

ANIMALS

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ALL COMPILED BY **BONSA GEREMEW** 2026

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- **Classification of Animals**
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 - Characteristics of Invertebrate Animals
 - Characteristics of Vertebrate Animals
 - Comparison of Vertebrates and Invertebrates
- **Reproduction in Animals**
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After successful completion of this unit, the student will be able to:

- Describe the general characteristics of animals.
- Differentiate between vertebrates and invertebrates.
- Compare and contrast modes of reproduction in vertebrates.
- Explain animal behavior and its significance.
- Identify and discuss the types and patterns of animal behavior.
- Explain homeostasis in animals, including thermoregulation, osmoregulation, and sugar balance.
- Evaluate the economic importance of animals, particularly insects, in agriculture, food production, industry, health, and medicine.
- Appreciate the contributions of a renowned zoologist in Ethiopia or in the local community.

GENERAL CHARACTERISTICS OF ANIMALS

○ THE FUNDAMENTAL NATURE OF ANIMALS

Animals represent a diverse kingdom of organisms, but regardless of their size or habitat, they share a specific biological blueprint. These are the core traits that define an animal:

- **Eukaryotic:** Every animal is made of complex cells that contain a membrane-bound nucleus and organelles.
- **Multicellular:** Animals are not single-celled organisms. They are composed of multiple cells working together to form specialized tissues and organs.
- **Heterotrophic:** Animals are consumers. Unlike plants, they cannot produce their own food through photosynthesis. They must ingest organic material—eating plants or other animals—to obtain energy.

◦ ESSENTIAL LIFE PROCESSES

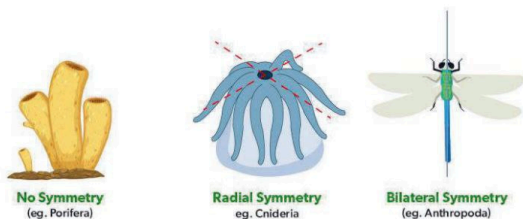
To survive and perpetuate their species, animals engage in specific physiological and behavioral activities:

- **Sensitivity to Stimuli:** Animals possess a nervous system or sensory mechanism that allows them to detect changes in their environment (such as heat, light, or danger) and respond accordingly.
- **Motility (Movement):** At some stage in their life cycle, most animals have the ability to move their bodies voluntarily to find food, mates, or shelter.
- **Reproduction:** Animals have the ability to produce offspring to ensure the continuity of their species. This can be sexual (involving two parents) or asexual (involving one parent).
- **Growth:** Animals undergo a process of increasing in size and physical complexity from birth to adulthood.
- **Respiration:** Animals engage in gas exchange, taking in oxygen and releasing carbon dioxide to generate energy for cellular activities.
- **Excretion:** The body produces metabolic waste during life processes. Animals have systems to remove these toxic waste products from their bodies.
- **Protection:** Animals have developed various biological mechanisms to defend themselves from predators and environmental hazards (e.g., shells, camouflage, speed).

◦ STRUCTURAL VARIATIONS

While all animals share the traits above, they exhibit different structural patterns:

- **Body Symmetry:** This refers to how the body parts are arranged.
 - **Bilateral Symmetry:** The body has distinct left and right sides that are mirror images of each other (typical of vertebrates).
 - **Radial Symmetry:** The body parts are arranged around a central axis (typical of some invertebrates like jellyfish).
 - **Asymmetry:** No specific pattern (sponges).



- **Skeletal Support:**
 - **Endoskeleton:** An internal framework made of bone or cartilage (found in vertebrates).
 - **Exoskeleton:** A hard external covering, often made of chitin, that protects soft inner bodies (found in invertebrates like insects).
- **Temperature Regulation:**
 - **Homeothermic (Warm-blooded):** Animals that maintain a constant internal body temperature regardless of the weather (Mammals, Birds).
 - **Poikilothermic (Cold-blooded):** Animals whose body temperature changes with the environment (Fish, Reptiles, Amphibians).

Animals – Classification

The Animal Kingdom is primarily categorized into two major groups based on a single structural feature: the presence or absence of a **backbone** (vertebral column).

- **Invertebrates:** Animals without a backbone.
- **Vertebrates:** Animals with a backbone

CHARACTERISTICS OF INVERTEBRATE ANIMALS

- Invertebrates represent the **most diverse group of animals** on Earth. They are found in almost every habitat, from the hottest deserts to the deepest seabeds.
 - **Skeletal System:** They lack a rigid internal skeletal system.
 - Many are **soft-bodied** (e.g., earthworms, jellyfish).
 - Some possess an **Exoskeleton** (external skeleton), usually made of **chitin**, which protects their soft inner bodies.
 - **Temperature Regulation:** They are **Cold-blooded** (Poikilothermic), meaning they cannot regulate their own body temperature internally.
 - **Classification:** They include several phyla such as:
 - Porifera (sponges)
 - Cnidaria (jellyfish)
 - Platyhelminthes (flatworms)
 - Annelida (earthworms);- segmented worm
 - Echinodermata (sea stars)
 - Mollusca (snails, squid);- soft bodied

- **Arthropoda:** This is the largest group, further classified into Crustacea, Spiders, Insects, and Myriapods (many-legs).

CHARACTERISTICS OF VERTEBRATE ANIMALS

- Vertebrates are the **most advanced group in the animal kingdom**. They are defined by having a well-developed internal skeleton.
 - **Internal Skeleton (Endoskeleton):** They possess a skeleton made of cartilage and bone, separated into two parts:
 - **Axial Skeleton:** Includes the skull (protects the brain), vertebrae (protects the nerve cord), ribs, and sternum.
 - **Appendicular Skeleton:** Includes girdles and appendages (limbs).
 - **Complex Organ Systems:**
 - **Circulatory:** A **closed circulatory system** with a **ventral heart** (located on the front side) having 2–4 chambers.
 - **Respiratory:** Gas exchange occurs through **gills** (aquatic) or **lungs** (terrestrial).
 - **Nervous:** A centralized system with a highly developed brain and specialized sensory organs (eyes, ears, nostrils).
 - **Excretory:** Consists of **paired kidneys**.
 - **Body Symmetry:** They are **Bilaterally Symmetrical** (the left and right sides of the body are mirror images).
 - **Temperature Regulation:**
 - **Homeothermic (Warm-blooded):** Maintain constant body temperature (Mammals, Birds).
 - **Poikilothermic (Cold-blooded):** Body temperature changes with the environment (Fish, Reptiles, Amphibians).
 - **The Chordate Rule:** All vertebrates are chordates, but not all chordates are vertebrates.
 - This is because, in vertebrates, the notochord develops into a vertebral column (backbone). In "invertebrate chordates," the notochord persists throughout their life or disappears, but it never becomes a backbone.

COMPARISON: VERTEBRATES VS. INVERTEBRATES

Feature: Backbone

- **Invertebrates:** Absent.
- **Vertebrates:** Present (Vertebral column).

Feature: Skeletal Support

- **Invertebrates:** Either soft-bodied or have an external **Exoskeleton** (often chitin).
- **Vertebrates:** Internal **Endoskeleton** (bone and cartilage).

Feature: Nervous System

- **Invertebrates:** Simple; often a solid nerve cord.
- **Vertebrates:** Complex; centralized brain protected by a skull and a spinal cord protected by vertebrae.

Feature: Circulatory System

- **Invertebrates:** open; if a heart is present, it is usually dorsal.
- **Vertebrates:** Closed system; **Ventral heart** with chambers.

Feature: Body Symmetry

- **Invertebrates:** Varied (Radial, Bilateral, or Asymmetrical).
- **Vertebrates:** Always **Bilaterally Symmetrical**.

Eyes

- **Invertebrates:** most have compound eyes (arthropods)
- **Vertebrates:** they don't have compound eyes

Reproduction in Animals

Reproduction is a fundamental characteristic of animals that ensures the continuity of species. It is the biological process by which living organisms duplicate themselves.

There are two primary modes of reproduction:

- **Asexual Reproduction:** Involves a single parent.
- **Sexual Reproduction:** Involves two parents and the fusion of gametes.

ASEXUAL REPRODUCTION

- This mode involves a single individual and **does not** require the fusion of gametes. It is more common in invertebrates than vertebrates.

Types of Asexual Reproduction:

- **Budding & Fragmentation**
- **Parthenogenesis:** A unique form of reproduction where **unfertilized eggs** develop directly into new offspring. This occurs in some insects (like bees) and some vertebrates.

SEXUAL REPRODUCTION

- This mode involves two parents (male and female) and requires the fusion of haploid gametes to produce a diploid offspring. This process creates genetic variation.

The Mechanism:

- **Parents:** Are **Diploid (2n)** organisms with a complete set of chromosomes.
- **Gametes:** Parents produce **Haploid (n)** cells through meiosis.
 - **Males:** Produce **Sperm** in the **Testes** (stored in the epididymis).
 - **Females:** Produce **Ovum (Egg)** in the **Ovary**.
- **Fertilization:** The fusion of a sperm cell with an egg cell to produce a **Zygote**.

Types of Fertilization:

- **External Fertilization:**
 - Eggs are released into the environment (usually water).
 - Sperm fertilizes the egg outside the female's body.
 - Common in aquatic animals (e.g., Frogs).
- **Internal Fertilization:**
 - Eggs are released from the ovary into the uterine tubes.
 - Fertilization occurs **inside** the female's body.

- This is advantageous for land animals as it protects the gametes from drying out.

EMBRYONIC DEVELOPMENT

- After fertilization, the single-celled **Zygote (2n)** undergoes a specific series of developmental stages to become a complex organism.

The Stages of Development:

1. Cleavage

- The first stage immediately following fertilization.
- Involves a series of rapid **mitotic cell divisions** of the zygote.
- Results in an eight-celled structure.

2. Blastula

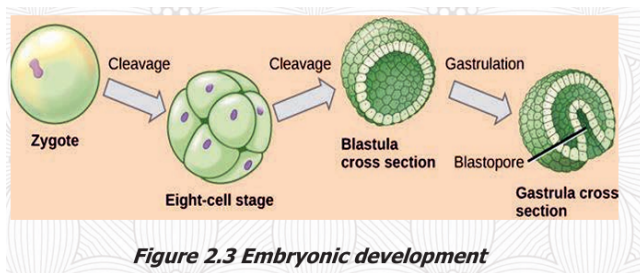
- The cells continue to divide and rearrange.
- They form a **hollow structure** (hollow ball of cells) called a **blastula**.

3. Gastrulation

- The blastula undergoes further division and structural rearrangement.
- This forms a **Gastrula**, which consists of different cell layers known as "**Germ Layers**." (which are *Ectoderm, mesoderm and Endoderm*)

4. Organogenesis

- This is the formation of organs.
- The **Germ Layers** created during gastrulation differentiate and develop into specific tissues, organs, and organ systems.
- Eventually, the embryo develops into an adult.



Reproduction in Insects

GENERAL CHARACTERISTICS OF INSECTS

Insects constitute the most diverse group of animals and are the largest class of the phylum **Arthropoda**.

- **Physical Features:** They possess segmented bodies, jointed legs, and an external skeleton (**exoskeleton**).
- **Examples:** Flies, grasshoppers, lice, butterflies, bees, and beetles.

REPRODUCTIVE PROCESS

Insects primarily undergo **Sexual Reproduction**, involving distinct male and female reproductive structures.

- **Fertilization:** Usually **Internal**.
 - **Male:** Produces sperm.
 - **Female:** Produces eggs.
 - **Mating:** The male fertilizes the egg produced by the female. After fertilization, the female lays eggs which eventually hatch.
- **Parthenogenesis:** Some insects have a unique process where an individual develops from **unfertilized eggs** (e.g., in some phases of bee reproduction).

METAMORPHOSIS

After hatching, insects do not just grow larger; they undergo a series of major changes in body structure as they develop into adults. This process is called **Metamorphosis**.

- **Regulation:** The process is controlled by **chemical substances** within the insect.
- **Types:** There are two main types of metamorphosis based on the developmental stages.

A. Complete Metamorphosis

- This type involves **four** distinct stages.
- The young (larva) looks completely different from the adult.
- **The Cycle:** **Egg** → **Larva** → **Pupa** → **Adult**.
- **Example:** Honeybees, Butterflies.

B. Incomplete Metamorphosis

- This type involves **three** stages.
- The young (nymph) often resembles a smaller version of the adult.
- **The Cycle:** **Egg** → **Nymph** → **Adult**.
- **Example:** Grasshoppers.

Reproduction in Frogs

- *Frogs are amphibians found throughout the world, including specific genera like **Ptychadena harena** and **Leptopelis ragazzi** found in the Bale Mountains and Shoa forests of Ethiopia.*
- *The common frog (**Rana temoraria**) is the most common in Europe*
- *The grass frog genus **Ptychadena goulenger** is found throughout sub-Saharan Africa, including Ethiopia.*
 - **Mode of Reproduction:** They undergo **Sexual Reproduction**.
 - **Reproductive Structures:** They possess distinct male and female reproductive systems.

FERTILIZATION AND EGGS

Unlike birds or reptiles, frogs have specific requirements for their eggs due to their lack of a hard shell.

- **Egg Structure:** Frogs do **not** produce amniotic eggs. Instead, their eggs are covered in a **jelly-like substance**.
- **Habitat Requirement:** Because they lack a hard shell, they must lay their eggs in **water** to protect them from drying out.
- **Type of Fertilization:** Most frogs undergo **External Fertilization**.
 - The female releases eggs from her body into the water.
 - The male releases sperm into the water to fertilize the eggs.
 - **Note:** Internal fertilization occurs in only a few rare species.
- **Quantity:** Frogs usually lay a **large number of eggs** in the same place at the same time to ensure the survival of some offspring.

METAMORPHOSIS IN FROGS

Frogs undergo a distinct developmental process called **Metamorphosis**, where the young look completely different from the adult.

- **Larval Stage:** After fertilization, the egg develops into a larva called a **Tadpole**.
- **Differentiation:** The tadpole is structurally very different from the adult frog (e.g., it lives entirely in water and has a tail).
- **The Life Cycle:**
 1. **Fertilized Eggs** (surrounded by jelly).
 2. **Tadpole** (larval stage).
 3. **Young Frog** (undergoing changes).
 4. **Adult Frog**.

Feature 	Tadpole (Larva)	Adult Frog
Habitat	Exclusively aquatic (water)	Semi-aquatic (land and water)
Breathing	Gills (extract oxygen from water)	Lungs and moist skin
Movement	Long tail for swimming; no legs	Four legs for hopping; no tail

Reproduction in Crocodiles

- Crocodilians are large **semi-aquatic reptiles** found in various parts of the world. Like other vertebrates, they reproduce sexually involving both male and female parents.

MATING AND FERTILIZATION

- **Mating Season:** Usually begins in **July or August**.
- **Location:** Mating takes place **underwater**.
- **Fertilization Type:** Crocodiles undergo **Internal Fertilization**. The sperm fertilizes the egg and develops inside the female before being laid.

EGG LAYING AND DEVELOPMENT

- **Nesting:** Females lay their eggs and either **bury them in sand** or deposit them in **mound vegetation**.
- **Egg Structure:** Unlike frogs, crocodiles produce **hard, leathery eggs**.
 - **Significance:** This shell enables them to protect their young and prevents the eggs from drying out on land.
- **crocodiles are amniotes**
- **Quantity:** The number of eggs deposited varies from **10 to 100**, depending on the specific species.

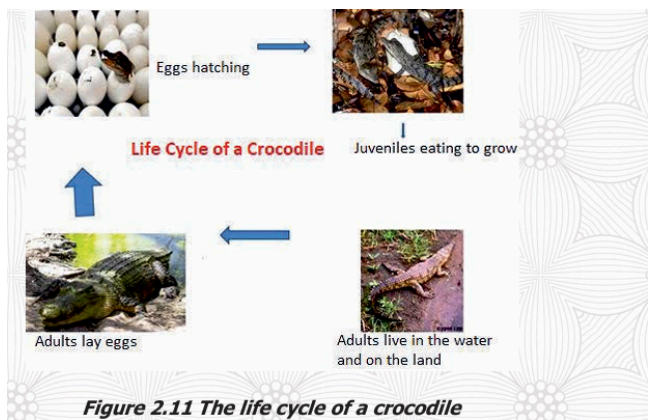


Figure 2.11 The life cycle of a crocodile

The general life cycle involves:

1. **Adults lay eggs** (on land/sand).
2. **Eggs hatch**.
3. **Juveniles** eat to grow.
4. **Adults** live in the water and on the land.

Reproduction in Birds

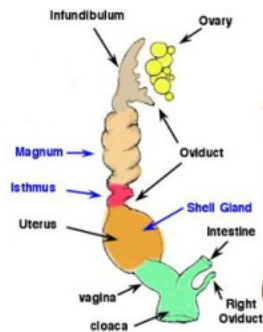
- Reproduction in birds is a key process for perpetuating species. All birds reproduce **sexually** and utilize **Internal Fertilization**.
 - **Mating Systems:**

- **Monogamous:** A mating system between a single adult male and a single adult female for an entire breeding season (most common).
- **Polygamous:** A mating system involving several partners during a single breeding season.

- **birds are amniotes**

REPRODUCTIVE ANATOMY

- **Male:** Does not have external genital organs.
- **Female:** Typically has a **single ovary**.
- **The Oviduct:** The tube where the egg travels and develops. It consists of five distinct parts:
 1. **Infundibulum:** Funnel-shaped upper portion; engulfs the yolk.
 2. **Magnum:** The longest part; secretes **albumen** (egg white).
 3. **Isthmus:** Short portion; forms the **shell membranes** (inner and outer) and produce sulfur-containing amino acids for shell formation
 4. **Uterus:** Where the egg takes the longest time; forms the **eggshell** over the membranes.
 5. **Vagina:** The final section separated by a sphincter; leads to the cloaca for laying.



FERTILIZATION AND EGG FORMATION

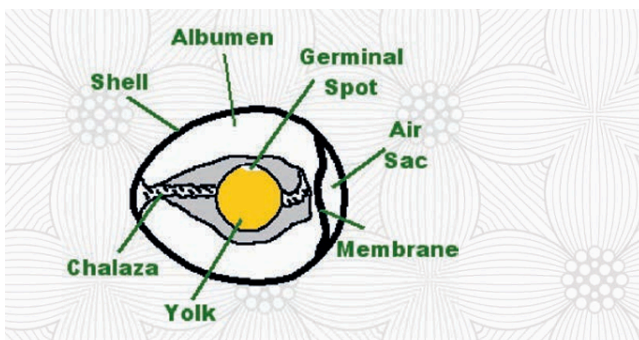
- **The Cloaca:** Both males and females possess a cloaca. During mating, sperm is transferred from the male cloaca to the female cloaca.
- **Fertilization:** The sperm travels up to the **Infundibulum** to fertilize the ovum.
- **Development:** As the fertilized egg travels down the oviduct:
 - A layer of **albumen** forms around it.
 - **Shell membranes** are added.
 - A **hard shell** forms in the uterus.
 - A fluid-filled **amnion** forms a closed sac around the embryo.



EGG STRUCTURE

The major parts of a bird egg include:

- Yolk, Chalaza, Albumen, Membranes, Air Sac & Shell



INCUBATION AND HATCHING

- **Incubation (Brooding):** The process of keeping eggs warm with body heat to allow embryonic development.
- In most cases, the female parent incubates the eggs, although males sometimes participate.
 - **Brood Patch:** Females develop a patch of skin with densely packed blood vessels to transfer heat effectively to the eggs(featherless area).
 - **Rotation:** Birds rotate eggs periodically to ensure even warmth.



Hatching:

- **Communication:** Chicks may communicate with parents via vocal sounds a day or two before hatching.
- **Egg Tooth:** The chick develops a hard, tooth-like structure at the tip of its beak to break the eggshell. This structure is lost after hatching.

PARENTAL CARE

- **Nests:** Built to protect young and hide from predators.
- **Camouflage:** Birds nesting in open areas often lay camouflaged eggs(to protect from predators).
- **Care Duration:** Varies widely.
 - Some hatchlings dig themselves out and are independent immediately (e.g., megapodes):- **mound-builders**.
 - Others require extended care and feeding from parents (e.g., African Paradise Flycatcher).



African Paradise Flycatcher caring for chicks

Reproduction in Rats

- **Rat (genus Rattus)** refers to many species of rodents.
- **Common species:**
 - **Black rat (Rattus rattus)** – mostly in warmer climates.
 - **Brown rat (Rattus norvegicus)** – mostly in temperate regions.
- Rats live almost everywhere humans have settled.
- **Giant mole rat (Tachyoryctes macrocephalus)**, or **giant root rat:**
 - **Endemic to Ethiopia.**
 - Found in high-altitude shrub and grasslands of the Afro-alpine habitat, e.g., **Bale Mountains**.

REPRODUCTIVE ANATOMY

- **Male Reproductive System:**
 - **Testes, Scrotum, Epididymis, Vas Deferens & Penis**
- **Female Reproductive System:**
 - **Ovaries, Oviducts, Uterine Horns & Vagina with Vulva**
- Reproduction in rats **representative of mammalian sexual reproduction**
- The processes of internal fertilization, gestation, and lactation observed in rats share fundamental similarities with other mammals, including humans.

PREGNANCY AND DEVELOPMENT

- **Internal Fertilization:** Sperm fertilizes the egg inside the female's body.
- **Gestation Period:** The length of pregnancy varies by species.
 - *Brown Rat:* 22–24 days.

- *Black Rat*: ~22 days.
- *Giant Mole Rat*: 37–49 days (longer gestation is typical for this species).
- **Developmental Stages:**
 1. **Zygote**: Single fertilized cell.
 2. **Blastocyst (Blastula)**: A hollow ball of cells that travels down the oviducts.
 3. **Implantation**: The blastocyst attaches to the wall of the **uterine horns**.
 4. **Support Systems:**
 - **Placenta**: The critical organ for exchange between mother and fetus (oxygen/nutrients in, waste out).
 - **Umbilical Cord**: The physical connection for transport.
 - **Amniotic Sac**: Fluid-filled protection for the embryo.

BIRTH AND MATURATION

- **State at Birth**: Pups are born **altricial** (undeveloped)—hairless, deaf, and with eyes sealed shut.
- **Litter Size**: Typically 7–12 offspring (Giant Mole Rats usually have fewer).
- **Lactation**: The mother produces milk to feed the young.
- **Weaning**: Young are fully weaned and foraging independently after **45 days**.
- **Sexual Maturity**:
 - *Common Rats*: 3–4 months.
 - *Giant Mole Rats*: 4–6 months

PARENTAL CARE BEHAVIOR

Parental care in mammals is often critical for offspring survival.

- **Nesting**: Mothers build nests to protect the vulnerable pups/kittens.
- **Communal Care**: Female rats exhibit strong maternal instincts, caring for pups regardless of biological relation. If a mother dies, other females will nurse her young.
- **Male Role**: Males generally do **not** participate in parental care.

Economic Importance of Insects

- Insects are the most diverse animals on Earth. They have **beneficial** and **harmful** impacts on agriculture, industry, health, and food security.

BENEFICIAL ASPECTS OF INSECTS

A. Agriculture

Insects provide essential ecosystem services that support crop production.

- **Pollination**:
 - **Pollinators**: Flower-visiting insects (e.g., bees) transfer male gametes (pollen) to female gametes, enabling plant reproduction.
 - **Impact: global crop production** depends on insect pollination. This has immense economic value.
- **Pest Regulation (Biological Control)**:
 - Predatory and parasitic insects attack harmful pests, acting as a **natural control method**.
 - **Examples**:
 - **Mantis (*Stagmomantis*)**: Feeds on grasshoppers and caterpillars.
 - **Ladybird Beetle (*Chilomenes*)**: Feeds on aphids (cotton pests) and scale worms (orange and lemon tree pests).
 - **Blister Beetle (*Epicauta*)**: Eats locust eggs.
- **Soil Improvement**: Insects aid in soil aeration, nutrient cycling, and decomposition.

B. Food Sources (Entomophagy)

- **Human Consumption**: Over 1,462 species are edible. Insects like crickets, grasshoppers, and termites are protein-rich food sources, particularly in Asia and Central America.
- **Animal Feed**: Insects serve as a sustainable protein source for livestock, poultry, and fish farming.
- **Advantages**: High growth rates, high nutritional value (protein, fats, minerals), and low environmental footprint.

C. Industrial Uses

Insects are biological factories for various commercial products:

- **Honey and Beeswax**: Produced by Honeybees (*Apis mellifera*). Used for food and commercial wax.
- **Silk**: Produced by Silkworms (*Bombyx mori*). The fibers are woven into luxurious textiles.
- **Shellac**: A resin secreted by **Lac insects** (*Laccifer lacca*). Used in dyes, inks, polishes, and sealing waxes.
- **Cochineal Dye**: A red pigment extracted from scale insects (*Dactylopius coccus*). Used in foods, cosmetics (lipsticks), and art.
- **Tannic Acid**: Produced in gall tissues of trees in response to secretions from tiny wasps (family Cynipidae). Used for tanning leather and making ink.

D. Medicinal Uses

- **Honey**: Treats burns and chronic wounds.
- **Bee/Ant Venom**: Used to treat joint pain and inflammation.
- **Cantharidin**: Secreted by **Blister Beetles**. It is a powerful protein blocker used to treat severe viral infections and potentially cancerous tumors.
- **Traditional Medicine**: Poultices made from ground grasshoppers are used in some African cultures as pain relievers.

HARMFUL ASPECTS OF INSECTS

A. Agricultural Pests

Insects can destroy crops in fields and stored grains, leading to massive economic losses.

- **Crop Destroyers**: Locusts, caterpillars, aphids, and bugs feed on plant parts (leaves, stems, fruits).
 - **Locusts**: The most destructive; migrate in huge swarms and devour vegetation in hot/dry regions.
- **Storage Pests**: Insects that infest stored cereal grains.
 - *Rice Weevil* (*Sitophilus oryzae*)
 - *Lesser Grain Borer*
 - *Flour Beetles*

B. Disease Vectors

Insects transmit diseases (vectors) or serve as intermediate hosts for pathogens affecting humans and animals.

- **Anopheles Mosquito:** Transmits **Malaria** (*Plasmodium* parasite).
- **Culex Mosquito:** Transmits **Filariasis** (filarial worms).
- **Tsetse Fly:** Transmits **African Sleeping Sickness** (*Trypanosoma gambiense*).
- **Housefly:** Spreads food and water-borne diseases mechanically.

Animal Behavior

- Animal behavior refers to all the ways in which animals interact with other organisms and their physical environment. It includes movement, social interaction, and learning. Behavior is generally categorized into two types: **Innate** and **Learned**.

INNATE (INHERENT) BEHAVIOR

- Innate behavior is **inborn**. It is determined by **genes**, is independent of experience (does not require learning), and is specific to a species.

There are three primary types of innate behavior:

A. Instinctive Behavior

These are complex behaviors that animals perform naturally without prior experience.

- **Web Making:** Spiders spinning webs.
- **Nest Building:** Birds constructing nests.
- Swimming with dolphins and other aquatic species
- **Survival Responses:** Chicks opening their mouths when the mother returns to the nest.
- **Communication:** Honeybees performing a "**dance**" to indicate food sources.

B. Reflex Behavior

A **Simple Reflex** is a sudden, **involuntary response** to a stimulus.

- **Mechanism:** In a reflex action, pain signals often travel only to the **spinal cord** (not all the way to the brain). The spinal cord sends an immediate command to the muscles.
- **Significance:** This allows for a much faster response to danger.
- **Examples:**
 - Pulling your hand away rapidly from a hot or sharp object.
 - Blinking when dust approaches the eye

C. Orientation Behavior

This involves movement in response to external stimuli. It is divided into two specific types:

- **Taxis (Directed Movement):**
 - Movement is **directed** in relation to the **source of the stimulus**.
 - **Positive Taxis:** Movement **towards** the stimulus.
 - **Negative Taxis:** Movement **away** from the stimulus.
 - **Example:** Cockroaches running away from light (Negative Phototaxis).
 - It can be *phototaxis*, *chemotaxis*, *thigmotaxis* and *geotaxis*
- **Kinesis (Undirected Movement):**
 - Movement is **random** and **undirected**.
 - The animal responds to the **intensity** of the stimulus rather than its direction.
 - **Example:** Woodlice moving more or less actively depending on the **temperature** around them.

Learned Behavior

- Learned (or acquired) behavior is **not inherited** and is not determined solely by genes. Instead, it is acquired during an individual's lifetime. It allows animals to adapt to environmental changes based on previous experiences.

TYPES OF LEARNED BEHAVIOR

A. Habituation

- **Definition:** A simple form of learning where an animal stops responding to a stimulus after repeated exposure because the stimulus provides no reward or punishment.
- The response **Decreases** over time.
- **Concept:** It is a form of **non-associative learning** (not linked to outcomes).
- **Example:** Reading a book while a television is on. At first, the sound is annoying, but after a while, you stop noticing it because you have become accustomed to the sound.

B. Sensitization

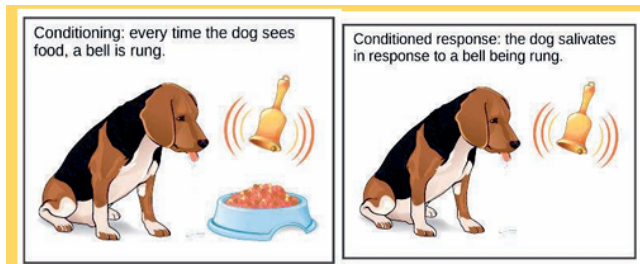
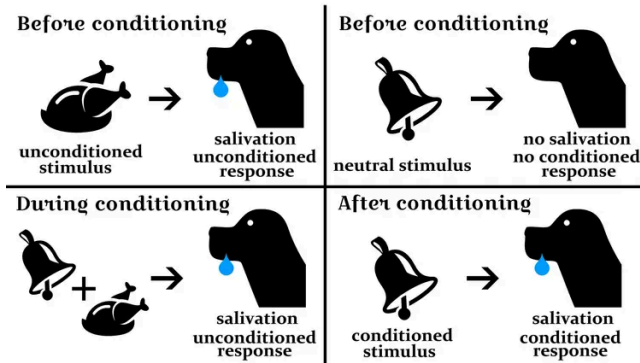
- **Definition:** A **non-associative** learning process where repeated exposure to a stimulus results in a **progressive amplification** (increase) of the response.
- The response **Increases** over time
- **Concept:** Also known as "reverse tolerance." It usually occurs when a stimulus is painful or intense.
- **Example:** If you are exposed to a painful stimulus, you may become **hypersensitive** to a subsequent loud noise that wouldn't normally bother you.
- **Another Example:** You are walking alone in a dark, scary alley and hear a loud bang (a car backfiring). Now, even the tiny sound of a rustling leaf makes you jump and heart race

Feature	Habituation	Sensitization
Response	Decreases over time.	Increases over time.
Why it happens	The stimulus is harmless or irrelevant.	The stimulus is dangerous or intense.
Goal	To ignore distractions (filter out noise).	To stay alert for potential threats.

C. Classical Conditioning

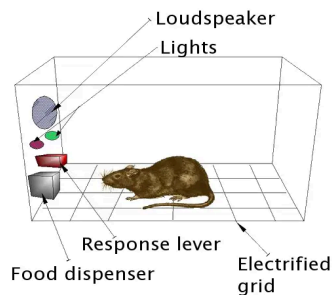
- **Definition:** A type of **associative learning** where a natural response becomes associated with a new, previously neutral stimulus.
- **Discovery:** Discovered by the Russian physiologist **Ivan Pavlov**.
- **The Process (Pavlov's Dog Experiment):**
 1. **Before Conditioning:** Food (Unconditioned Stimulus) naturally causes salivation (Unconditioned Response,). A bell (Neutral Stimulus) causes no response.

2. **During Conditioning:** The bell is rung just before giving food. This is repeated many times. Unconditioned Response and conditioned stimulus
3. **After Conditioning:** The bell alone (now the Conditioned Stimulus) causes salivation (Conditioned Response).



D. Operant Conditioning

- **Definition:** A type of **associative learning** where behavior is modified by its consequences (reward or punishment).
- It is the only **trial-and-error learning**
- **Discovery:** Discovered by **B.F. Skinner**.
- **Mechanism:** An organism performs a behavior and receives a consequence.
 - **Reinforcement (Reward):** Increases the likelihood of the behavior being repeated (can be positive or negative).
 - **Punishment:** Decreases the likelihood of the behavior being repeated.
- **Skinner's Responses:**
 - **Neutral Operants:** Responses that neither increase nor decrease the behavior.
 - **Reinforcers:** Increase probability of repetition.
 - **Punishers:** Decrease probability of repetition.



E. Insight Learning

- **Definition:** The most complex form of learning, based on **reasoning** and past experience to solve new problems without trial and error.
- **Characteristic:** It is a hallmark of human behavior and higher primates.
- **Insight learning** involves **sudden understanding** of a problem and The solution appears **all at once**, not gradually
- **Example:** Humans using logic to solve complex problems, ranging from starting a fire to traveling to the moon.

Insight Learning in Chimpanzees experiment

In the famous 1920s studies by **Wolfgang Köhler**, a chimpanzee named **Sultan** was placed in a room with a bunch of bananas hanging out of reach from the ceiling. Several crates were scattered around the room.

1. **Not Trial-and-Error:** Sultan didn't just jump randomly for hours.
2. **The "Aha!" Moment:** After a period of calm observation, Sultan suddenly moved the crates, stacked them on top of each other, climbed up, and grabbed the bananas.

Theory of Insightful learning



F. Latent Learning

- Latent learning is a type of learning that occurs **without conscious awareness** and **without immediate reinforcement**.
- The knowledge gained is **not shown right away** but is **used later when needed**.
- In latent learning, the learner draws a **cognitive map** (a mental picture of the environment).
- Example:** A student learns the layout of a school by walking around every day, even without trying to memorize it. Later, the student can easily find a new classroom.

Patterns of Behavior

- While behavior varies by species, many animals exhibit common **behavioral patterns** essential for survival and reproduction. These include cycles, social structures, and methods of interaction.

BEHAVIORAL CYCLES

These are patterns where animals respond to periodic changes in the environment.

- Seasonal Migration:**
 - Definition:** The movement of species from one habitat to another at different times of the year.
 - Triggers:** Seasonal fluctuations in food, sunlight, temperature, or breeding needs.
 - Example:** Whales migrating from summer feeding grounds in the Arctic/Antarctic to warmer tropical waters near the equator to breed.
- Circadian Rhythms (Biological Clocks):**
 - Definition:** 24-hour cycles driven by the body's internal clock.
 - Function:** Regulates essential processes like the **sleep-wake cycle**.

REPRODUCTIVE BEHAVIOR

This pattern coordinates the timing and actions required for reproduction.

- Purpose:** Vital for locating mates, selecting suitable partners, and rearing offspring.
- Courtship:** A specific set of display behaviors to attract a mate.
 - Examples:** Pigeons engaging in courtship displays; birds using sounds, visual displays (like the Paradise Dance), or chemicals.

SOCIAL BEHAVIOR

Observed in animals that live in groups, allowing for cooperation and division of labor.

- Insect Societies:** Insects like ants, termites, and bees have highly developed social structures.
 - Benefit:** Division of labor (e.g., workers vs. soldiers) increases efficiency and survival.
- Vertebrate Societies:** Elephants, penguins, and primates (including humans) exhibit complex social bonds.
 - Example:** *Elephants paying homage(respect) to dead relatives.*



COMPETITION

A natural interaction between organisms coexisting in the same environment, striving for limited resources.

- Resources:** Space, territory, water, mates, and food.
- Types:**

- **Intraspecific:** Competition between members of the **same** species.
- **Interspecific:** Competition between members of **different** species.

TERRITORIALITY

A behavioral pattern involving the defense of a specific space containing necessary resources.

- **Defense Strategy:** Animals often use **display behavior** (signaling) rather than fighting, as it saves energy and is safer.
- **Examples:**
 - **Chemical Signals:** Male dogs and lions use **pheromones** in urine to mark territory boundaries.
 - **Visual/Auditory Signals:** Male gorillas pound their chests; Robins display their red breasts to warn intruders.



Figure 2.30 Lion keeping territory



- Robins display their red breasts to warn intruders.

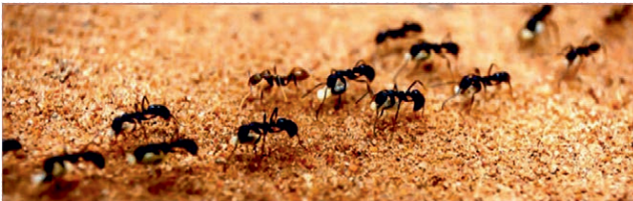


Male gorillas pound their chests

COMMUNICATION BEHAVIOR

Vital for interaction, animals communicate using various sensory cues.

- **Visual:** Sight-based signals (e.g., body posture).
- **Auditory:** Sound-based signals (e.g., birds singing, frogs croaking).
- **Tactile:** Touch-based signals.
- **Chemical:** Using special chemicals called **Pheromones**.
 - **Example:** Ants use pheromones to mark trails to food sources so other ants can follow.



Homeostasis in Animals

- Homeostasis is the **self-regulatory process** by which animals maintain stable internal conditions (equilibrium) despite changes in the external environment.
 - **Significance:** Environmental changes can negatively affect physiological functions. Animals must maintain their internal environment (body temperature, glucose, water levels) at a "set point" or normal range to survive.
 - **Mechanism:** Body systems constantly adjust to internal and external changes to keep this balance.

THE FOUR COMPONENTS OF HOMEOSTASIS

Homeostasis relies on a **feedback loop** involving four distinct components:

A. Stimulus

- **Definition:** A change in the internal or external environment that forces the organism to respond.
- **Examples:** An increase or decrease in body temperature, a rise in blood glucose levels, or a change in water balance.

B. Receptor (Sensor)

- **Definition:** A specialized structure that detects the change (stimulus) and sends a signal to the control center.
- **Example:** **Thermoreceptors** (nerve endings) in the skin detect temperature changes.

C. Control Center

- **Definition:** The processing center that receives messages from receptors and issues commands to the effectors.
- **Key Organ:** The **Hypothalamus** (a region of the brain) acts as the primary control center for homeostasis in vertebrates.

D. Effector

- **Definition:** An organ or tissue that acts on the command from the control center to counteract the change and return the body to normal.
- **Examples:**
 - **Kidneys:** Adjust water levels.
 - **Liver:** Adjusts glucose levels.
 - **Muscles/Glands:** Shiver or sweat to adjust temperature

Stimulus → Receptor (Sensor) → Control Center → Effector → Response

Thermoregulation

- Thermoregulation is the process of maintaining the internal body temperature at a constant or optimal level. Animals use behavior, physiology, and morphology to achieve this.

CLASSIFICATION BY TEMPERATURE REGULATION

A. Poikilothermic (Cold-blooded) Animals

- **Definition:** Also known as **ectotherms**. They lack internal physiological control over their body temperature. Their temperature generally matches the environment.
- **Regulation Methods:** They rely largely on **behavioral control**.
 - **Hot Days:** They may burrow into the ground or seek shade.
 - **Cold Days:** They may bask in sunlight or climb onto rocks to absorb heat.
 - **Examples:** Fish, Reptiles, Amphibians, and Invertebrates.

B. Homeothermic (Warm-blooded) Animals

- **Definition:** Also known as **endotherms**. They generate **internal heat** to maintain a constant body temperature regardless of the environment.
- **Regulation Methods:** They use physiological, morphological, and behavioral methods.
 - **Examples:** Mammals and Birds

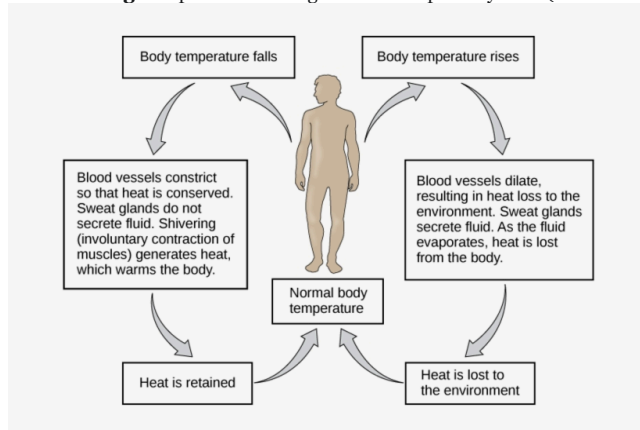
PHYSIOLOGICAL CONTROL IN HOMEOTHERMS

Response to Cold (Retaining Heat):

- **Insulation**(Subcutaneous fat): Using fur, fat, or feathers (e.g., Arctic Fox uses its fluffy tail to sleep in curled).
- **Vasoconstriction:** Narrowing of blood vessels near the skin surface to reduce blood flow and heat loss.
- **Shivering:** Involuntary muscle contractions that generate heat through respiration.

Response to Heat (Losing Heat):

- **Vasodilation:** Widening of blood vessels near the skin surface to increase blood flow and release heat via radiation.
- **Sweating (Diaphoresis):** Releasing fluid from sweat glands to cool the body via evaporation.
- **Panting:** Evaporative cooling from the respiratory tract (common in dogs).



- Body temperature is regulated through four heat-exchange mechanisms with the environment: radiation, evaporation, convection, and conduction.

IMPACT OF BODY SIZE (Surface Area to Volume Ratio)

The physical structure of an animal affects how fast it loses or gains heat.

- **The Principle:**
 - **Small Animals (e.g., Rabbit):** Have a **High** Surface Area-to-Volume ratio. They lose heat **quickly**.
 - **Large Animals (e.g., Elephant):** Have a **Low** Surface Area-to-Volume ratio. They lose heat **slowly**.

Morphological Adaptations:

- **Hot Climates:** Animals often have **large ears** (e.g., desert foxes, elephants) to increase surface area and maximize heat loss.
- **Cold Climates:** Animals often have **small ears** and compact bodies to minimize surface area and conserve heat.

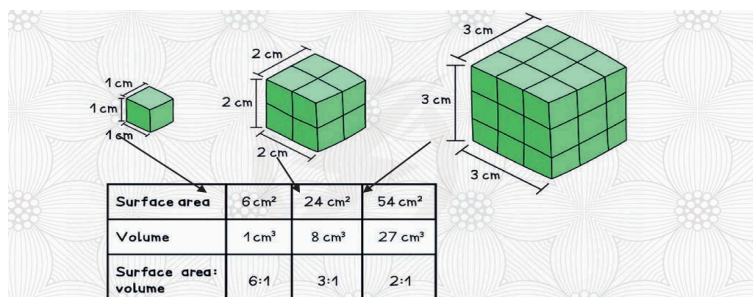


Figure: As size increases the surface area: volume ratio decreases



Osmoregulation

Osmoregulation is the homeostatic process that regulates the **osmotic pressure** of body fluids and the **electrolytic balance** in organisms.

- **Context:** About 60% of the human body is fluid.
 - **Intracellular Fluid:** Fluid inside cells (2/3 of body water).
 - **Extracellular Fluid:** Fluid outside cells, including interstitial fluid and blood plasma (1/3 of body water).
- **Importance:** A disruption in osmotic pressure causes an imbalance in water movement and electrolyte concentration, which can damage cells.

MECHANISM OF CONTROL

- **Osmoreceptors:** Specialized sensors that detect changes in osmotic pressure. In humans and warm-blooded animals, these are located in the **Hypothalamus** (brain) and the **Kidneys**.
- **Key Organ:** The **Kidney** is the primary organ responsible for osmoregulation.
- **Key Hormone:** **Antidiuretic Hormone (ADH)**, secreted by the pituitary gland, controls how much water the kidneys reabsorb.

TYPES OF OSMOREGULATION

A. Osmoconformers

- **Definition:** Organisms that match the osmolarity of their body fluids with their surrounding environment.
- **Characteristic:** Their internal osmotic pressure is the same as the outside water.
- **Examples:** Marine invertebrates like **Starfish, Jellyfish, and Lobsters**.

B. Osmoregulators

- **Definition:** Organisms that actively regulate their internal osmotic pressure, keeping it independent of the surrounding environment.
- **Characteristic:** They maintain constant internal conditions regardless of whether they are in fresh or salt water.
- **Examples:** Most vertebrates, including **Humans**.

PHYSIOLOGICAL RESPONSE IN HUMANS

The kidneys adjust urine production based on the body's water level:

- **High Water Level:** The kidney releases a large amount of **hypotonic** (dilute) urine to remove excess water.
- **Low Water Level:** The kidney retains water and produces a small amount of **hypertonic** (concentrated) urine to conserve water. (This is why urine appears yellow when you are dehydrated).

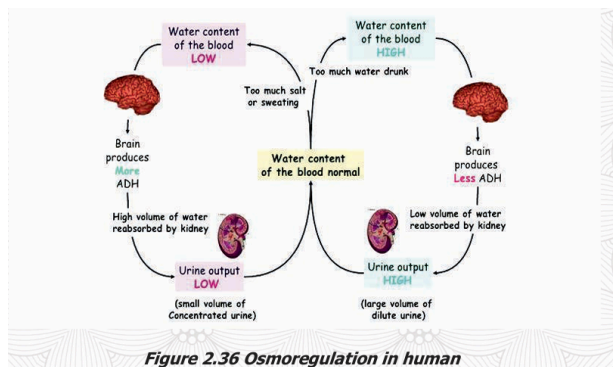


Figure 2.36 Osmoregulation in human

Blood Sugar Regulation

IMPORTANCE OF GLUCOSE

- Glucose is the primary source of energy for the body's normal functioning, especially the brain. The body must maintain a constant concentration of glucose in the blood to ensure a continuous energy supply for cellular respiration.

HORMONAL CONTROL

- The **Pancreas** produces two key hormones responsible for regulating blood sugar levels: **Insulin** and **Glucagon**.

A. Insulin (Lowers Blood Sugar)

- **Trigger:** Released when blood glucose levels are **High** (e.g., after a meal).
- **Action:**
 - Promotes the uptake of glucose by cells.
 - Stimulates the **Liver** to convert excess glucose into **Glycogen** for storage.
- **Result:** Blood glucose levels decrease.

Glucagon (Raises Blood Sugar)

- **Trigger:** Released when blood glucose levels are **Low** (e.g., during fasting or exercise).
- **Action:**
 - Stimulates the **Liver** to convert stored **Glycogen** back into **Glucose**.
- **Result:** The new supply of glucose is released into the blood, raising levels back to normal.

LIVER FUNCTION

The liver acts as the storage bank for sugar:

- **Storage:** Stores glucose as glycogen (facilitated by Insulin).
- **Release:** Breaks down glycogen into glucose (facilitated by Glucagon).

Control of Homeostasis

FEEDBACK MECHANISMS

- To maintain homeostasis, animals use feedback mechanisms. A feedback mechanism is a physiological regulation system that returns the body to its normal internal state after a change (stimulus) occurs.

There are two primary types of feedback mechanisms: **Negative** and **Positive**.

NEGATIVE FEEDBACK MECHANISM

This is the primary mechanism for maintaining homeostasis.

- **Definition:** A process that **reverses** the direction of the stimulus. If a level is too high, the body brings it down; if it is too low, the body raises it.
- **Goal:** To return the body to a normal "set point."
- **The Loop:**
 1. **Sensor (Receptor):** Monitors physiological values and detects deviation.
 2. **Control Center:** Compares the value to the normal range and activates the effector.
 3. **Effector:** Causes a change to reverse the situation.
- **Example: Thermoregulation**
 - **If Body is Hot:** Vasodilation and sweating occur to cool the body. Once cooled, the mechanism stops.
 - **If Body is Cold:** Vasoconstriction and shivering occur to warm the body.

POSITIVE FEEDBACK MECHANISM

This mechanism is less common in homeostasis but vital for specific physiological processes.

- **Definition:** A process that **accelerates** or amplifies a change rather than reversing it.
- **Goal:** To push the body further away from the normal state to complete a specific process.
- **Difference:** Unlike negative feedback, positive feedback does **not** restore balance; it drives a process to completion.
- **Example:**
 - **Childbirth:** Contractions stimulate the release of oxytocin, which causes even stronger contractions. This cycle continues until the baby is born.
 - **Blood Clotting:** Platelets release chemicals to attract more platelets, rapidly forming a clot to stop bleeding.

Renowned Zoologists in Ethiopia

- Zoology is the scientific study of animals, covering their evolution, anatomy, physiology, behavior, habitats, and health.

CONTRIBUTION OF ETHIOPIAN ZOOLOGISTS

Many zoologists from various Ethiopian universities have dedicated their lives to studying the country's diverse animal life.

- **Scientific Impact:** Their research contributes significantly to the global understanding of zoological science.
- **Economic Impact:** Their work supports national economic development through insights into agriculture, conservation, and resource management.
- **Patriotism:** these researchers exemplify patriotism not just through defense of the country, but through **diligence and hard work** in their professional duties to advance knowledge and development.