

CHAPTER 6. Nervous system

Introduction

The nervous systems of animals show a wide range of structural and functional diversity. **Invertebrates** generally possess nervous systems that are **less centralized**, ranging from simple **nerve nets** in organisms like jellyfish to more advanced arrangements with **ganglia and a ventral nerve cord** in annelids and arthropods. In contrast, **vertebrates** have a highly **centralized and complex** nervous system, consisting of a **dorsal brain and spinal cord** forming the central nervous system (CNS), along with a peripheral nervous system (PNS) that extends throughout the body. The main distinctions between invertebrate and vertebrate nervous systems involve the **degree of centralization**, the **level of structural complexity**, and the **position and protection of the main nerve cords**.

I. Invertebrate Nervous System

1. Structure and Organization

The nervous system in invertebrates shows a wide range of forms, reflecting the great diversity of this group. It may be **very simple**, such as the **nerve net** found in cnidarians (e.g., jellyfish), where neurons are loosely arranged without a central control center. In more advanced invertebrates, such as annelids and arthropods, the nervous system becomes **more structured**, containing a **series of ganglia** (clusters of nerve cells) connected to **longitudinal nerve cords**. In the most complex invertebrates, like cephalopods (octopus and squid), a **highly developed brain** and specialized nerve centers exist, supporting advanced behaviors.

2. Central Nervous System (CNS)

When a central nervous system is present, it is generally **less centralized** than that of vertebrates. The CNS usually consists of:

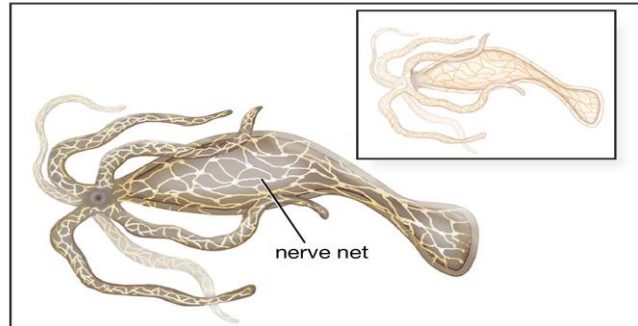
- A **primitive brain**, formed by a concentration of ganglia at the anterior (head) region.
- A **ventral nerve cord**, located on the belly side of the body, unlike vertebrates where the spinal cord is dorsal (on the back).
- **Segmental ganglia** distributed along the ventral nerve cord, which control local body segments and movements.

3. Complexity and Functional Variation

The complexity varies significantly across groups:

- **Cnidarians:** Simple nerve net with no true brain.

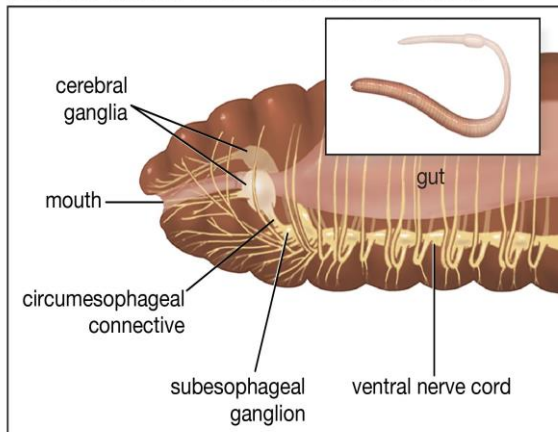
Nervous system of the cnidarian (*Hydra*)



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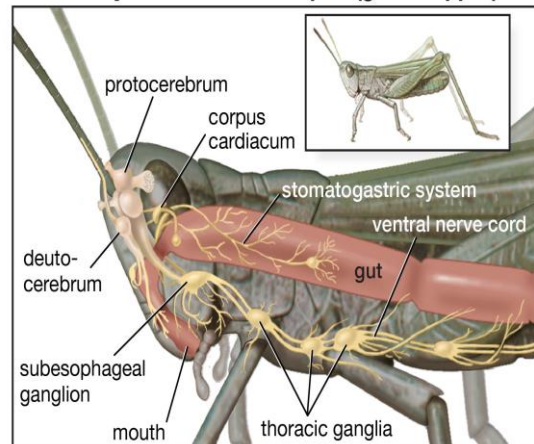
- **Annelids and Arthropods:** Ladder-like nervous system with paired ganglia and a ventral nerve cord.

Nervous system of the annelid (earthworm)



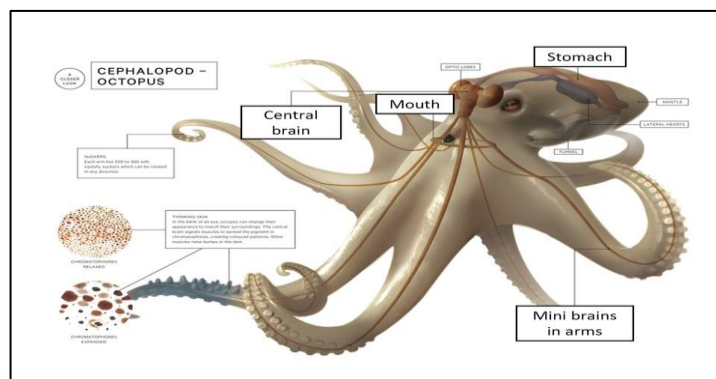
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Nervous system of the arthropod (grasshopper)



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- **Cephalopods (e.g., octopus):** Highly developed, centralized brain capable of learning, memory, and problem-solving.



4. Protection and Support

The invertebrate nervous system is generally **less protected** than that of vertebrates. Most invertebrates lack a rigid internal skeleton, so their nerve cords and ganglia are not enclosed within a protective bony structure like a vertebral column. Instead, they are often protected only by soft tissues or a simple exoskeleton.

5. Representative Examples

- **Cnidarians** → *Nerve net* allowing basic reflexive responses.
- **Annelids (e.g., earthworms)** → *Segmented ganglia + ventral nerve cord.*
- **Arthropods (e.g., insects, crustaceans)** → *Distinct brain + large ventral nerve cord with segmental ganglia.*
- **Cephalopods (e.g., octopus)** → *Highly developed brain and complex sensory organs.*

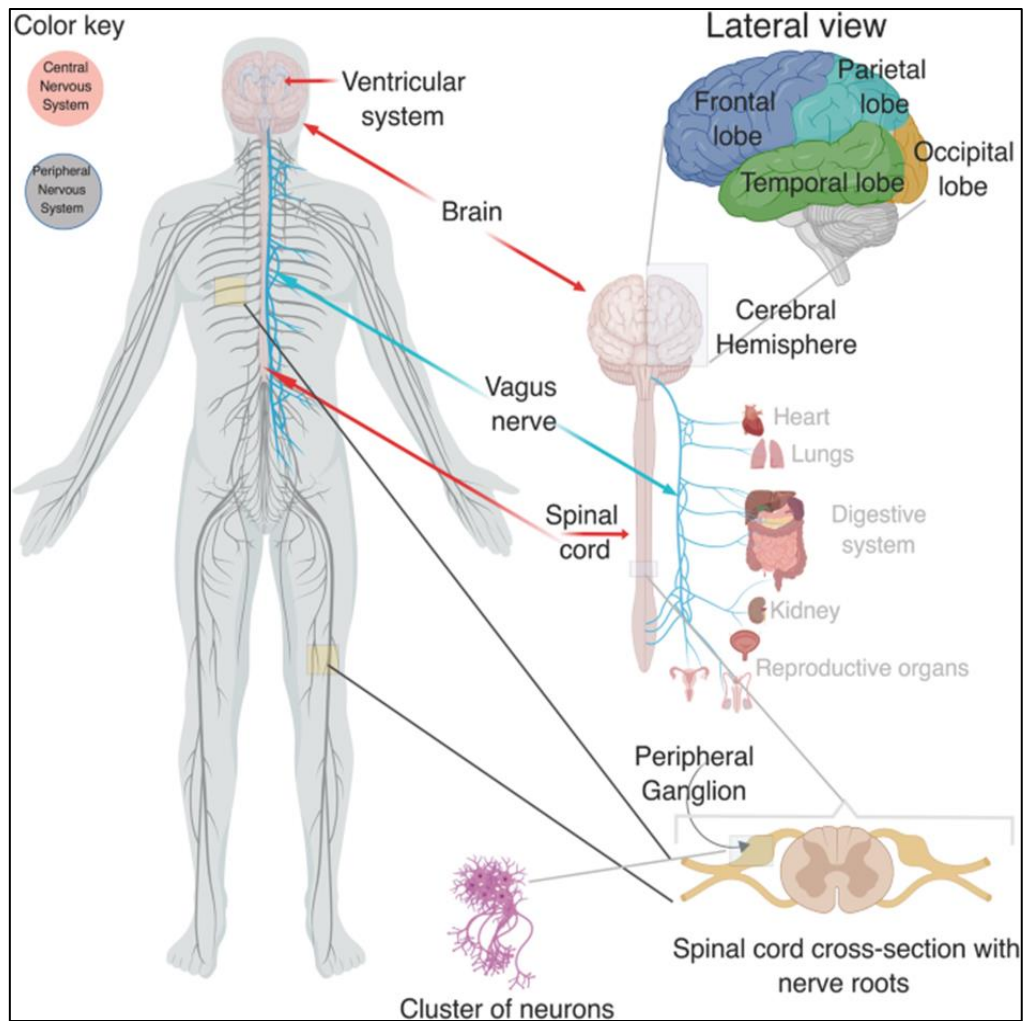
Vertebrate Nervous System

1. Structure and Organization

The vertebrate nervous system is **highly centralized** and more structurally complex than that of invertebrates. It is divided into:

- A **Central Nervous System (CNS)**, composed of the **brain and spinal cord**
- A **Peripheral Nervous System (PNS)**, composed of nerves and sensory receptors distributed throughout the body

This system allows for precise control of movement, complex behavior, learning, memory, and coordination between organ systems.



Vertebrate Nervous System

2. Central Nervous System (CNS)

- The **brain** is well-developed and housed within the **cranium**, a protective skull structure.
- The **spinal cord** extends from the brain and is enclosed within the **vertebral column** (backbone).
- The CNS is **dorsal** (located on the back side), in contrast to the ventral nerve cord of most invertebrates.
- The brain is typically divided into major regions such as the **forebrain**, **midbrain**, and **hindbrain**, each controlling different functions (e.g., sensory processing, coordination, behavior).

3. Peripheral Nervous System (PNS)

The PNS consists of:

- **Sensory nerves**, which carry information *to* the CNS from the environment and body organs.
- **Motor nerves**, which carry signals *from* the CNS to muscles and glands. It includes both **somatic** (voluntary) and **autonomic** (involuntary) subdivisions, the latter regulating functions such as heart rate, digestion, and breathing.

4. Complexity and Functional Specialization

The vertebrate nervous system demonstrates:

- **High levels of integration and specialization**
- The ability to form **complex neural circuits** for learning, memory, reasoning, and advanced behaviors
- Increasing brain complexity from simple vertebrates (e.g., fish) to highly developed mammals (e.g., humans)

5. Protection and Support

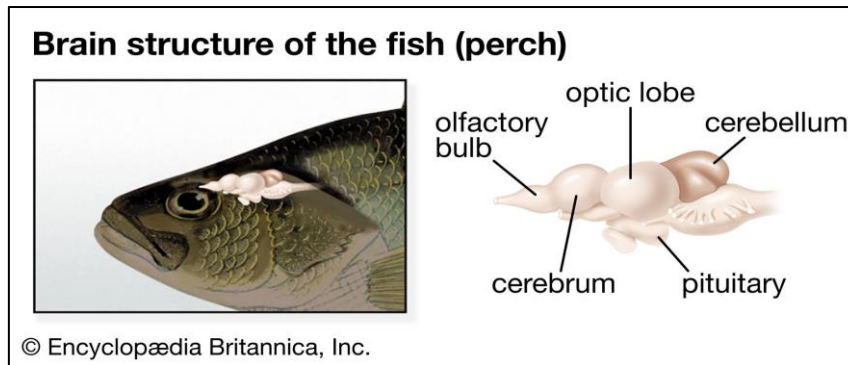
The vertebrate nervous system is **strongly protected**:

- The **brain** is enclosed in the **skull** and cushioned by **meninges** and **cerebrospinal fluid (CSF)**.
- The **spinal cord** is protected by the **vertebral column** and also surrounded by meninges and CSF.

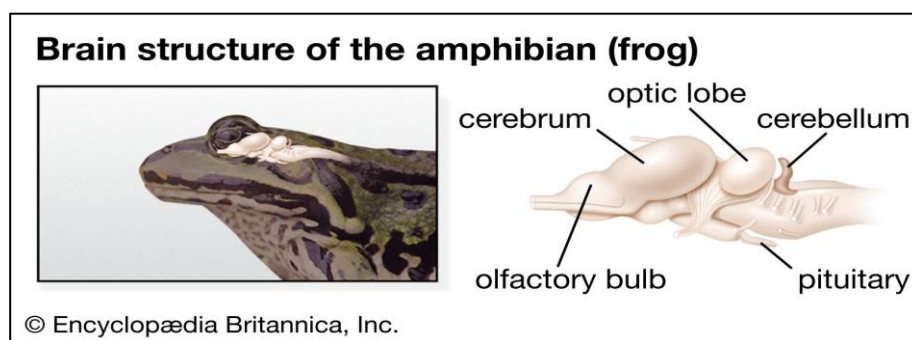
This high level of protection reduces injury risk and allows the development of larger and more complex nerve tissues.

6. Representative Examples

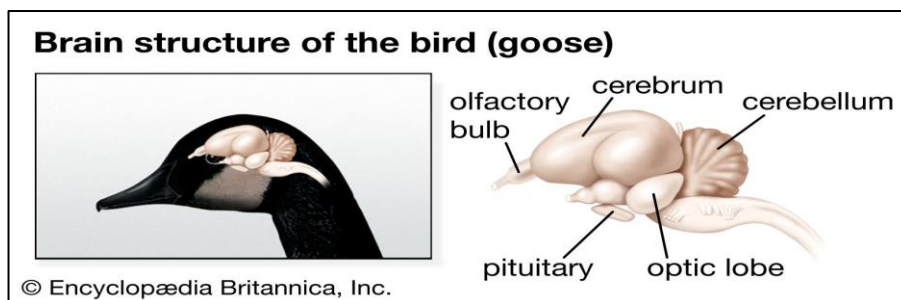
- **Fish** → Simple but functional brain; spinal cord controls swimming coordination.



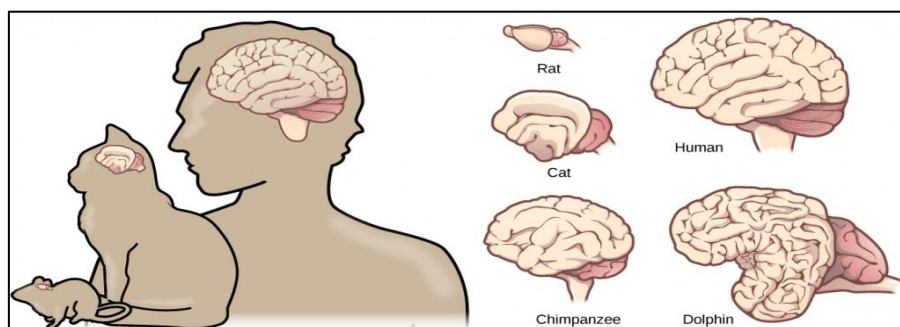
- **Amphibians** → Slightly more developed brain regions to coordinate movement on land and water.



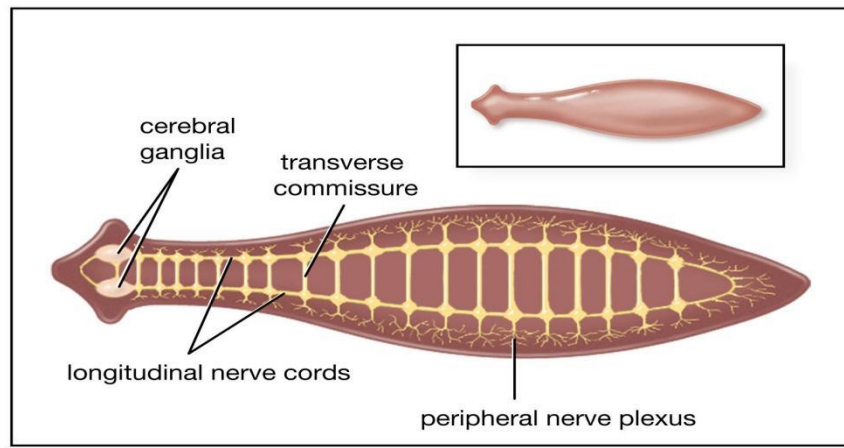
- **Reptiles & Birds** → Increased cerebrum and cerebellum; improved sensory processing and coordination.



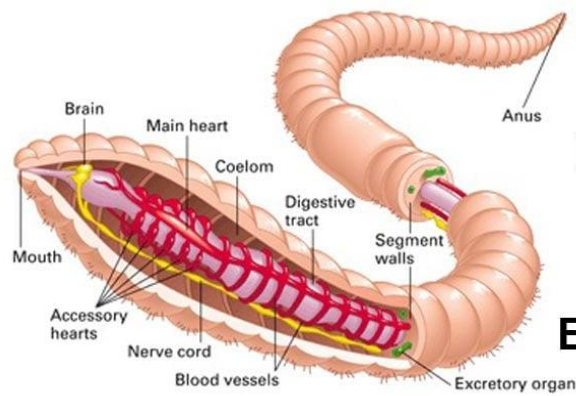
- **Mammals (including humans)** → Highly developed brain with advanced reasoning, learning, memory, and refined motor control.



Nervous system of the flatworm (*Planaria*)



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Nervous System of Earthworm

