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Animal Physiology

Topic: Introduction

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At the end of the unit, you should be able to:

1. Discuss the importance of physiological adaptation.

2. Compare the different levels of physiological adaptation.

3. Explain the importance of plasma membrane in cell's physiological functions.

Introduction to Animal Physiology

- Adaptation is the key for animal survival in a constantly changing environment.

- **Physiological adaptation** allows an animal to either:
  - **Stabilize** their internal environment (homeostasis) regardless of the changes occurring inside or outside of their body

  or

  - **Adjust** their internal environment (metabolism) to suits the changes occurring inside or outside of their body.

Examples of physiological adaptation

- **Stabilize**
  - maintain blood glucose level (internal stimulus).
  - constant body temperature of warm-blooded animal (external stimulus).

- **Adjust**
  - increase of uterine contractions during labor (internal stimulus).
  - decrease of basal metabolic rate in hibernating animal (external stimulus).

- Physiological adaptation can also be discussed in broader, evolutionary point of view:
  - specialized physiological adaptation in various animal species to occupy a particular niche in the environment.

Example:

Differences in respiratory system between aquatic and terrestrial animals.

QUIZ:

Can you relate why frog can survive in terrestrial environment but tadpole can't?

Why frog can survive in terrestrial environment but tadpole can't? (Answer)

- ✓ Frog have specialized physiological adaptation for both aquatic and terrestrial environment while tadpole only specialized to live in aquatic environment.

- ✓ Examples:
  - ✓ Respiratory system
    - Frogs have lungs that enable them to breath on land and moist skin that enable direct respiratory gas exchange in wet environment.
    - Tadpoles have gills and tail that only enable direct respiratory gas exchange in aquatic environment.
  - ✓ Locomotion
    - Frogs have legs to move on land or swim on water.
    - Tadpoles can only swim with their tail

Levels of physiological adaptation

- Physiological adaptation within an organism may occur at different levels:
  - **Cellular**
  - **Tissue**
  - **Organ**
  - **Organ system**

Cellular

- Cell is the **building block** of a multicellular organism.
- The base of all physiological activity occurs in cellular level (physiological unit).
- The cells contain organelles (little organ) that enable them to perform their own physiological function, and also act as the working unit for higher physiological level.
- Example:
  - Muscle cell can temporarily switch to anaerobic respiration (due to restricted O_2 supply) during strenuous exercise .

Tissue

- Tissues are made up from **cluster of similar cells** and they work as a group to perform a specific function.

- Example:
  - Alpha-cells of Langerhans produce glucagon hormone when blood glucose level drops.
  - Beta-cells of Langerhans produce insulin hormone when blood glucose level arises.

Organ

- An organ that is made up by **combination of different tissues** carries out a more advance function.

- Example:
  - The pancreas is made up of both alpha-cells and beta-cells of Langerhans, and function to regulate blood glucose level.

Organ system

- **A team of organs** performing an arrays of functions in a physiological niche.

- Example:
  - Pancreas along with other endocrine organs made-up the endocrine system; the body's communication system which regulate slow and long term response.

Plasma membrane

- As a living unit itself, the cell of multicellular organism also need to adapt and respond to changes occurring inside and outside of the cell.
- The **plasma membrane** creates the boundary between internal (cytoplasm) and external cellular environment (extracellular fluid).
- It regulates what goes into and out of the cell via **selective permeability** and **transport system.**
- It also **contain receptors** that determine how the cell reacts to a specific stimuli.

Selective permeability

- The structure of plasma membrane contributes to its selective permeability characteristic.
- The main component is **phospholipid**, an amphipathic molecule, which contains both hydrophobic (water repelling) and hydrophilic (water soluble) regions.
- The phospholipid is arranged as two layers of continuous barrier facing each other in the hydrophobic region **(phospholipid bilayer).**
- This arrangement creates a hydrophobic layer in the middle of the membrane and two hydrophilic surfaces with one facing the extracellular fluid and another facing the cytoplasm.

Selective permeability (continue)

- The hydrophobic layer within the membrane only allow lipid-soluble substances and small uncharged molecules to pass through freely.
- Ions and water soluble substances on the other hand rely on **transport protein** to pass through.
- A transport protein could either be a **channel protein** or a **carrier protein** that span across the membrane (transmembrane).
- Large macromolecules which unable to pass through freely or with the help of transport protein are imported via **endocytosis** and exported via **exocytosis**.

Membrane-bound receptor

- **Membrane-bound receptor** is a type of protein that serves in recognition purposes.
- It is embedded in the plasma membrane with unique binding site projected on the surface.
- It determines whether a certain cell can recognize or respond to a certain stimuli such as hormone.

QUIZ:

How do the plasma membranes contribute to physiological function of the cell?

How do the plasma membranes contribute to physiological function of the cell? (Answer)

- ✓ Plasma membrane controls the cellular traffic via selective permeability and transport system

- ✓ Plasma membrane contain receptors that serve in recognition and respond toward stimuli

- ✓ Example:
  - When antidiuretic hormone (ADH) binds to a complimentary membrane-bound receptor on collecting tubule of the kidney, it increases the numbers of channel protein (aquaporin) that facilitate water reabsorption.

Further reading:

Reece, Urry, Cain, Wasserman, Minorsky & Jackson. (2013). Campbell Biology (10th edition). Benjamin Cummings.

Willmer, Stone & Johnston. (2005). Environmental Physiology of Animals (2nd edition). Blackwell Publishing.