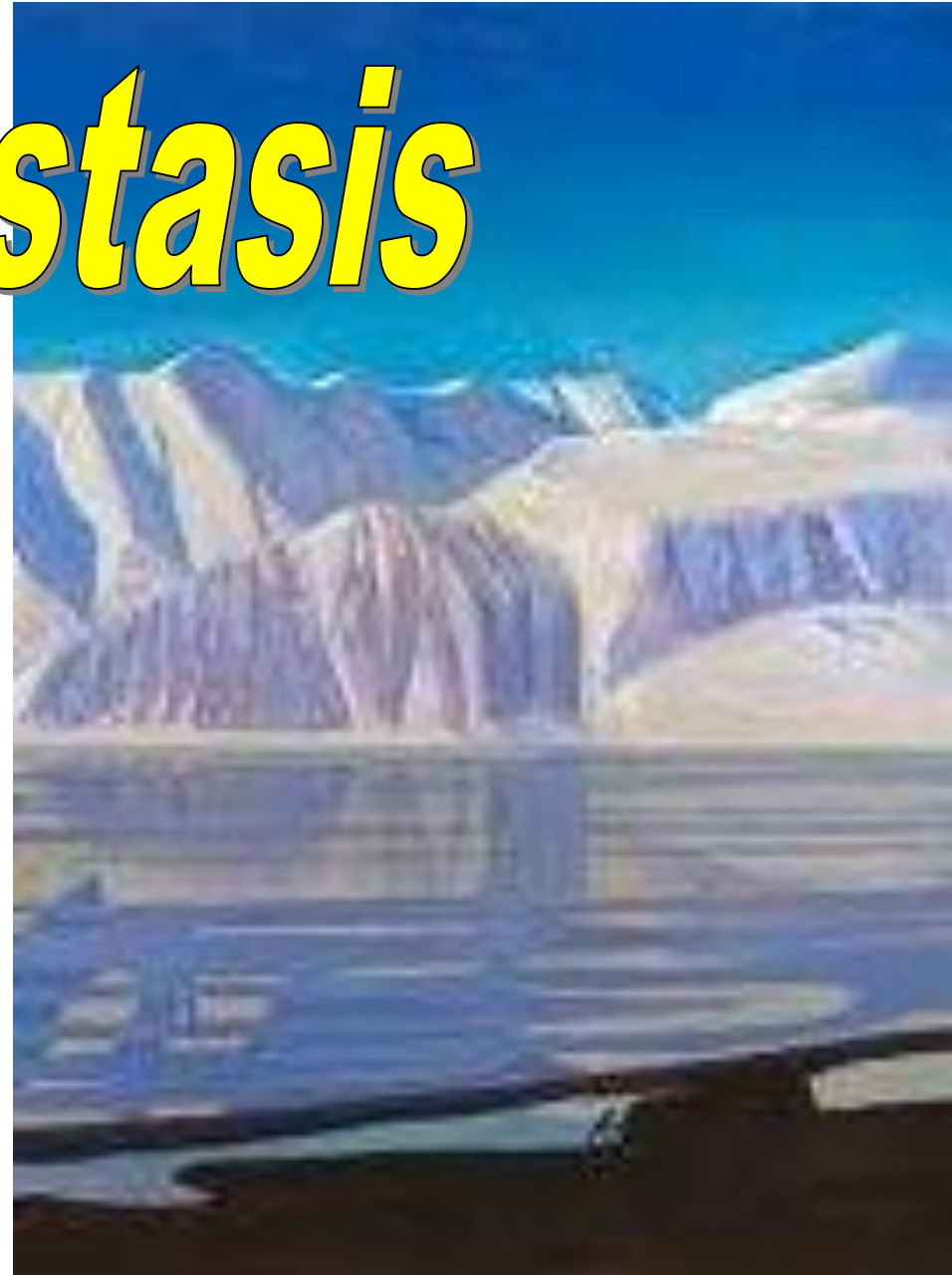


Homeostasis



The term 'homeostasis' is derived from two Greek words; *Homeo* which means 'unchanging' and *Stasis* which means 'standing'

In its simplest form it means 'staying the same'

It is an organism's internal environment which 'stays the same'

The 'internal environment' refers to the conditions inside an organism. These conditions remain more or less constant despite changes such as pH or temperature in the outside environment

In practice, it comes down to providing a stable environment for the cells of the body

Characteristics of Control Systems

There are some key features which are common to all control systems

1. Communication: In the body the main communication pathways are the nervous system and the endocrine system (hormones). Some hormones are released locally rather than into the blood and they act locally, which is known as paracrine control. A variety of agents can be released by cells which can have an effect on the releasing cell, and this is known as autocrine control. The peripheral nervous system can be divided into the afferent branch (signal direction towards the brain; sensory input) and the efferent branch (signal direction away from the brain; motor output).

2. Control centre: Two important control centers in the brain are the hypothalamus and the medulla oblongata in the brain stem. The hypothalamus is involved in the control of the endocrine system and the medulla are involved in the control of ventilation and the cardiovascular system.

3. Receptor: In the body sensors are usually specialized nerve endings, such as chemoreceptor, thermoreceptors. Sensors communicate input to the control centre via afferent nerves.

4. Effector: For example, in the body effectors could be sweat glands which are activated to produce more sweat which causes heat loss via evaporation.

Feedback:

Feedback is also an important feature of control systems. In negative feedback the output inhibits the function of the control centre and the effector acts to oppose the stimulus. An example of negative feedback in the body would be hyperglycaemia stimulating the release of insulin from beta cells in the Islets of Langerhans in the pancreas, which acts to decrease the level of glucose in the blood, thus returning the glucose level to the normal range. In positive feedback the stimulus produces a response which increases its effect, rather than counteracts it.

Fortunately there are not many examples of positive feedback in the body.

One example is blood clotting, which involves a complex signaling cascade incorporating positive feedback resulting in a change of state in blood from liquid to solid.

Another example is ovulation in which a build up of the hormone follicle stimulating hormone (FSH) causes release of an oocyte from a follicle in the ovary.

Homeostasis:

The living processes in the cells depend on the activity of **enzymes**.

These enzymes work best in specific conditions such as those of temperature and pH. Any change in these conditions affects the function of the enzymes and may lead to the death of the cells or, ultimately, the whole organism

This is why the internal environment needs to be regulated and kept constant.

In fact, the internal conditions are not absolutely constant, but allowed to vary within very narrow limits. Human body temperature, for example, varies between 36.1 – 37.8 °C. The average temperature is usually expressed as 36.8° C

So, a better definition of 'homeostasis' is **the maintenance of the internal environment within narrow limits**

The skin, kidneys, liver, endocrine system, nervous system and sensory system all play a part in maintaining the internal environment within narrow limits

The skin is a homeostatic organ which helps maintain the body temperature within the limits given in the previous slide

The external temperature varies during the day and from season to season, sometimes by as much as 40°C, (See slide 1) but the human body temperature stays at about 37°C

This is achieved by sweating, vasodilation, vasoconstriction, and shivering

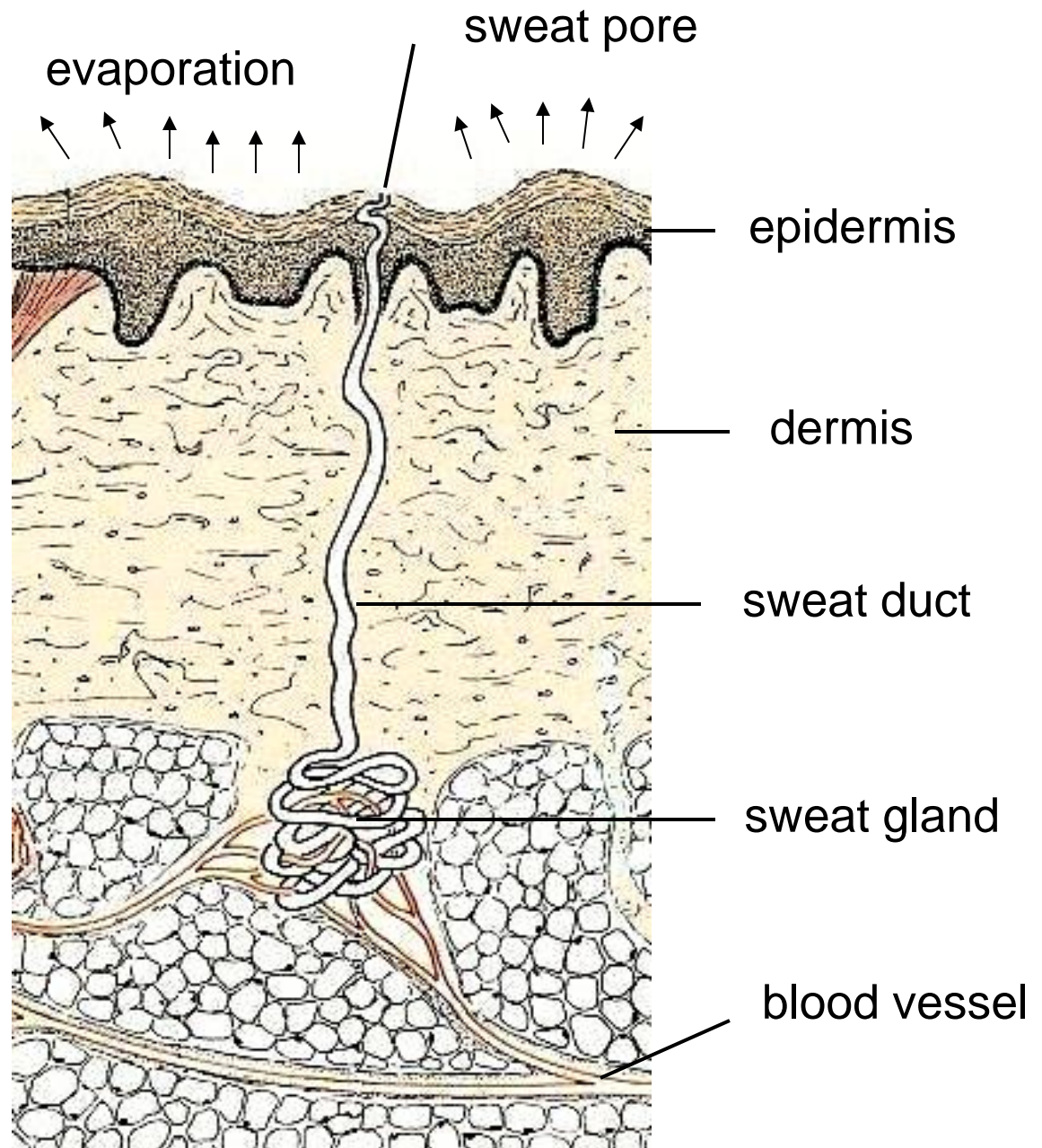
If the body temperature rises, the sweat glands in the skin are activated and secrete sweat on to the surface of the skin

When the sweat evaporates, it takes heat from the body and cools it down

Section through skin

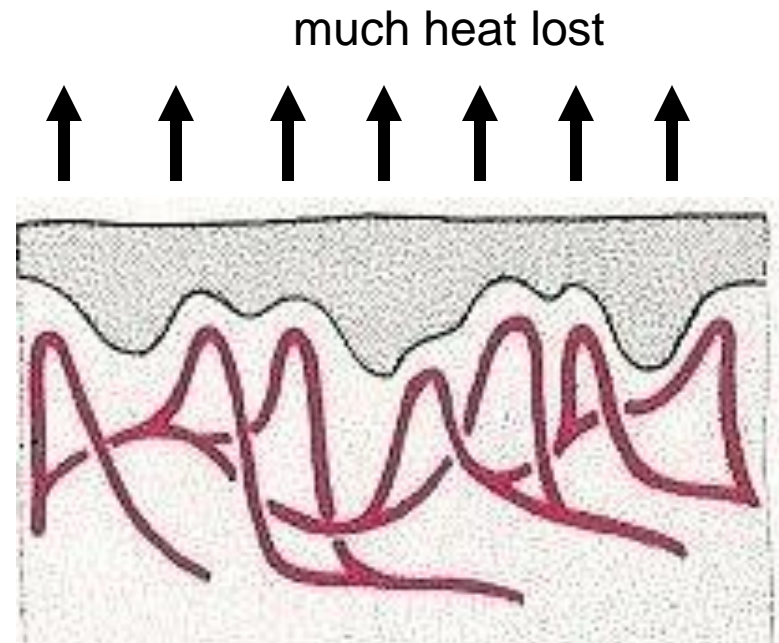
The sweat gland extracts sweat from the blood and passes it up the duct to the skin surface where it evaporates

0.25 mm



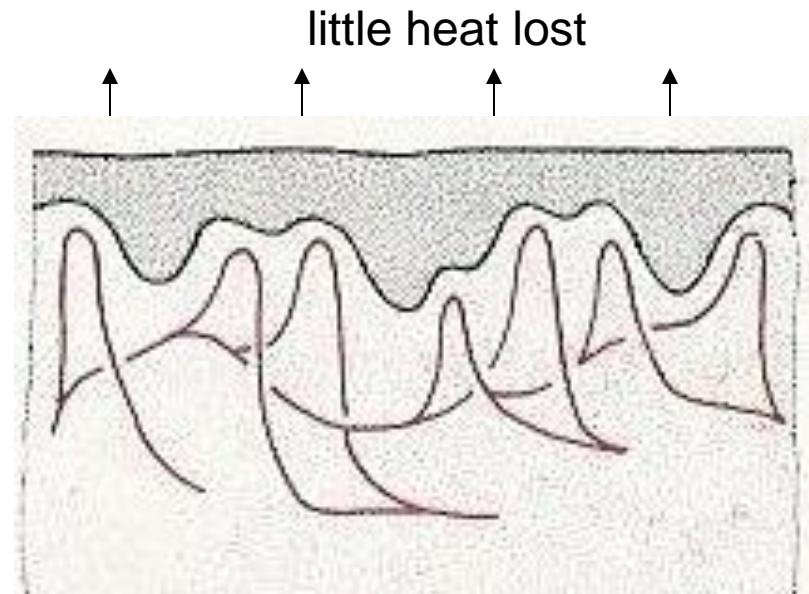
Vasodilation

If the body temperature rises, the blood vessels in the skin dilate (become wider) and allow more blood to flow near the surface. The heat loss from the blood through the skin helps cool the circulating blood



Vasoconstriction

If the body temperature falls. The blood vessels in the skin constrict. Less warm blood flows near the surface so less heat is lost

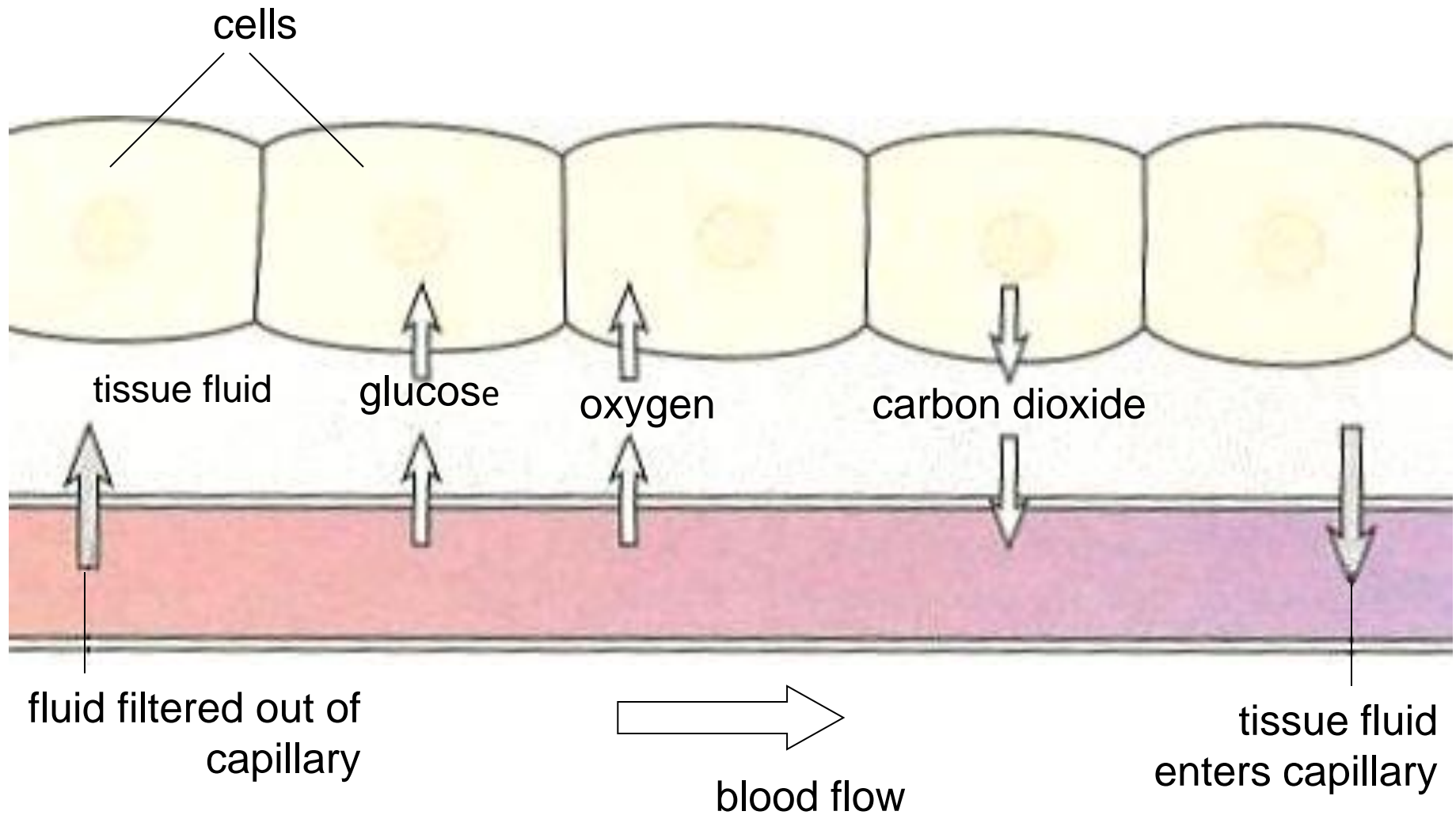


To carry out its living processes, every cell in the body needs a supply of oxygen and food. Waste products such as carbon dioxide have to be removed before they reach harmful levels and damage the cell

These conditions are maintained by tissue fluid bathing the cells. Tissue fluid is derived from the blood

The tissue fluid contains oxygen and food which the cells can absorb, and also accepts the carbon dioxide and other waste products produced by the cells

The blood system maintains the composition of the tissue fluid



In the cells, the chemical breakdown of proteins produces the nitrogenous compound, urea. If this were allowed to accumulate in the cells it would damage or kill them.

The concentration of the blood and tissue fluids tends to vary. If water is lost through evaporation and sweating, the fluids become more concentrated. The intake of water dilutes the fluids

It is important that the concentration of blood and tissue fluid is kept within narrow limits if the cells are to function properly

These homeostatic functions are carried out by the kidneys

Microscopic slice of kidney tissue

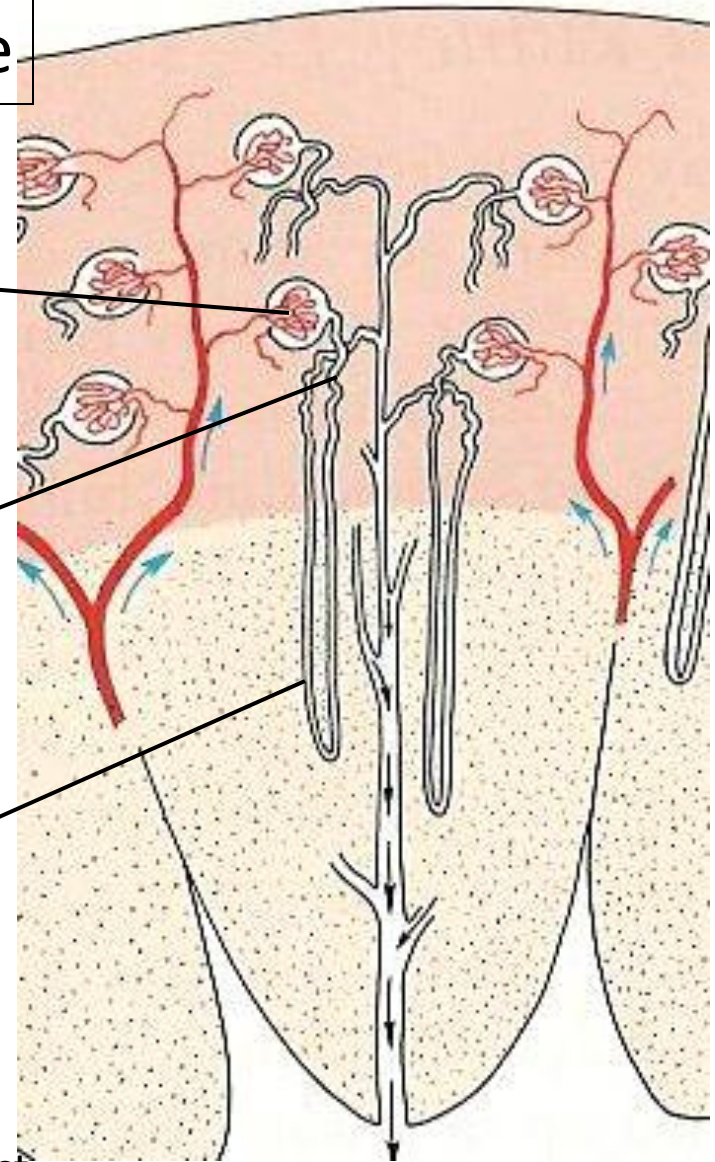
Blood pressure forces tissue fluid out of a clump of narrow capillaries

The fluid contains urea, salts, glucose and other soluble substances

The fluid trickles down this tubule and the useful substances such as glucose are reabsorbed into the blood

In this tubule more or less water is reabsorbed to maintain the blood concentration

Excess water, some salts and urea collect here before passing to the bladder as urine



The glucose concentration in the blood is controlled by the pancreas

The pancreas contains cells which produce digestive enzymes but it also contains cells (alpha and beta cells) which produce the hormones **insulin** and **glucagon**

If the glucose concentration rises, the beta cells release insulin

If the glucose concentration falls, the alpha cells release glucagon

Insulin stimulates the liver and muscles to remove excess glucose from the blood and store it as glycogen

Glucagon stimulates the liver to convert its stored glycogen into glucose which is then released into the bloodstream

In this way, the concentration of glucose in the blood is kept within narrow limits

One important method of achieving homeostasis is **negative feedback**

It applies to many systems in the body. Temperature regulation is one example

If the blood temperature rises, a 'heat gain' centre in the brain sends nerve impulses to the skin, which causes vasodilation and sweating, which cool the blood (Slide 5)

If the blood temperature falls, it stimulates a 'heat loss' centre in the brain which sends impulse to the skin causing vasoconstriction and the cessation of sweating. These changes reduce heat loss from the skin

The warmer or cooler blood provides negative feedback to the thermoregulatory centre in the brain

Another example of negative feedback is the control of the hormone oestrogen

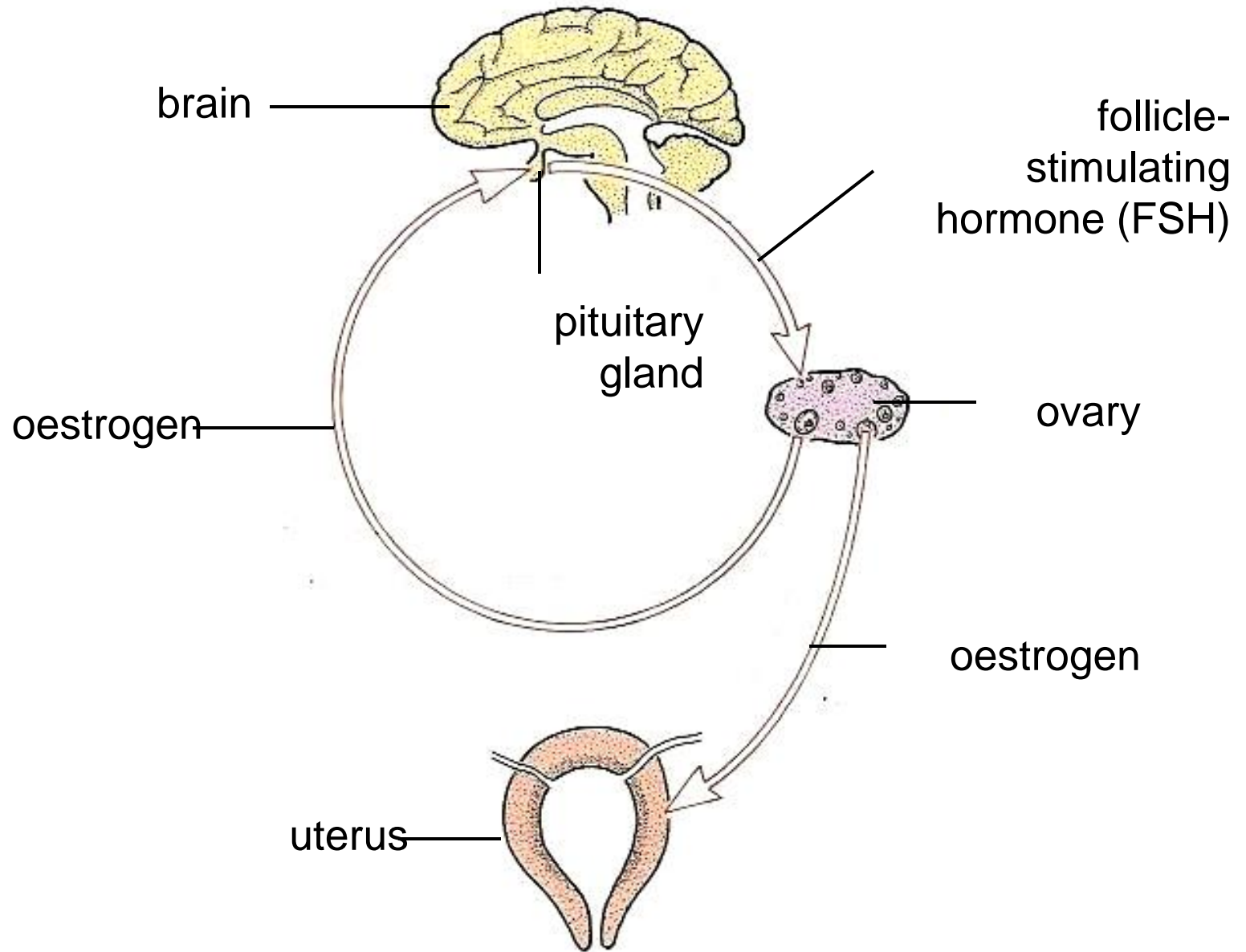
The pituitary body produces follicle-stimulating hormone (FSH) which promotes the development of the ovarian follicles and causes the ovaries to produce oestrogen

Oestrogen also acts on the uterus and causes its lining to thicken

When the oestrogen reaches a certain level in the blood, it acts on the pituitary and stops the production of more FSH

In this case, oestrogen is exerting a **negative feedback** on the pituitary

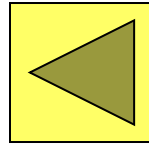
If the oestrogen level in the blood falls, the pituitary begins to secrete FSH again



Biological Rhythms:

Rather than the set point being a fixed, steady value it can vary over time, giving rise to biological rhythms. For example the levels of the hormone cortisol in the blood varies during the day from a peak at about 7.00 am to a trough at about 7 pm. The menstrual cycle is an obvious example of a biological rhythm and women's body temperature varies during the cycle. A sudden increase in body temperature can be used as a marker of ovulation.

Back to start



End show

