Regulatory Mechanisms in Animals

Why are they doing?

Learning Intentions

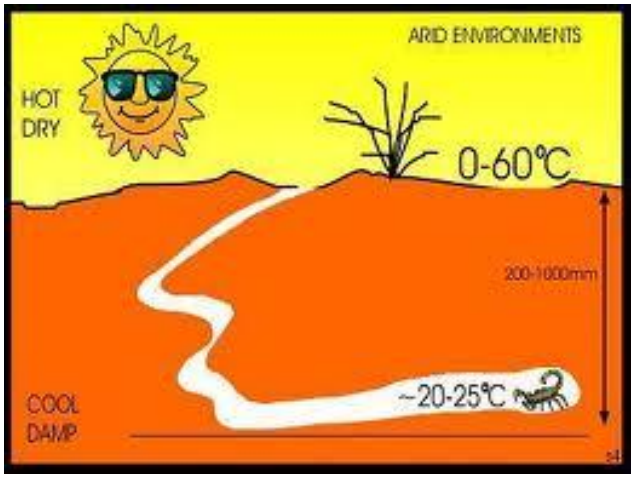
- Understand that animals respond to changes in their external and internal environment

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

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

Let’s recap what we have learnt…

Water balance



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.

Thermoregulation

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

Examples…….

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

What are some responses?

Temperature

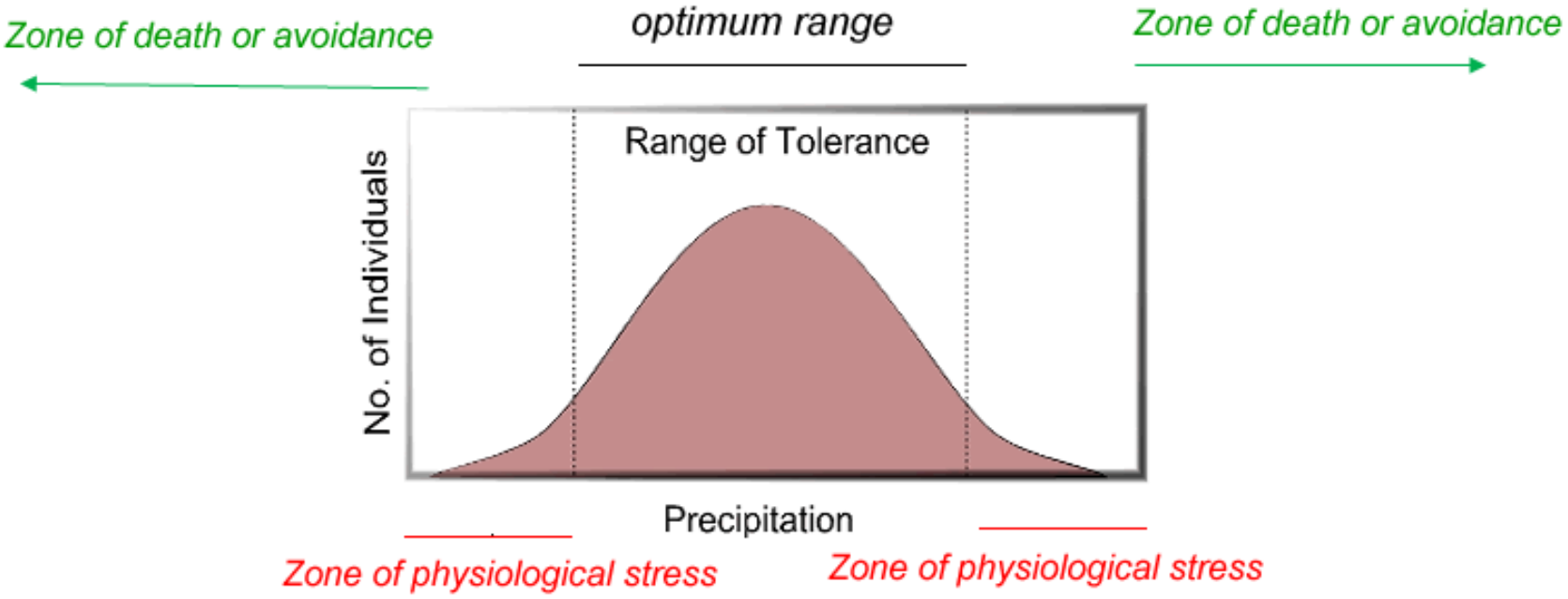
Water and solute

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 237, 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.

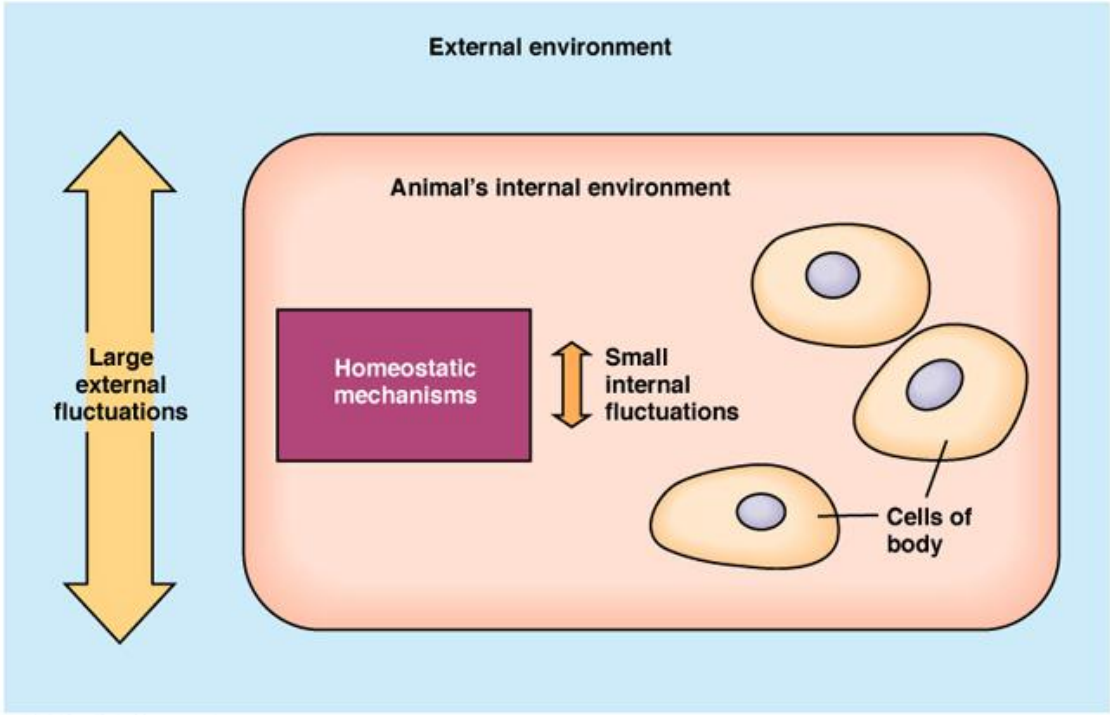
Now a new concept to learn….

Homeostasis

Homeostasis is the tendency of a system, the physiological system of higher animals, to maintain internal stability, owing to the coordinated response of its parts to any situation or stimulus tending to disturb its natural condition or function.

or more simply

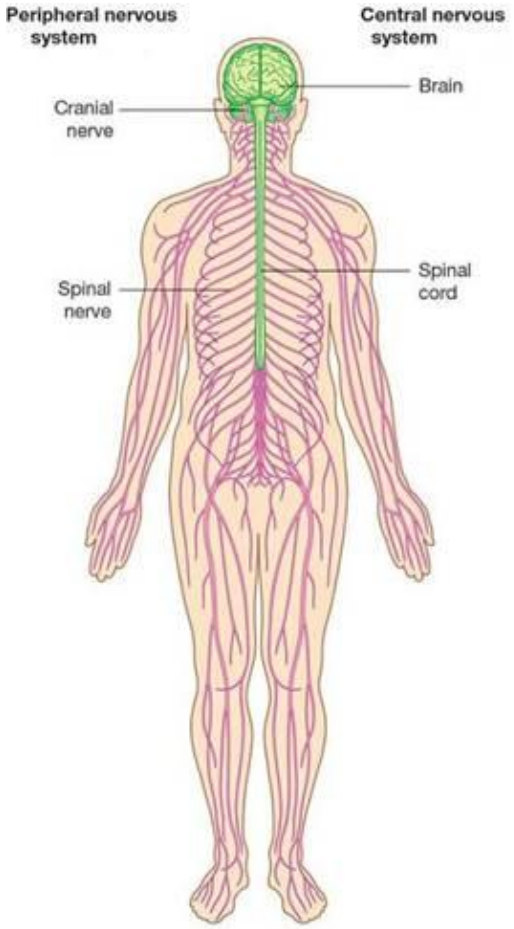
Homeostasis is the maintenance of a constant internal environment.. That is the tissue fluid around the cells needs to remain in a relatively constant state.



- https://www.youtube.com/watch?v=QKT47A-LBj4

Homeostasis is maintained by:

- The Endocrine System
- The nervous system

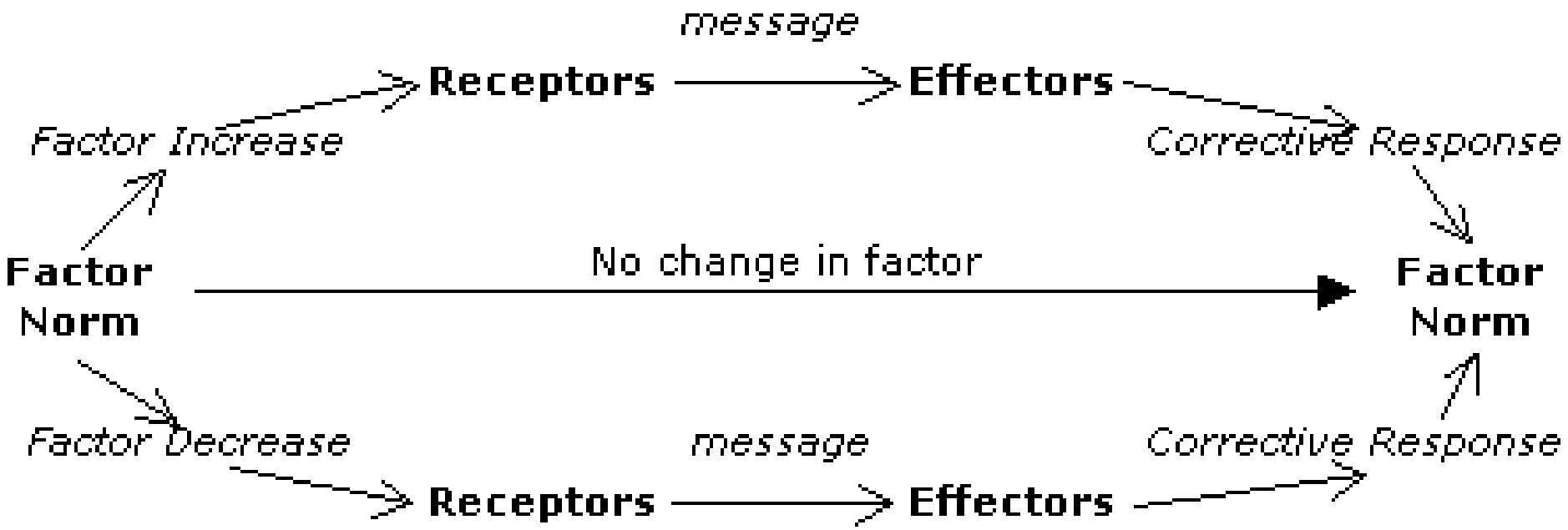


Negative Feedback Control

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.

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.*

Some examples…

What factors are under homeostatic control?

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

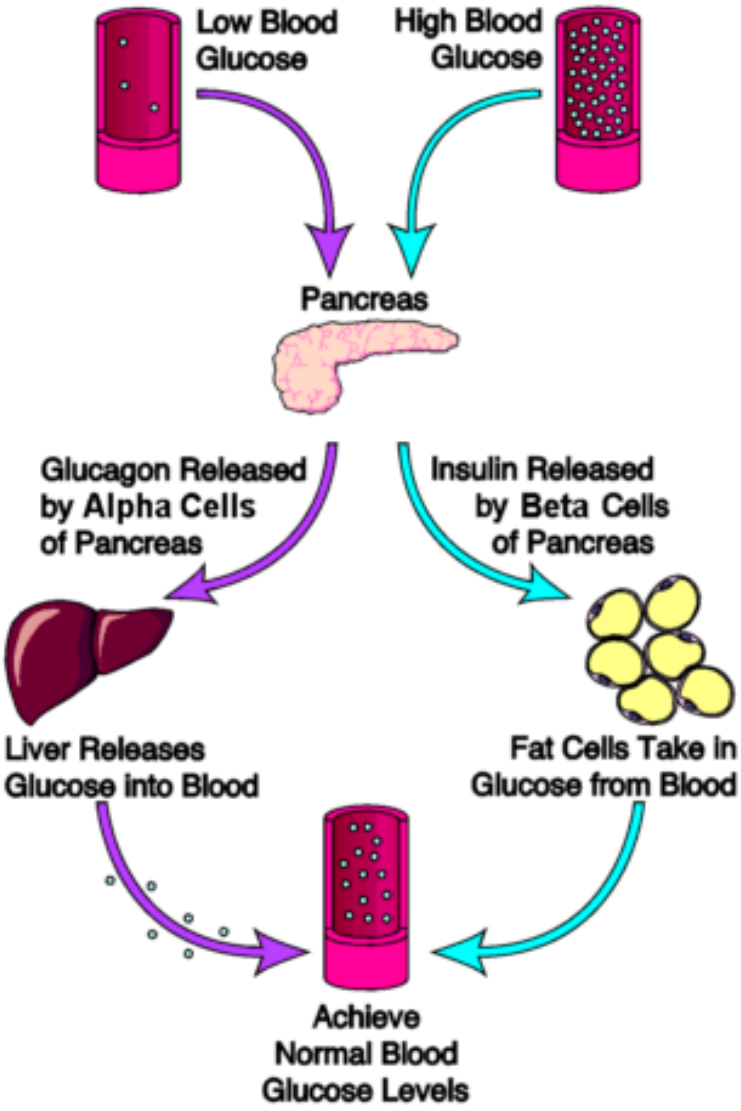
Example 1 - Blood Glucose Regulation

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.



Video on blood glucose

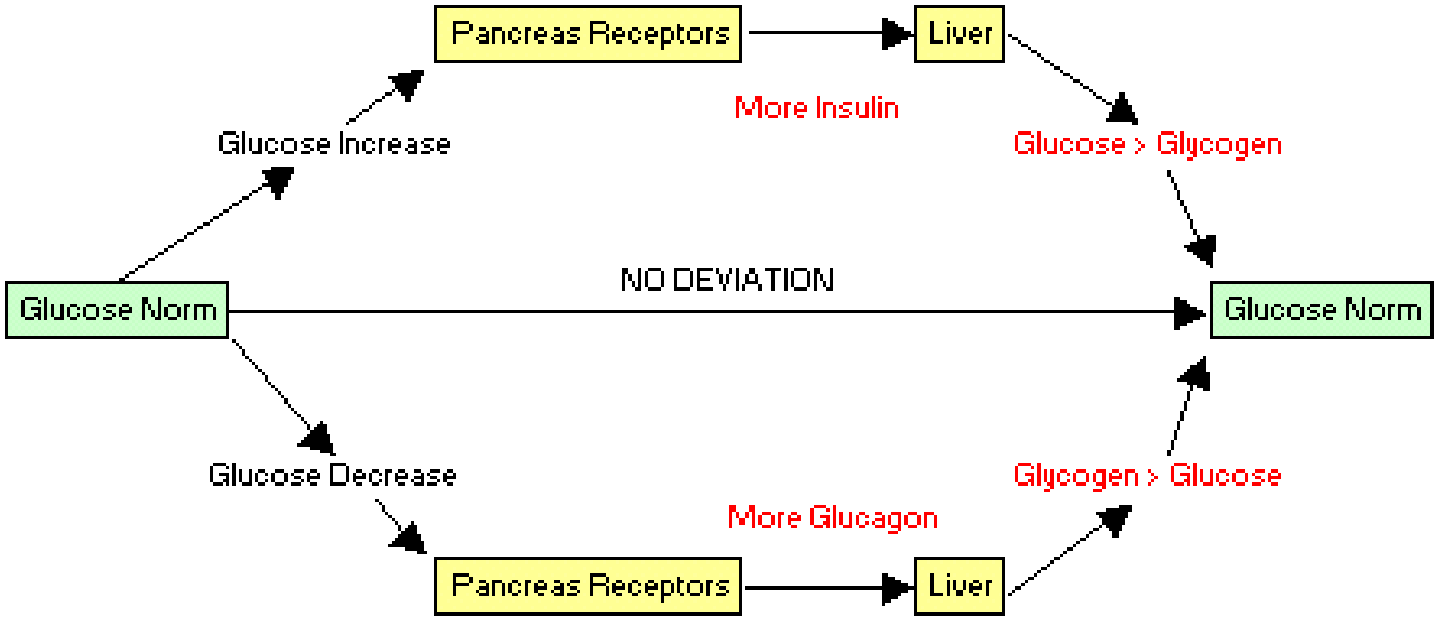
https://www.youtube.com/watch?v=XZxuQo3ylII

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



Diabetes

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

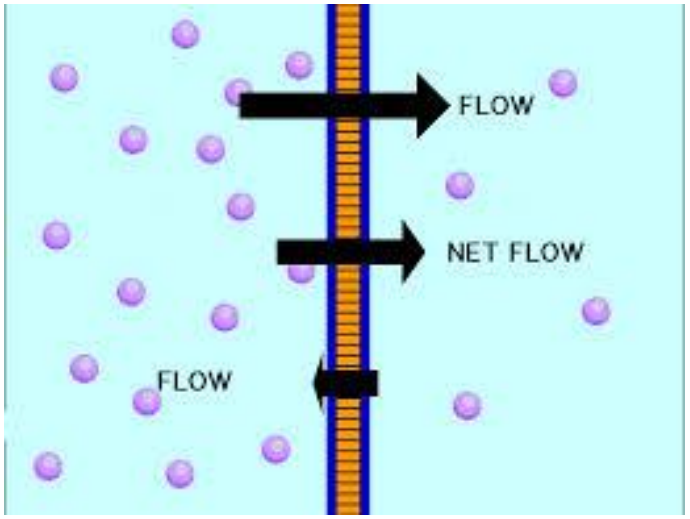
Anyone who has this condition usually has to take injections of insulin after meals and snacks to maintain their storage of glucose needed in emergencies.

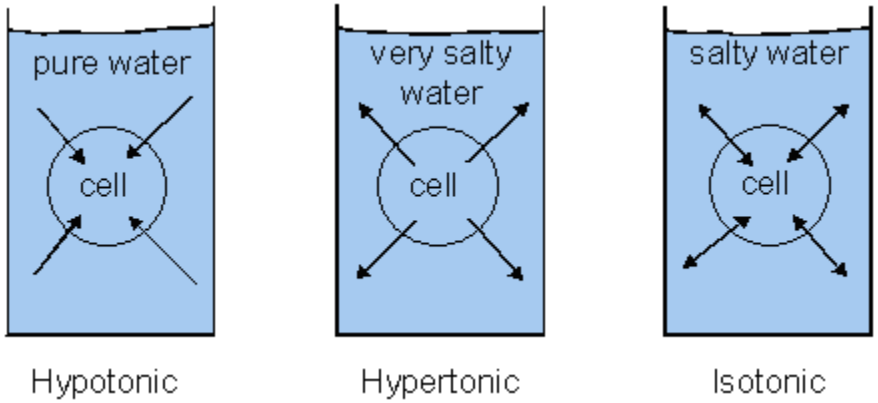
Example 2 - Blood Glucose Regulation

Example 2 - Osmoregulation in fish

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)





The homeostatic control of water is as follows:

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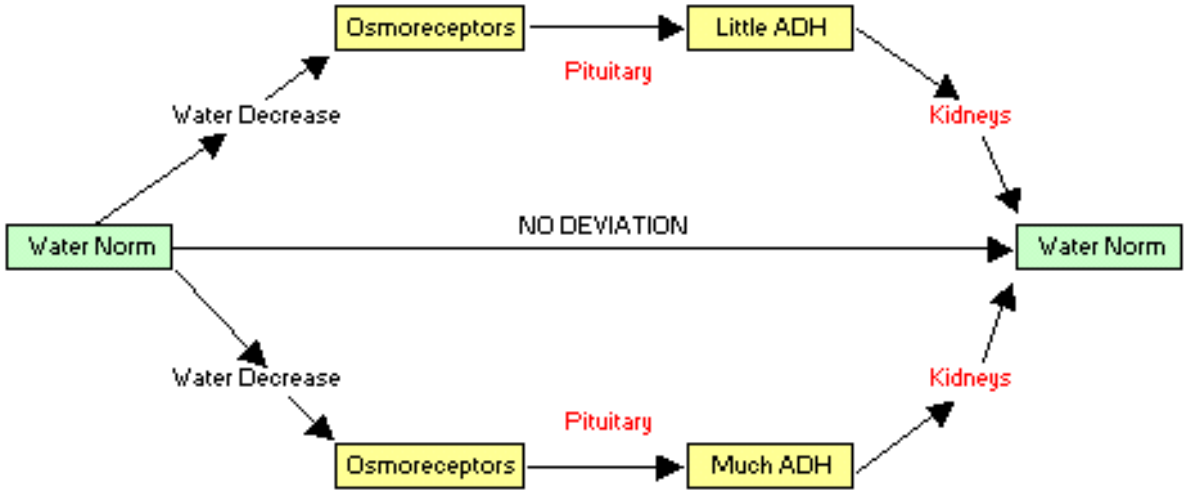
- When the hormone reaches its target tissue, it alters the tubules of the kidney to become more / less permeable to water (corrective response)
  - If more water is required in the blood stream, high concentrations of ADH make the tubules more permeable. (corrective response1)

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



Example 3 - Thermoregulation in animals

Temperature Control

https://www.youtube.com/watch?v=RgjKRJxvG-k&feature=youtu.be

Interesting fact:

Whales do not shiver.
They have an effective thermo regulatory system, which keeps their body temperature still; whether they are in warm, tropic waters or icy Arctic waters. Whales have a thick layer of blubber, (that can be up to 20 inches thick), this protects the whales from extreme temperatures.

Piloerection- not just a funny name

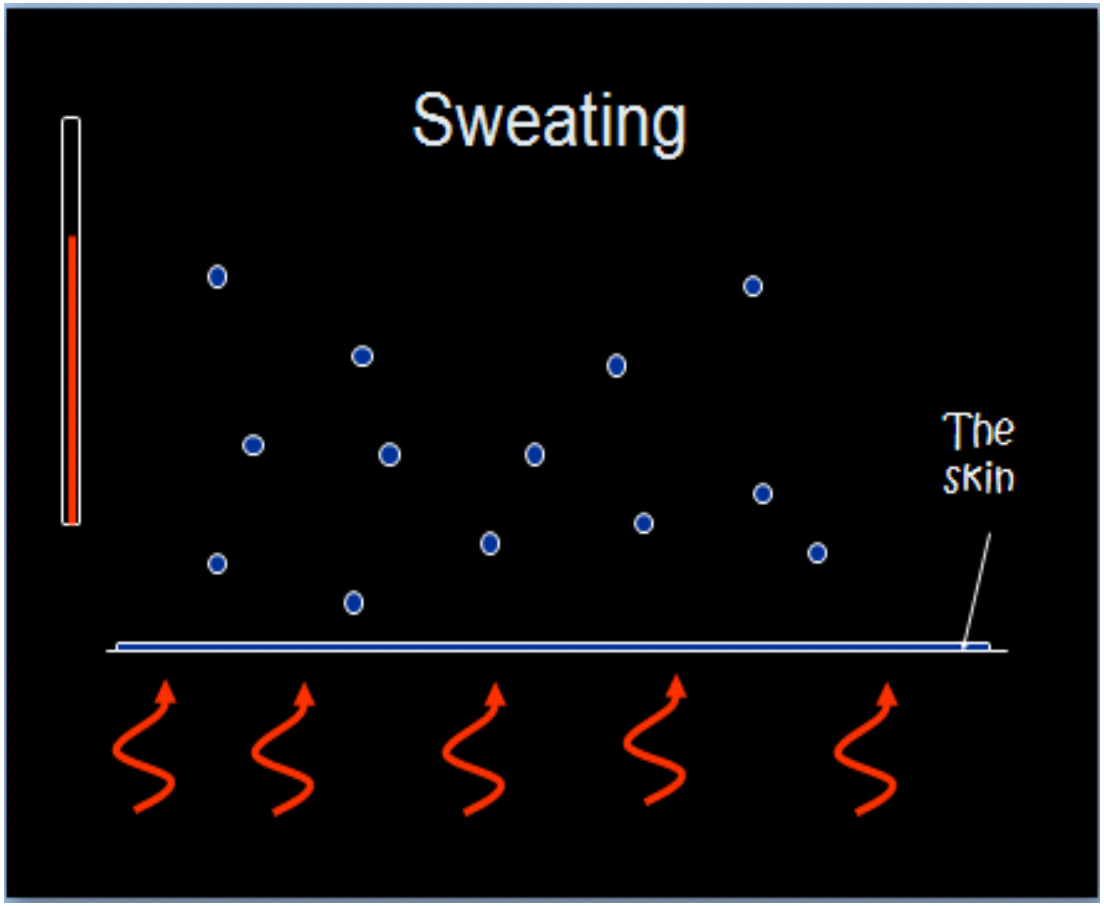
Erection of the hair of the skin.

E.g. Piloerection of the hair on the arm causes it to "stand on end."

It is begun when a stimulus (drop in temperature/a fright) causes a release from the (involuntary) nervous system which triggers tightening of muscles.

The contractions which are triggered, raise the hair follicles & trap an insulating layer of still, warm air next to the skin.

Sweating – a horrible stench or vital mechanism?



Sweating is a negative feedback response when our core temperature rises over 37˚C

• The hypothalamus senses that the body is too hot via neuron impulse.

• Sweat glands underneath your skin activate releasing

The negative feedback system and temperature regulation

Temperature in mammals is detected by **thermoreceptors** in the skin and **hypothalymus** which is in the brain. Changes in temperature bring about nerve impulses from the brain to the muscles and glands which will bring about changes depending on whether it is hot or cold.

Control center
— where the messages are received from the receptors about change in the body's temperature then sending messages to effectors to change their function to correct the recognized change

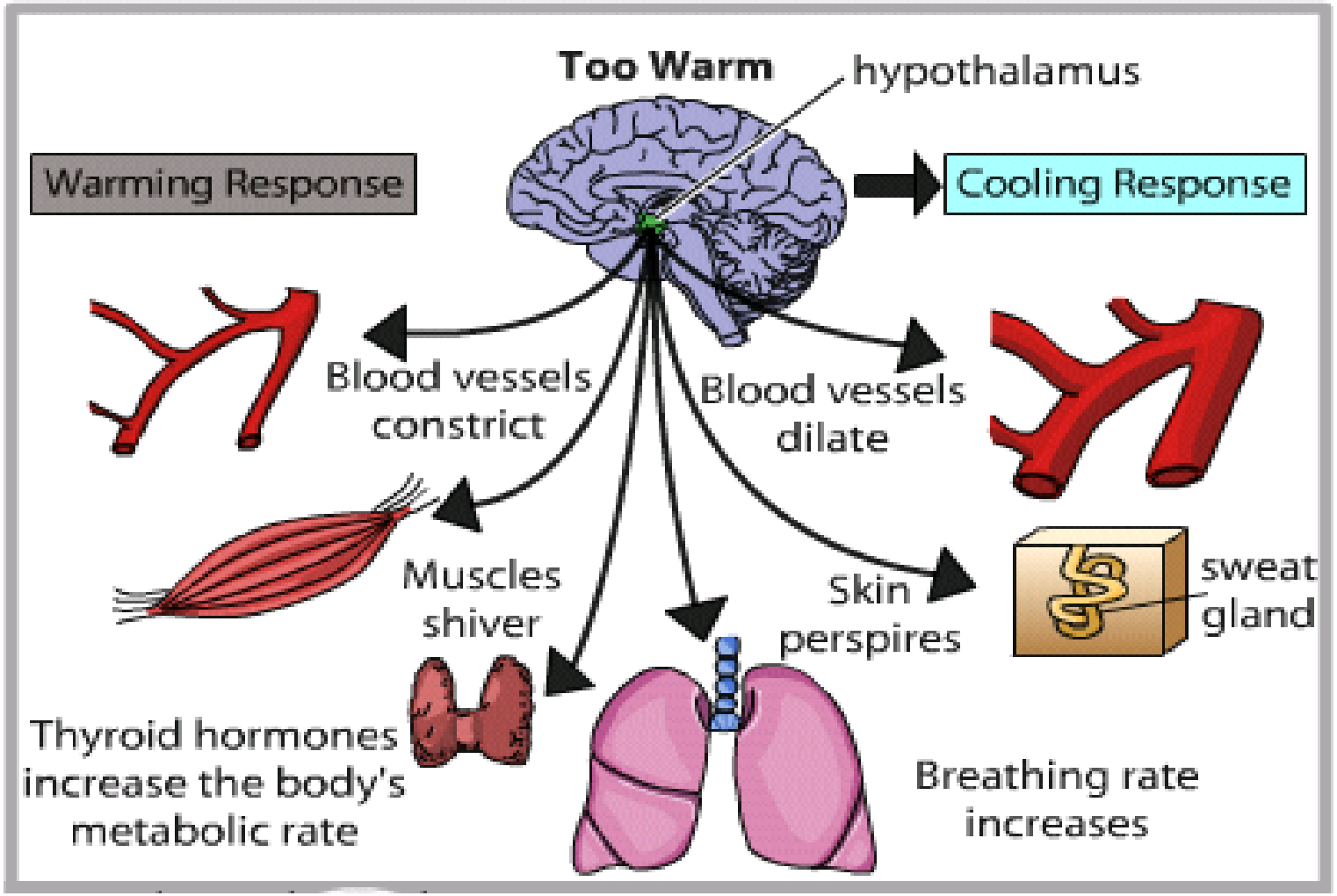
Effector
— the muscle or organ that receives messages from the control center to change its function in order to correct the change of the body's internal conditions.

Hormone
— chemical the body produces to alter function or messages being sent

Receptor
— A structure that monitors the body's internal functions and conditions; detects changes in the body's internal environment, in this case is temperature.

Set point
— The range of normal functional values of an organ or structure which for a human body would be set at 37 degrees.

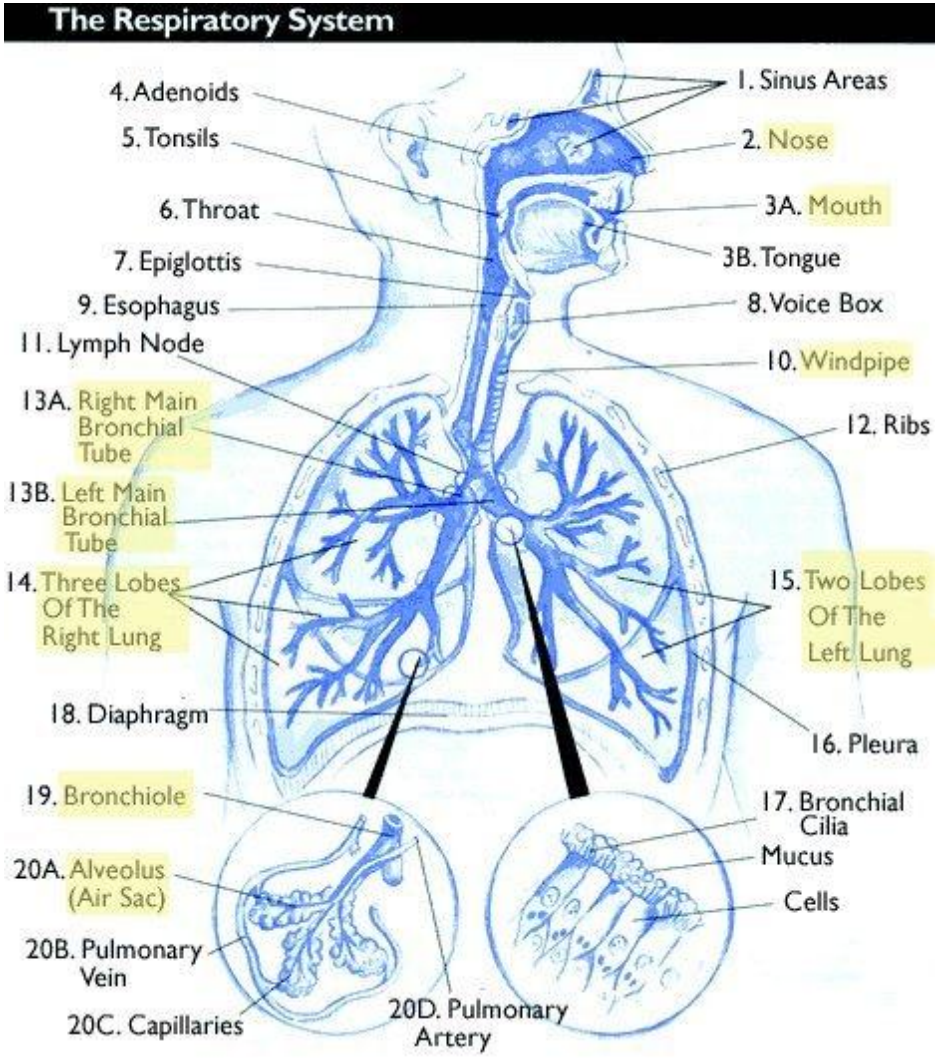
Negative Feedback Response

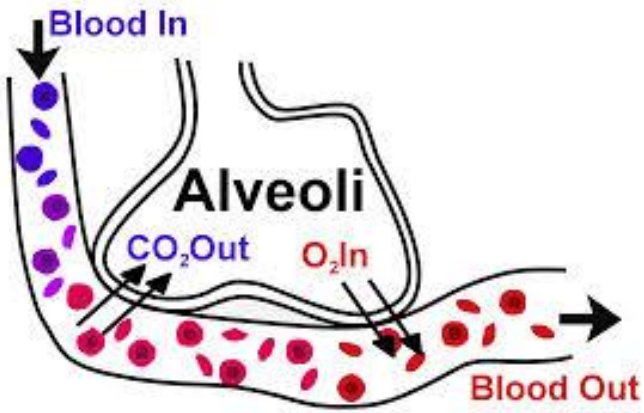


Your turn to try and create a diagram and explanation.

Other examples that are regulated by negative feedback responses.

Oxygen and carbon dioxide concentration in blood





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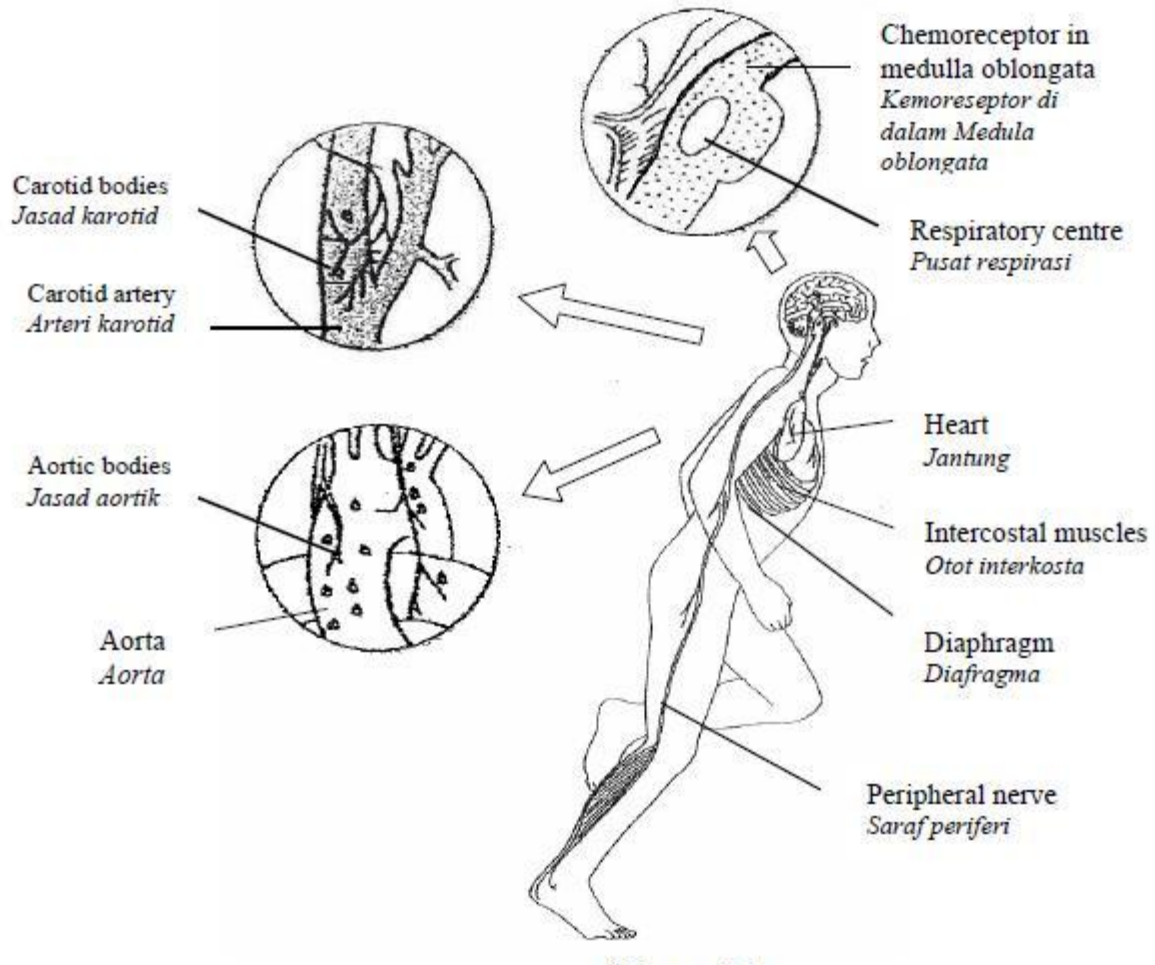
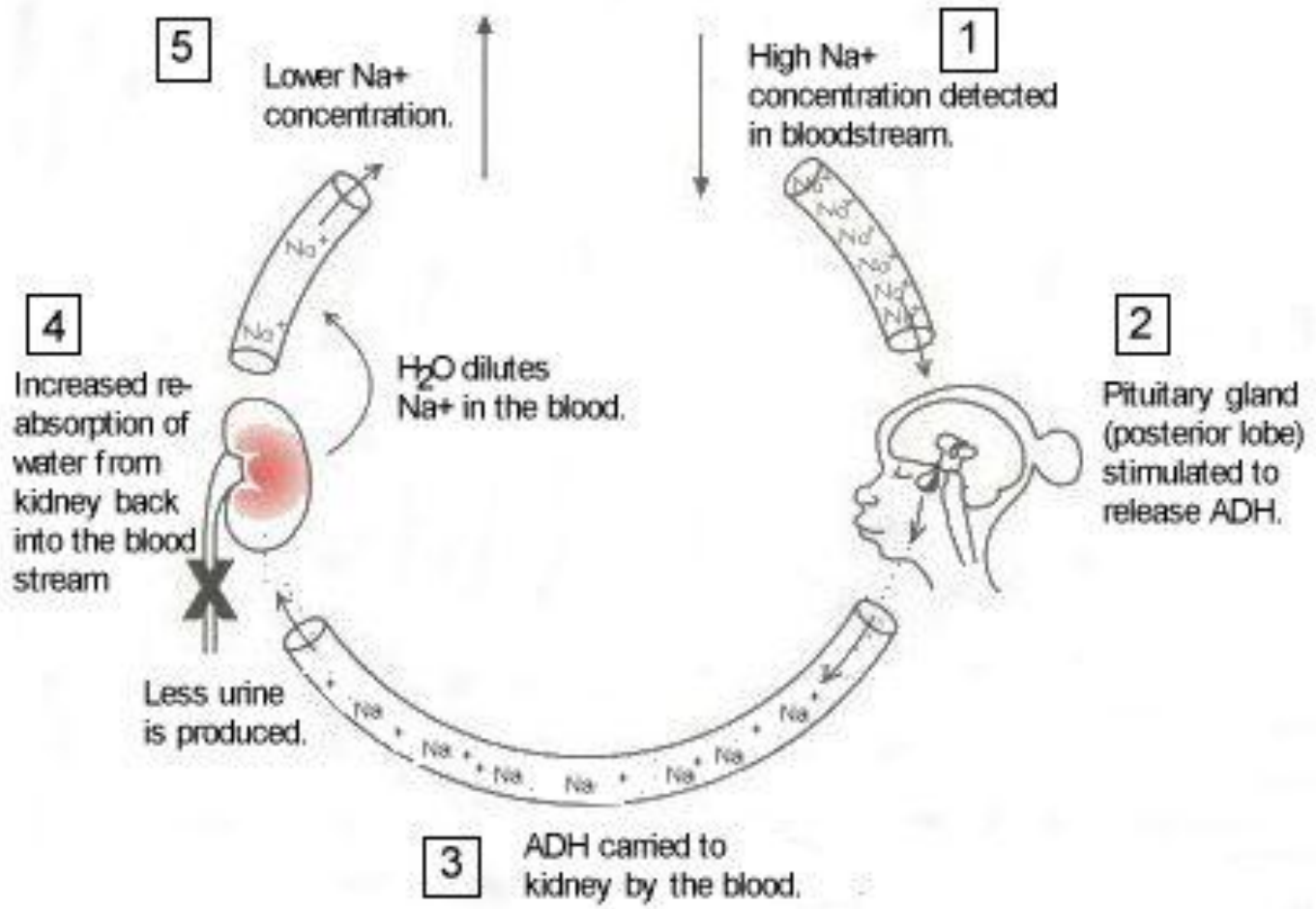


Diagram 6.1
Rajah 6.1

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



Homeostasis

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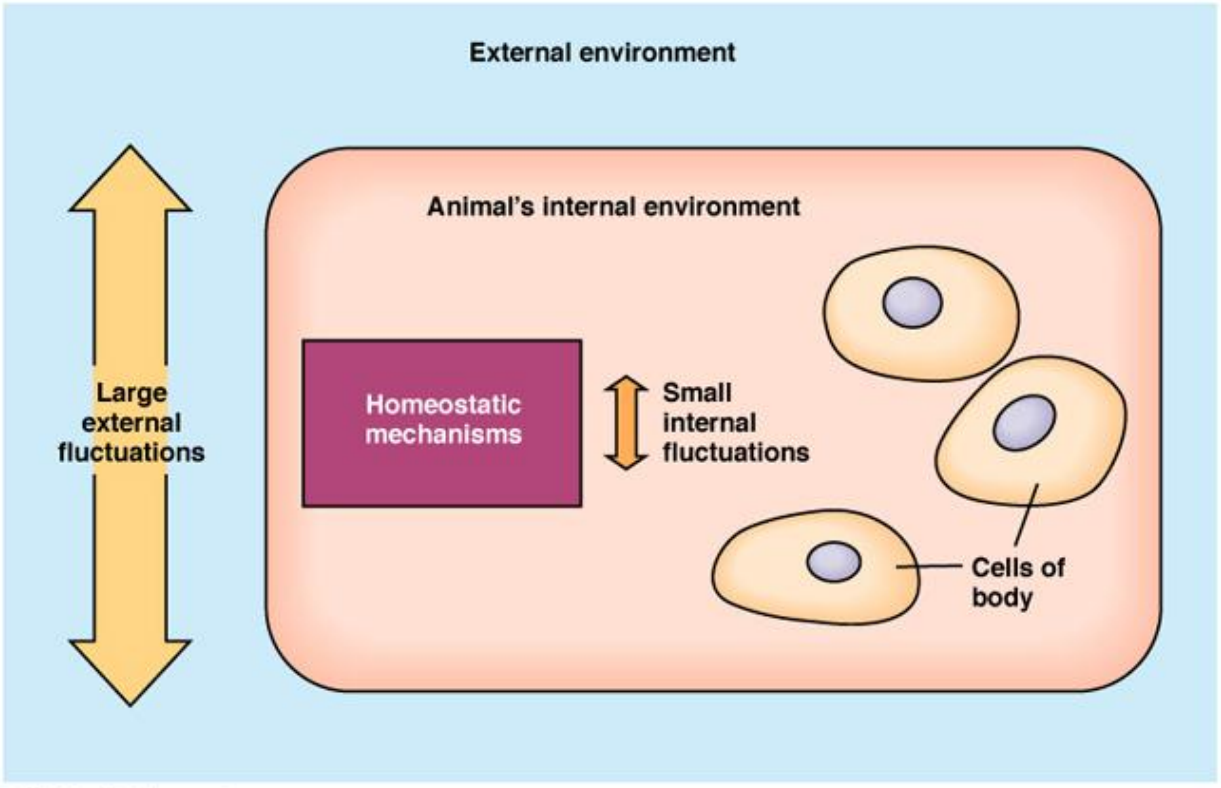

Advantages of Homeostasis

- 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.