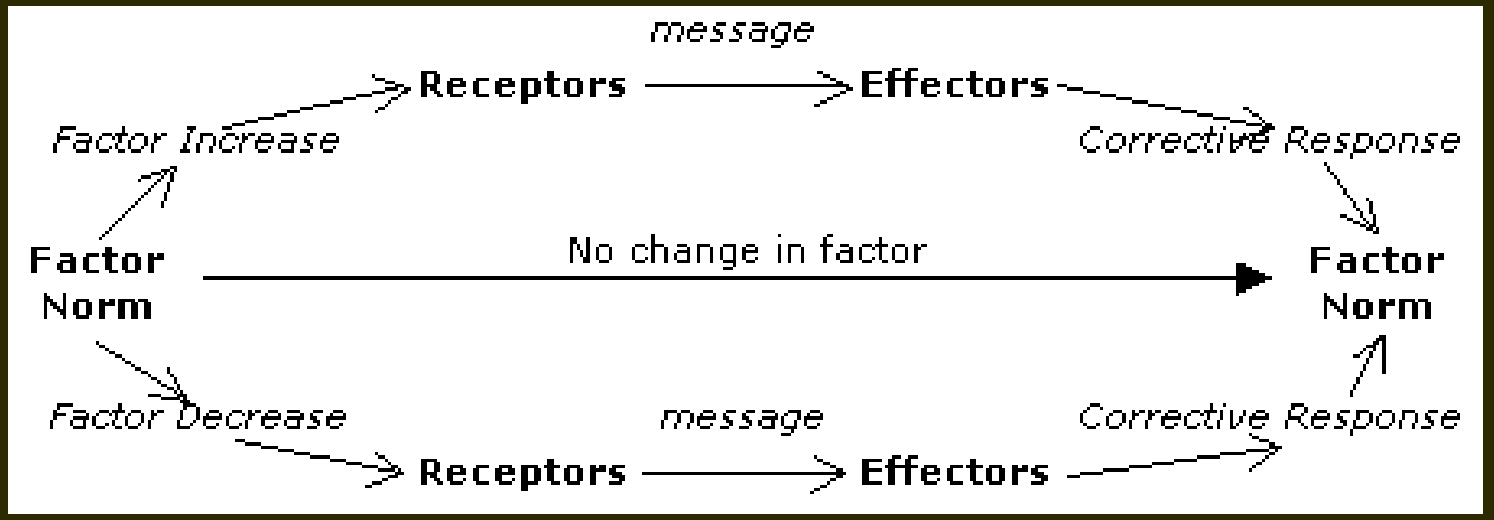
- when glucose levels increases to secrete less glucagon and more insulin
- When glucose levels decreases is to secrete less insulin and more glucagon by the pancreas

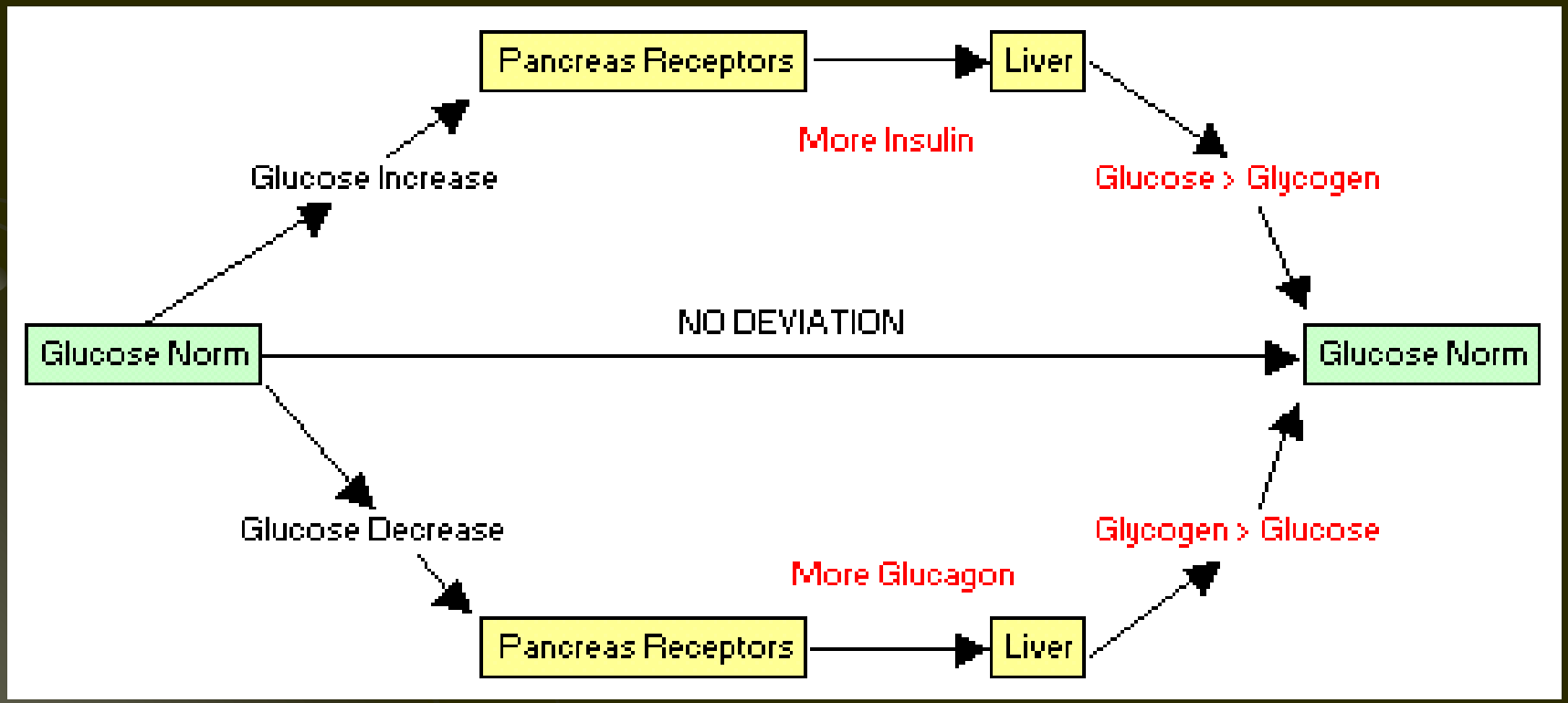
The negative feedback process is as follows:

The level of glucose in the bloodstream drops. (Factor decreases)

The person requires glucose in cells to meet the demand for ATP (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


message
Receptors
Effectors
Factor Increase
Corrective Response
Factor Norm
No change in factor
Factor Norm
Factor Decrease
message
Corrective Response
Receptors
Effectors


Pancreas Receptors
Liver
More Insulin
Glucose Increase
Glucose > Glycogen
NO DEVIATION
Glucose Norm
Glucose Norm
Glucose Decrease
Glycogen > Glucose
More Glucagon
Pancreas Receptors
Liver

Diabetes

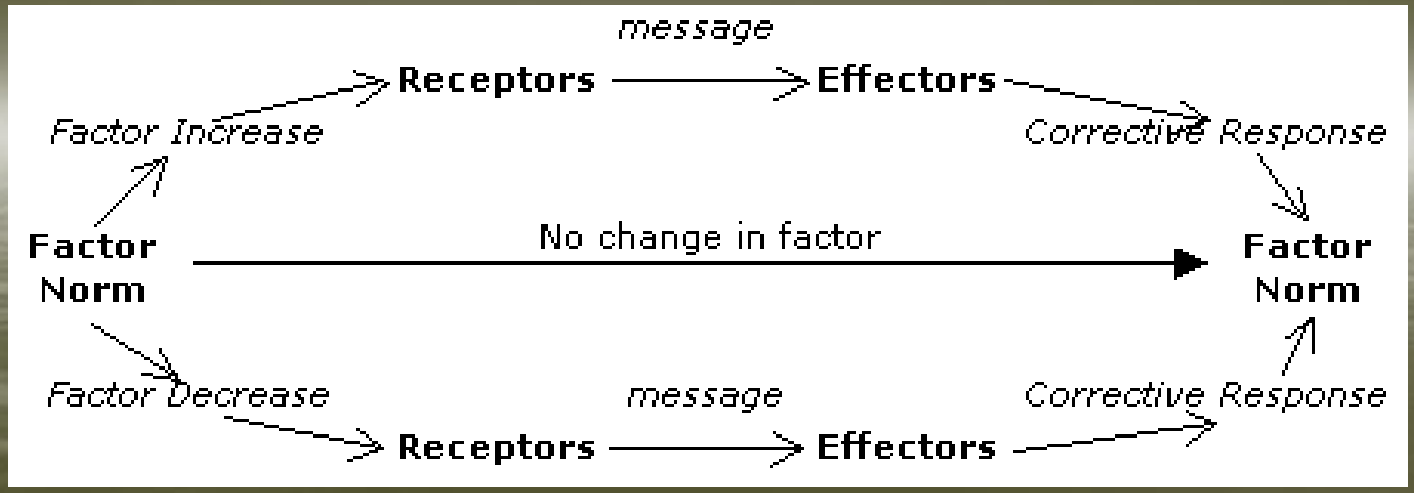
Diabetes is a where the sufferer does not have the ability to produce sufficient insulin, meaning that glucose cannot be converted into glycogen.

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.

Example 2 - negative feedback scenario of osmoregulation in fish

The homeostatic control of water is as follows: sider the following

- 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)


message
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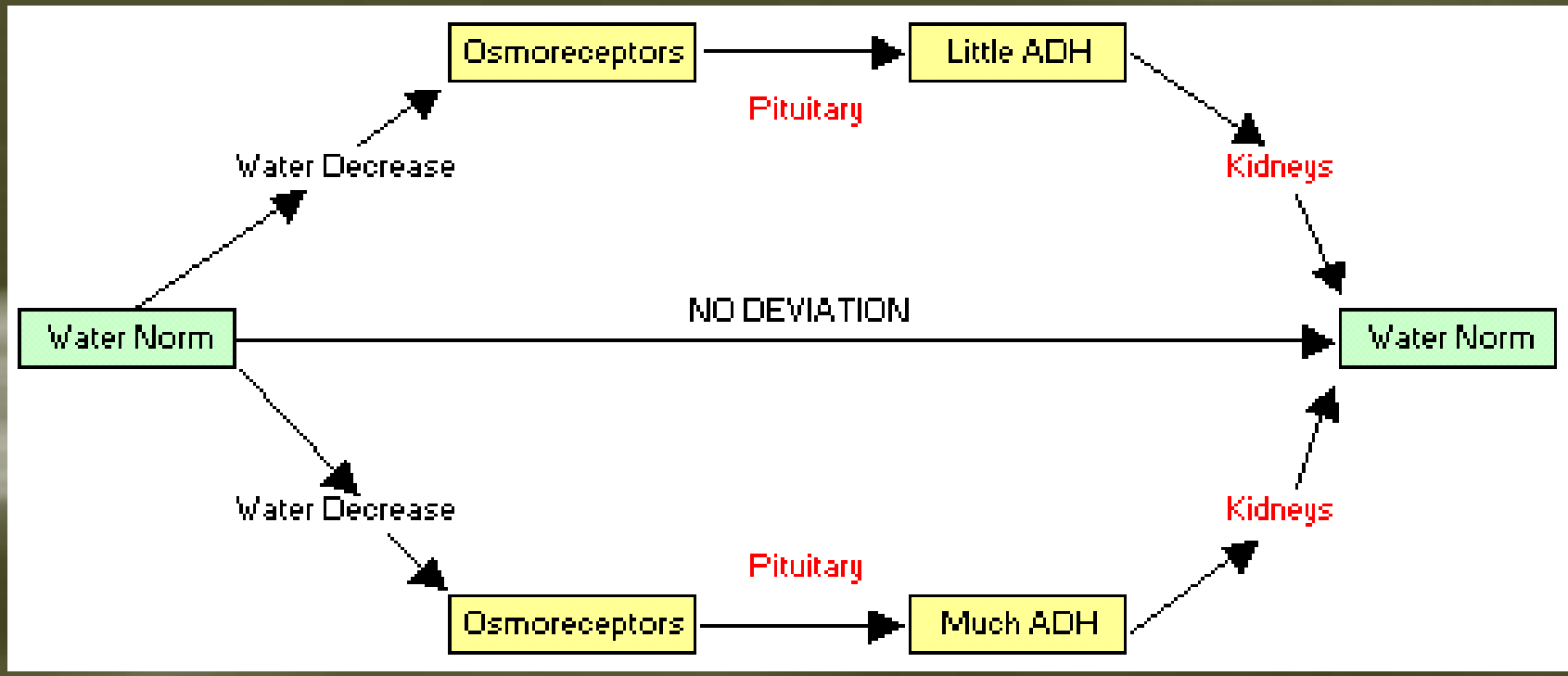
Osmoreceptors
Little ADH
Pituitary
Water Decrease
Kidneys
Water Norm
NO DEVIATION
Water Norm
Water Decrease
Kidneys
Pituitary
Osmoreceptors
Much ADH

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.

Other examples where negative feedback occurs

Fight or Flight

Adrenaline is released by the body to override the homeostatic control of glucose. This is done to promote the breakdown of glycogen into glucose to be used in the emergency. These emergencies are often known as 'fight or flight reactions'.

- Adrenaline is secreted by the adrenal glands. The secretion of it leads to increased metabolism, breathing and heart rate. Once the emergency is over, and adrenaline levels drop, the homeostatic controls are once again back in place

Temperature in Homeotherms

Animals capable of temperature regulation within a given range are deemed homeotherms (alternatively homiotherms or homotherms).

They have the ability to regulate temperature via negative feedback control.

Temperature is controlled in a variety of ways in these animals....

Corrective Mechanisms in Temperature Control

- The hypothalamus once again acts as a receptor in regulation, by detecting fluctuations in temperature. These receptors are better known as thermoreceptors (found in skin).

- Increased sweating is a corrective response aimed to reduce the temperature of the organism.

- A corrective response can occur where the hairs 'stand on end', and trap a layer of air between the hair and the skin. This insulation of warmer air next to the skin reduces heat lost, while a thin layer of insulation would increase heat loss.

Corrective Mechanisms in Temperature Control

- **Vasodilation** is a corrective response where the blood vessels close to the skin surface become more dilated, meaning there is a larger surface area for heat to be lost to the external environment from the blood vessel carrying over-heated blood.

- **Vasoconstriction** is the opposite of this and occurs when temperatures in an organism drop. The blood vessels become constricted so that minimal heat loss occurs.

- Other corrective mechanisms are involved, such as a drop in metabolic rate and shivering when temperatures drop.