

CHAPTER 1 – Introduction to Animal Physiology

(Physiology, organization, homeostasis)

Animal physiology is the study of **how animals function**. It asks questions such as: How does a fish obtain oxygen? How does a bird produce energy for flight? How does a mammal stay warm in cold weather? Physiology connects the structure of an animal's body with what that body does and how it responds to its environment.

1. Anatomy and physiology

These two subjects are closely related, but they ask different questions:

- **Anatomy** describes structures: for example, a heart has chambers and blood vessels.
- **Physiology** explains functions: for example, how the heart pumps blood through those vessels.

A useful principle is that **structure and function work together**. The shape and organization of a body part help it perform its job. Animal physiologists study this relationship in different species and environments.

1. Levels of organization

The body is organized from simple components to the whole animal. Each level builds on the one before it.

Level	What it is	Example	Main role
Atoms	Basic units of matter	Carbon, oxygen	Combine to form molecules
Molecules	Groups of atoms	Proteins, lipids, sugars	Support processes such as ATP synthesis and hormone signaling
Cells	Smallest living units	An ion-transporting cell	Carry out life processes and specialized tasks
Tissues	Groups of similar cells	Muscle tissue	Perform a shared function, such as movement
Organs	Different tissues working together	Heart	Perform a specific function, such as pumping blood

Level	What it is	Example	Main role
Organ systems	Organs working together	Respiratory system	Carry out a major body function
Organism	The entire animal	A fish or bird	Coordinates all systems to maintain homeostasis and survive

A change at a lower level can affect higher levels—for example, a change in a cell's molecules may alter how an organ functions.

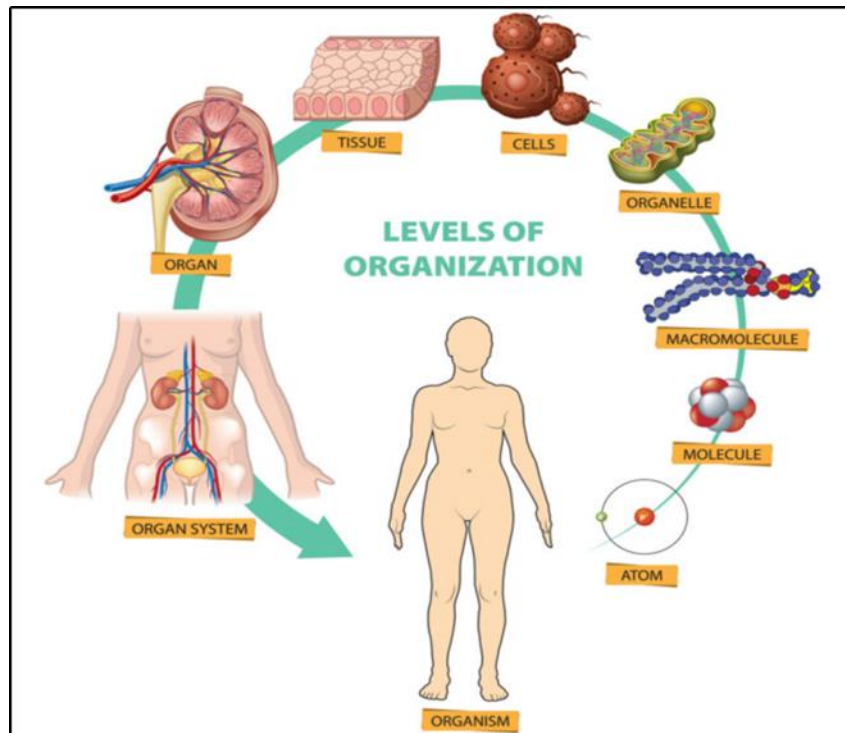


Fig. 1. Levels of organization

2. Homeostasis: Maintaining Internal Balance

Homeostasis is the ability of an organism to keep its internal environment stable despite external changes. Key factors such as body temperature, blood pressure, pH, fluid levels, and oxygen must stay within narrow limits to support life. The term comes from Greek words meaning “same” and “steady,” highlighting a **dynamic balance**, not a fixed state. Too much of even essential substances can be harmful (e.g., excess water → hyponatremia, pure oxygen → oxygen toxicity).

Main Components

- **Sensors (receptors):** Detect changes (e.g., thermoreceptors sense temperature).
- **Integrator (control center):** Compares the information to a set point (e.g., hypothalamus).
- **Effectors:** Produce responses to correct deviations (e.g., sweat glands, blood vessels).

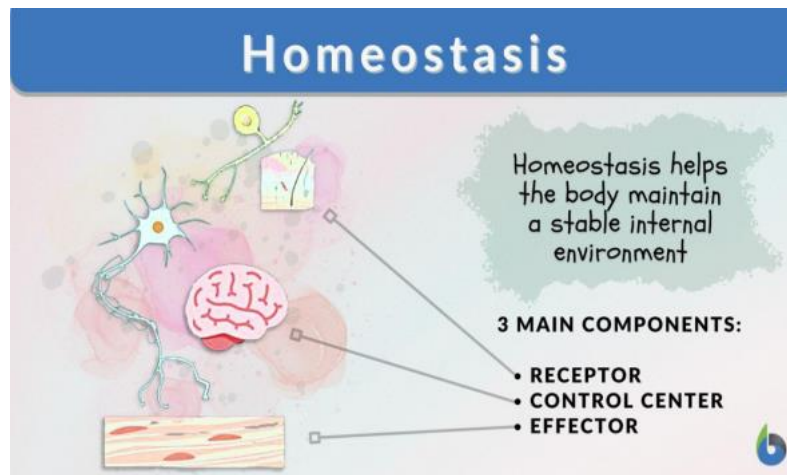


Fig. 2. Main Components of homeostasis

Regulatory Mechanisms

1. Negative feedback (most common): Reduces or counteracts a change to maintain a specific condition or return the system toward its original state.

Example of Negative Feedback – Temperature Control (Sweating or Shivering): When body temperature rises above normal (e.g., during exercise or in hot weather), temperature receptors in the skin and hypothalamus detect the change. The hypothalamus signals sweat glands to produce sweat and causes blood vessels to dilate (vasodilation), promoting heat loss and lowering body temperature back to normal. When body temperature drops below normal (e.g., in cold weather), the hypothalamus triggers shivering (rapid muscle contractions) to generate heat and causes blood vessels to constrict (vasoconstriction), reducing heat loss and restoring normal temperature.

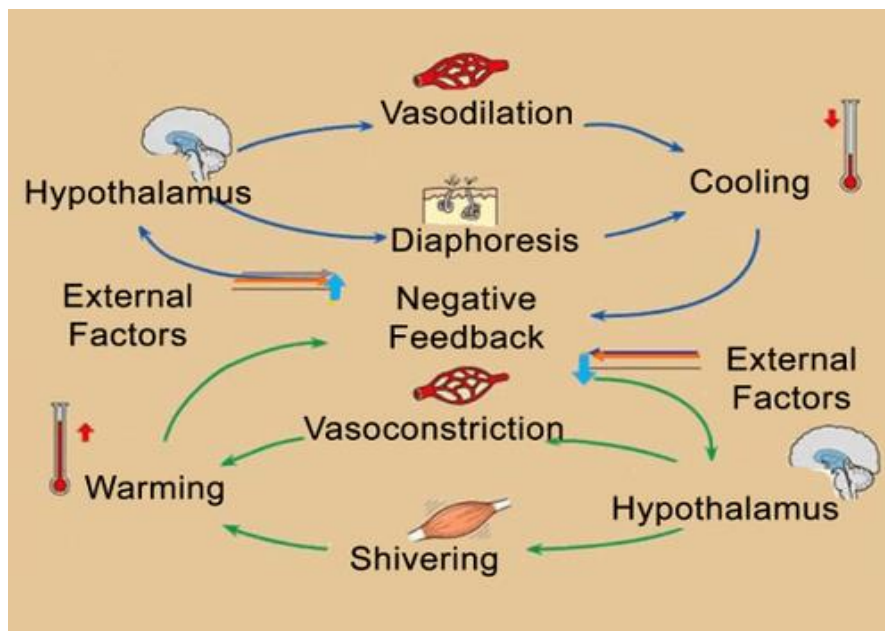


Fig.3. Negative Feedback – Temperature Control (Sweating or Shivering):

Example of Negative Feedback – Blood Pressure Regulation:

When blood pressure rises above normal, baroreceptors (pressure sensors) in the arteries detect

the change and send signals to the brain (medulla oblongata). The brain responds by lowering heart rate and dilating blood vessels, which reduces blood pressure back to normal. Conversely, if blood pressure drops, baroreceptors trigger an increase in heart rate and constriction of blood vessels to raise blood pressure to the set point.

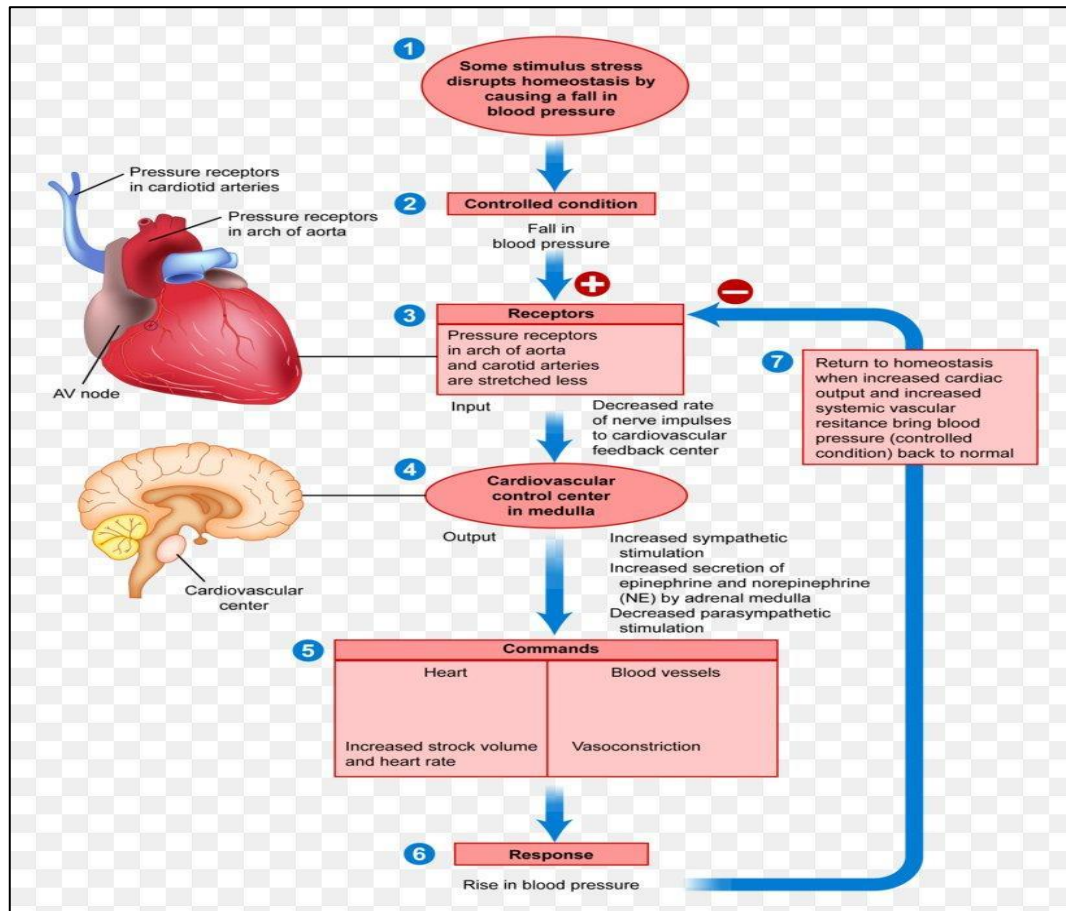


Fig.4. Negative Feedback – Blood Pressure Regulation:

Example of Negative Feedback – Urine Production for Fluid Balance:

When the body has excess water, receptors in the hypothalamus detect the lower blood osmolarity (diluted blood). The pituitary gland reduces the release of antidiuretic hormone (ADH), causing the kidneys to excrete more water as dilute urine, which restores normal fluid balance. When the body is dehydrated and blood osmolarity increases, the hypothalamus signals the pituitary gland to release more ADH. ADH makes the kidneys reabsorb more water, producing concentrated urine, which conserves water and brings fluid levels back to normal.

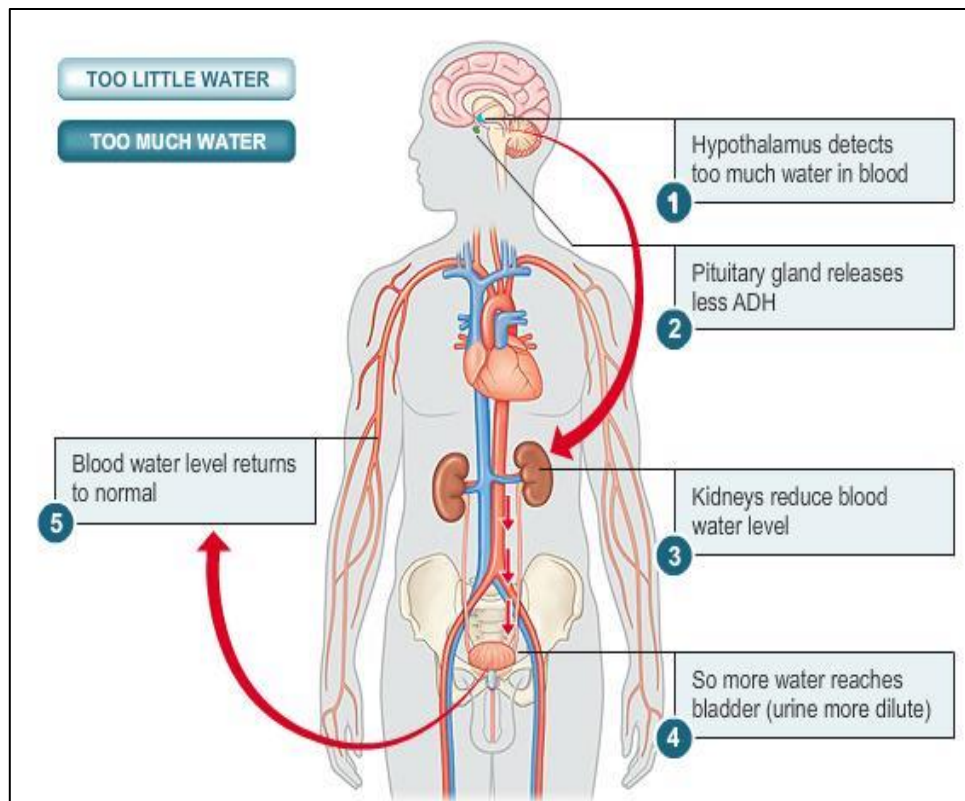


Fig.5. Negative Feedback – Urine Production for Fluid Balance

Example of Negative Feedback – Breathing Adjustments for Oxygen Needs:

When the level of oxygen decreases or carbon dioxide increases in the blood (such as during exercise), chemoreceptors in the carotid arteries and aorta detect the change and send signals to the respiratory center in the brainstem. The brain responds by increasing the rate and depth of breathing, which brings in more oxygen and removes excess carbon dioxide, restoring normal gas levels. If oxygen levels are sufficient and carbon dioxide levels drop, breathing rate slows down to maintain balance.

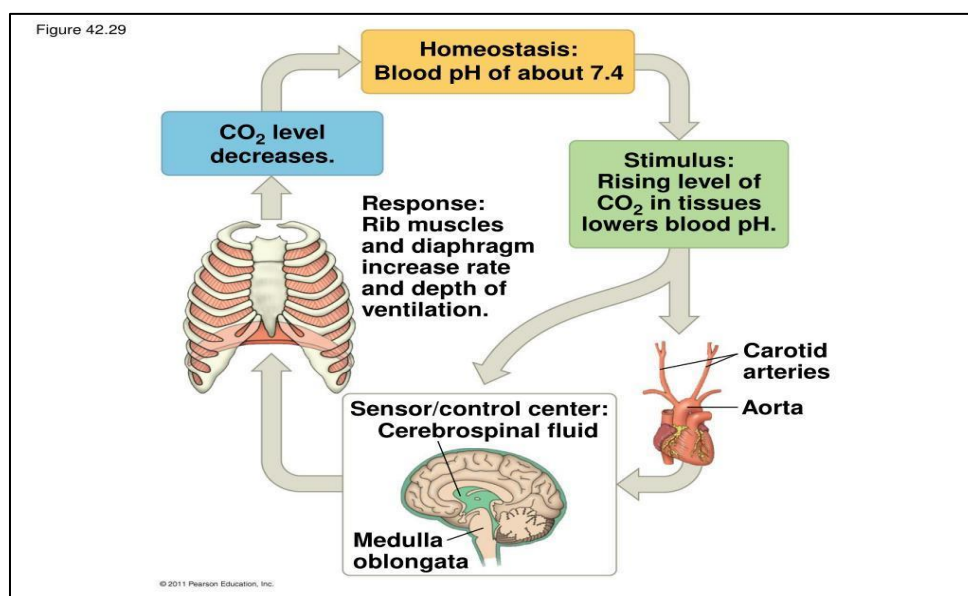
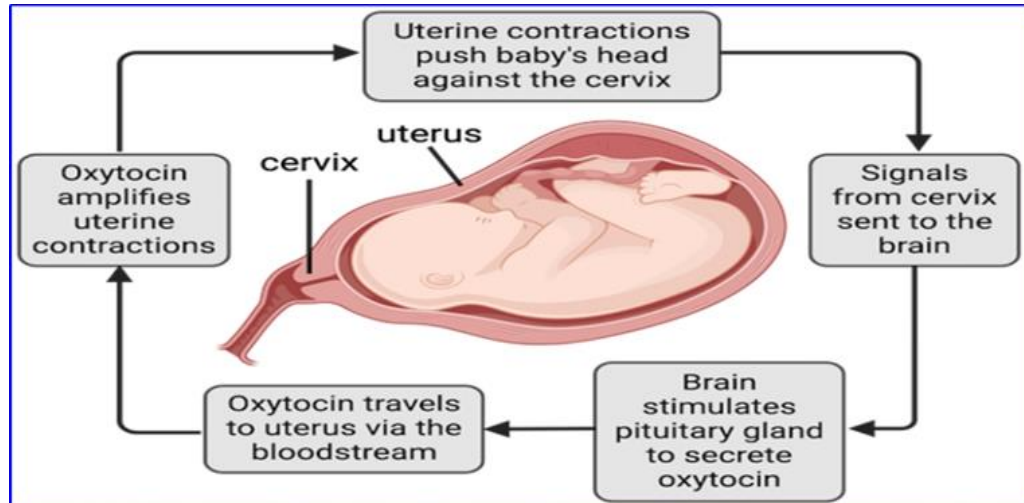


Fig.6. Negative Feedback – Breathing Adjustments for Oxygen Needs

2. Positive feedback: Amplifies a change until a specific goal is reached.

Example of Positive Feedback – Uterine Contractions during Childbirth:

During labor, the baby's head presses against the cervix, stimulating the release of the hormone oxytocin from the pituitary gland. Oxytocin increases the strength and frequency of uterine contractions, which push the baby further down, causing more pressure on the cervix. This pressure triggers even more oxytocin release, amplifying contractions until childbirth is complete.



Example of Positive Feedback – Blood Clotting:

When a blood vessel is injured, platelets adhere to the site and release chemicals that attract more platelets. These newly arriving platelets release additional chemicals, which further recruit platelets, rapidly amplifying the response. This cycle continues until a stable clot forms and the bleeding stops.

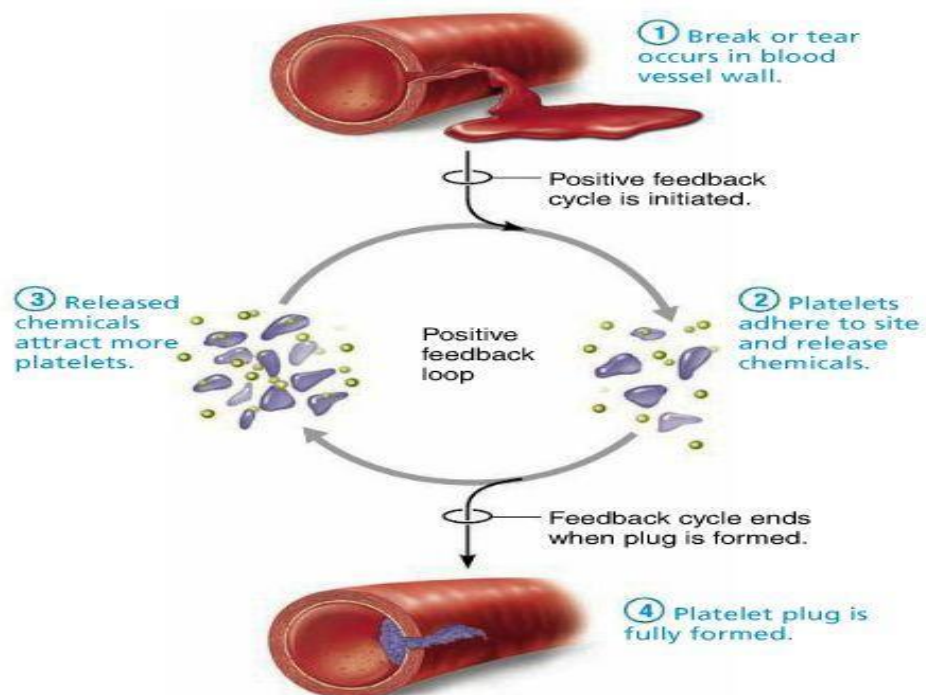


Figure 1.6 A positive feedback mechanism regulates formation of a platelet plug.

Example of Positive Feedback – Immune Inflammation:

During an infection or injury, immune cells release signaling molecules (cytokines) that attract more immune cells to the site. These newly recruited cells release even more cytokines, amplifying the inflammatory response to help fight pathogens or repair tissue. This loop continues until the threat is eliminated or controlled.

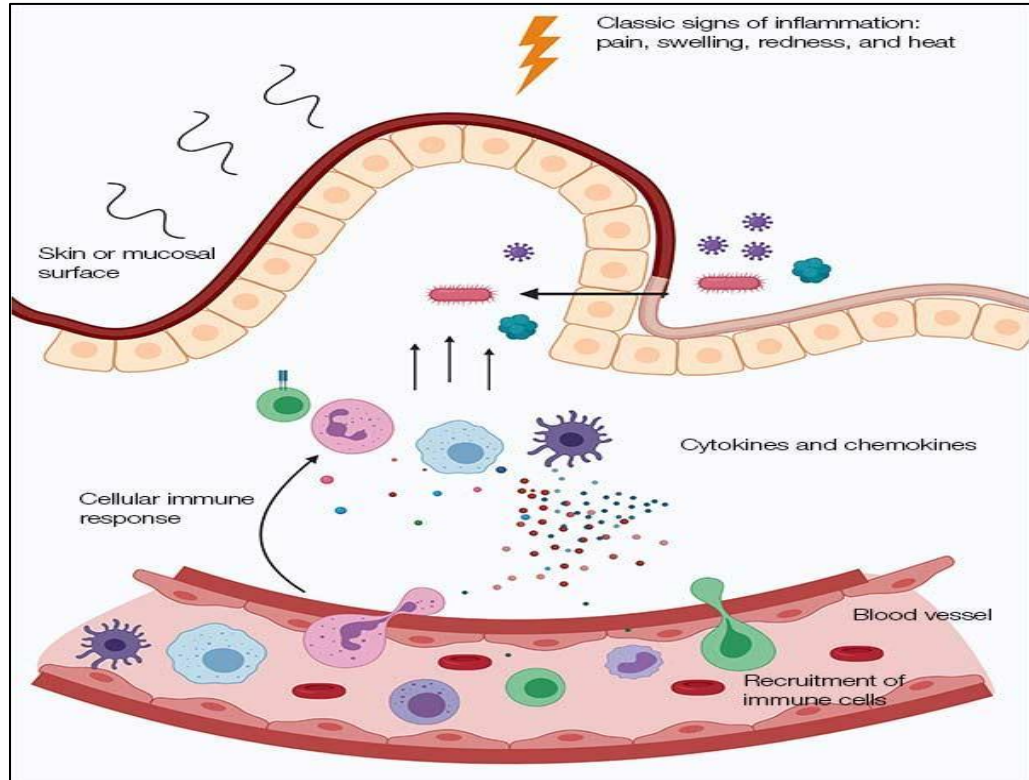


Fig. 7. Positive Feedback – Immune Inflammation