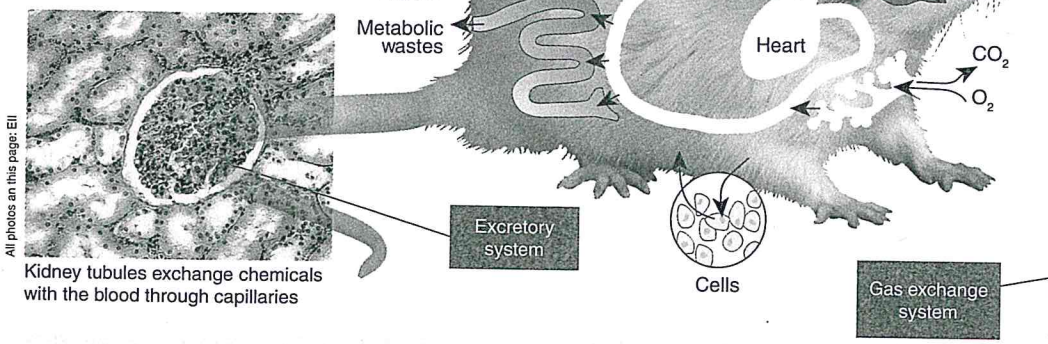
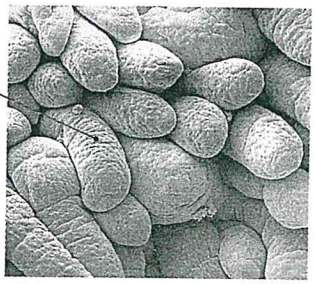
Principles of Homeostasis

Homeostasis the relative physiological constancy of the body, despite external fluctuations. Homeostasis of the internal environment is an essential feature of complex animals and it is the job of the body's **organ systems** to maintain it, even as they make necessary exchanges with the environment. Homeostatic control systems have three functional components: a receptor to detect change, a control centre, and an effector to direct an appropriate response. In **negative feedback** systems, movement away from a steady state triggers a mechanism to counteract further change in that direction. Using negative feedback systems, the body counteracts disturbances and restores the steady state. **Positive feedback** is also used in physiological systems, but to a lesser extent since positive feedback leads to the response escalating in the same direction.

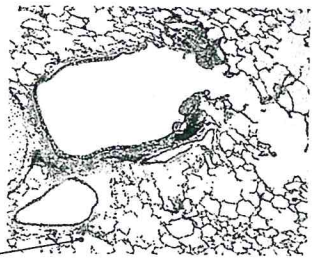
Organ systems maintain a constant internal environment that provides for the needs of all the body's cells, making it possible for animals to move through different and often highly variable external environments. This representation shows how organ systems permit exchanges with the environment. The exchange surfaces are usually internal, but may be connected to the environment via openings on the body surface.

Exchanges with the Environment



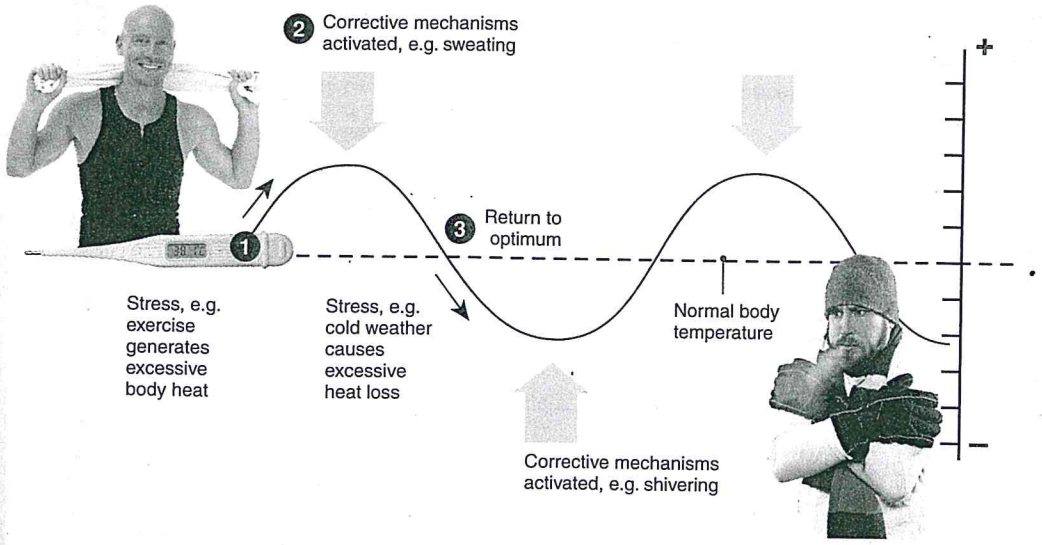

The villi of the small intestine increase surface area for nutrient absorption.

Kidney tubules exchange chemicals with the blood through capillaries


Lung tissue provides an expansive, moist surface for gas exchange.

All photos on this page: EII

Negative feedback and control systems



1. A stress or disturbance, e.g. exercise, takes the internal environment away from optimum.
2. Stress is detected by receptors and corrective mechanisms (e.g. sweating) are activated.
3. The corrective mechanisms act to restore optimum.

Negative feedback acts to counteract any departures from a steady physiological state. The diagram shows how a stress (disturbance) is counteracted by corrective mechanisms in the case of body temperature.

In contrast to negative feedback, positive feedback will push physiological levels out of the normal range. While it is inherently unstable, it has a useful role at certain times, e.g. during childbirth.

1. Describe the three main components of a regulatory control system in the human body: _____

_____

_____

2. Explain how negative feedback mechanisms maintain homeostasis in a variable environment: _____

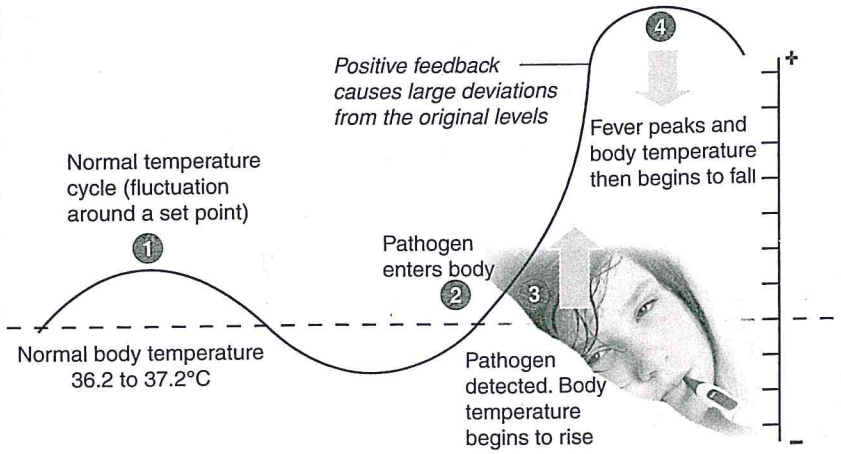
_____

_____

Positive Feedback

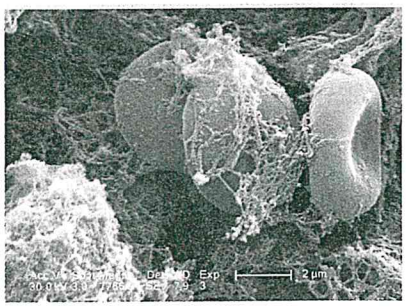
Positive feedback mechanisms amplify a physiological response in order to achieve a particular result. Labor, lactation, fever, and blood clotting all involve positive feedback mechanisms. Normally, a positive feedback loop is ended when a natural resolution is reached (e.g. baby is born, pathogen is destroyed, blood clot forms). Very few physiological processes involve positive feedback because such mechanisms are unstable. If left unchecked, they can be dangerous or even fatal.

Fever, positive feedback, and response escalation



1. Body temperature fluctuates on a normal, regular basis around a narrow set point.
2. Pathogen enters the body.
3. The body detects the pathogen and macrophages attack it. Macrophages release interleukins which stimulate the hypothalamus to increase prostaglandin production and reset the body's thermostat to a higher 'fever' level by shivering (the chill phase).
4. The fever breaks when the infection subsides. Levels of circulating interleukins (and other fever-associated chemicals) fall, and the body's thermostat is reset to normal. This ends the positive feedback escalation and normal controls resume. If the infection persists, the escalation may continue, and the fever may intensify. Body temperatures in excess of 43°C are often fatal or result in brain damage.

Labor and lactation: During childbirth (above), the release of oxytocin intensifies the contractions of the uterus so that labor proceeds to its conclusion. The birth itself restores the system by removing the initiating stimulus. After birth, levels of the milk-production hormone prolactin increase. Suckling maintains prolactin secretion and causes the release of oxytocin, resulting in milk release. The more an infant suckles, the more these hormones are produced.



Positive feedback also occurs in **blood clotting**. A wound releases signal chemicals that activate platelets in the blood. Activated platelets release chemicals that activate more platelets, so a blood clot is rapidly formed.

1. (a) What is the biological role of positive feedback loops? Describe an example: _____

(b) Why is positive feedback inherently unstable (compare with negative feedback)? _____

(c) How is a positive feedback loop normally stopped? _____

(d) Describe a situation in which this might not happen. What would be the result? _____