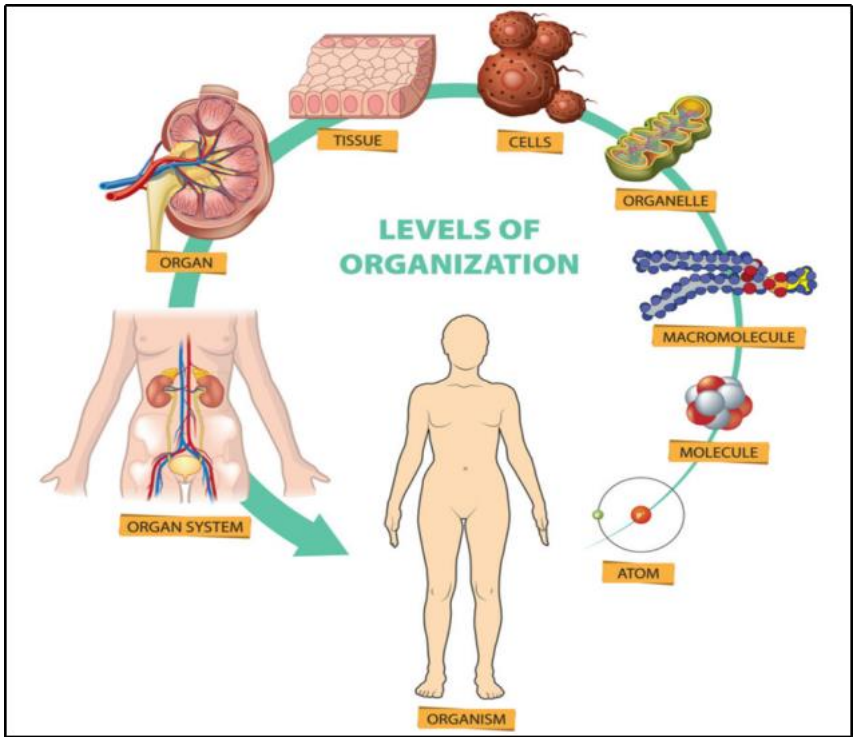
CHAPTER 1 – Introduction to Animal Physiology

1. What Is Animal Physiology?

Animal physiology is the study of how **animals** function and how their **body systems** work together to sustain **life**. It focuses on the **mechanisms** behind vital processes such as **feeding**, **respiration**, **circulation**, **excretion**, **movement**, and **reproduction**, and how these are **regulated** under different **environmental conditions**. Unlike **anatomy**, which describes **structure**, physiology explains **how** and **why** functions occur, using principles of **physics** and **chemistry**. It also explores how animals **adapt** to challenges like **temperature changes**, **water balance**, and **food acquisition**. A **comparative** and **environmental approach** reveals common **principles** and the diverse **strategies** animals use to **survive** in their **habitats**.

2. Levels of Organization



The body is organized in a **hierarchical** structure, increasing in complexity from **atoms** and **molecules** to **cells**, **tissues**, **organs**, **organ systems**, and the entire **organism**. **Atoms** combine to form **molecules** (like **proteins**, **lipids**, and **sugars**) that support biochemical processes such as **ATP synthesis** and **hormone signaling**. Molecules form **cells**, the smallest living units, which can function independently or specialize in tasks like **ion transport**. Similar cells create **tissues** (e.g., **muscle tissue** for movement), which join to form **organs** (e.g., the **heart**) where different tissues work together. Organs cooperate in **organ systems** (e.g., the **respiratory**

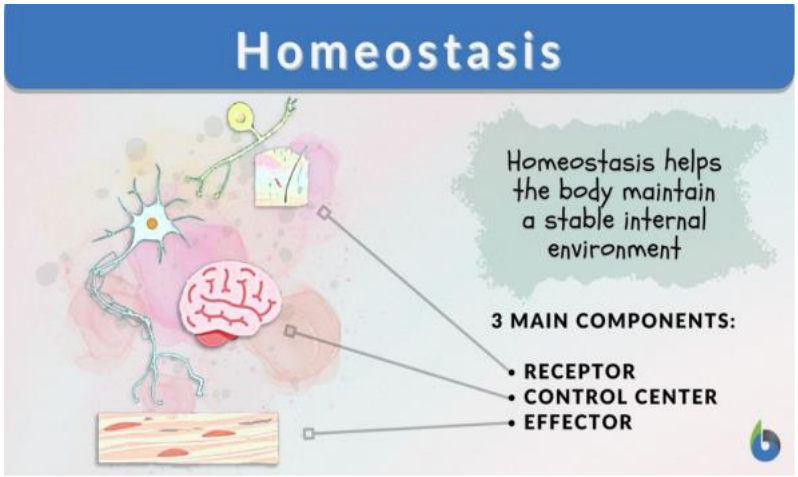
system) to perform major functions. At the **organismal level**, all systems interact to maintain **homeostasis** and survival, illustrating how changes at the molecular level can affect the entire animal.

3. 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).



Regulatory Mechanisms

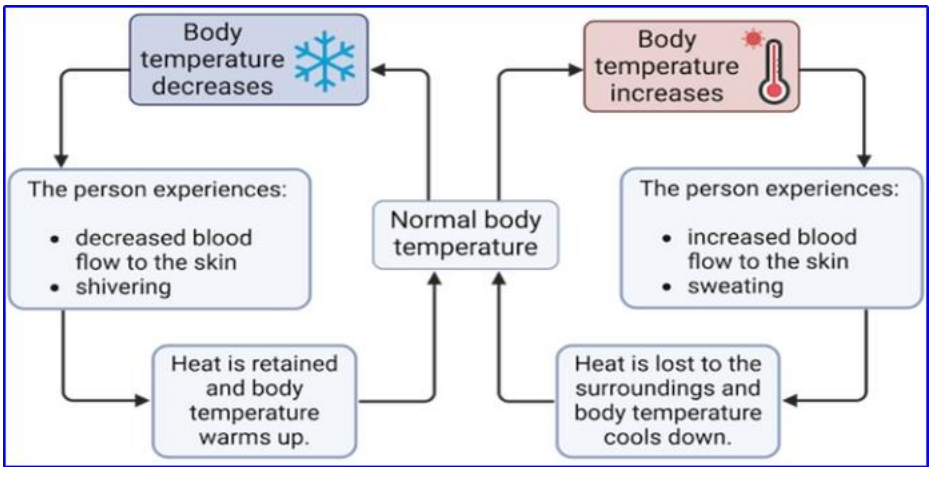
- **Negative feedback (most common):** Counteracts changes to restore balance.
    - ***Examples:*** Sweating or shivering for temperature control, blood pressure regulation, urine production for fluid balance, breathing adjustments for oxygen needs.
    - **Example of Negative Feedback – Temperature 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.

- **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.

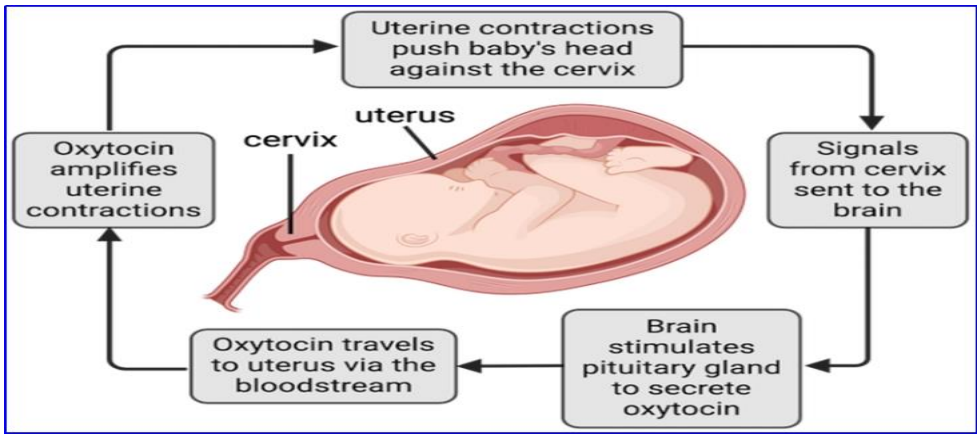
- **Example of Negative Feedback – Urine Production for Fluid Balance:**
  When the body has excess water, receptors in the hypothalamus detect the lower blood osmolarity (diluted blood). The pituitary gland reduces the release of antidiuretic hormone **(ADH)**, causing the kidneys to excrete more water 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.

- **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.



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

- ***Examples:*** Uterine contractions during childbirth, blood clotting, immune inflammation.
- **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.
- **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.



Importance

Homeostasis is essential for survival. Diseases occur when these mechanisms fail or overreact:

- *Fever* is a controlled reset to fight infection.
- *Chronic disorders* (e.g., hypertension, autoimmune diseases) result from long-term imbalance.
- *Severe cases* (e.g., sepsis) can be life-threatening.

Summary:
Homeostasis ensures stable internal conditions through sensors, control centers, and effectors using mainly negative feedback. Its failure leads to disease or death.