- Major groups of animals are defined by the design and construction of their basic body plan, which differs in the number of tissues observed in embryos, symmetry, the presence or absence of a body cavity, and the way in which early events in embryonic development proceed.

- Recent phylogenetic analyses of animals have shown that there were three fundamental splits during evolutionary history, resulting in two **protostome** groups (Lophotrochozoa and Ecdysozoa) and the **deuterostomes**. The most ancient animal group living today is the sponges. The closest living relatives to animals are choanoflagellates, a group of protists.
- Within major groups of animals, evolutionary diversification was based on innovative ways of feeding and moving. Most animals get nutrients by eating other organisms, and most animals move under their own power at some point in their life cycle.

An Introduction to Animals

Why Do Biologists Study Animals?

A. Animals are **heterotrophic.**
    1. They obtain energy and carbon compounds from primary producers, photosynthetic organisms such as plants, bacteria and protists.
    2. Some animals are consumers that eat the primary producers.
    3. Some animals are predators that eat the consumers.

B. Animals are fascinating and diverse.
    1. They are the most species-rich and diverse multicellular lineage of organisms.
    2. To understand the diversity of life, it is important to understand how animals became so diverse.

C. Humans depend on animals for food, transportation, and power.

D. Humans are animals!
    1. We need to study other animals to understand ourselves.
    2. Most testing and genetic studies done on other mammals.

II. How Do Biologists Study Animals?

A. Animals

1. are a monophyletic group of multicellular eukaryotes.
2. move on their own and are heterotrophs.
3. lack cells walls- have a supportive extracellular matrix.
4. are the only lineage with muscle and nervous tissue.
5. can reproduce sexually and asexually, but do not exhibit alternation of generations.
6. are extremely diverse, with **34 phyla** having distinct morphological features.

B. Analyzing Comparative Morphology

1. Animals are eating and moving machines.

a. Variation in mouth and limb morphology underlies the variation in eating and moving.

b. However, the basic animal **body plan** is remained relatively unchanged and is defined by:

(1) Number & types of tissues in the body
(2) Type of body symmetry and degree of cephalization
(3) Presence or absence of a fluid-filled cavity
(4) Steps of early embryonic development

2. The Evolution of Tissues

a. Sponges are considered **parazoans** ("beside animal"); they have specialized cell types, but lack **tissues**.

b. All other animals - **eumetazoans** (" truly-among-animals"); they have two or more different tissue types.

c. **Diploblasts** ("two-sprouts) have two tissue layers (**ectoderm** & **endoderm**).

(1) Embryonic endoderm gives rise to the gut.

(2) Ectoderm gives rise to skin & nervous system.

(3) Only cnidarians and ctenophorans are diploblastic.

(4) Cnidaria have been important model organisms for studying animal development.

d. **Triploblasts** have three tissue layers.

(1) Endoderm & ectoderm are similar to diploblasts.
(2) **Mesoderm** gives rise to muscles & circulatory system.
(3) All other animals have three tissue layers.

3. Symmetry and cephalization

a. Sponges are **asymmetrical**
b. Some animals have **radial symmetry**.
(1) have at least two planes of symmetry.
(2) Most float in water or are attached to a substrate.
(3) They capture prey or react to predators from more than one direction.
(4) Echinoderms - the only radial symmetrical triploblasts
c. Remaining animal phyla have **bilateral symmetry**.
(1) one plane of symmetry.
(2) Bodies long, narrow cylinders with a distinct head region.

(3) **Cephalization** - the evolution of a head region

(*a*) posterior region is specialized for movement.

(*b*) efficient for hunting and prey capture.

(4) All triploblasts are bilaterally symmetrical.

4. Evolution of a body cavity

a. Many animals have a fluid-filled internal cavity - a **coelom**

b. Diploblasts –no coelom.

(1) have a central canal for digestion & respiration.

(2) without a coelom- they are acoelomates.

c. Some animals have a cavity between the endoderm and mesoderm (**pseudocoelomates**)

(1) roundworms and rotifers are examples.

(2) coelom forms differently than that of other animals.

d. Remaining triploblasts have a true coelom;

(1) develops is encased by mesoderm

(2) surrounded by circulatory vessels & muscles

(3) it contains the internal organs.

(4) the coelom (and pseudocoelom) serves as a hydrostatic skeleton - facilitates movement in some animals (earthworms),

(*a*) filled with incompressible watery fluid.

(*b*) when surrounding muscles contract, water moves to a different part of the body.

(*c*) coordinated contractions = writhing & swimming motions.

5. The protostome and deuterostome patterns of development.
    a. Bilaterans (triploblastic, bilaterally symmetrical animals) two subgroups.
        (1) **Protostomes** include arthropods, mollusks, & annelids.
        (2) **Deuterostomes** include chordates and echinoderms.
    b. Different development for protostomes & deuterostomes
        (1) Differences in cleavage patterns

Most protostomes exhibit spiral cleavage resulting in a helical arrangement of cells.

Many deuterostomes exhibit radial cleavage resulting in cells stacked onto one another.

(2) Differences in gastrulation

(*a*) Gastrulation begins when cells invaginate and move toward the inside of the ball of cells.

(*b*) In protostomes, pore resulting from invagination becomes the mouth.

(*c*) In deuterostomes, the pore becomes the anus.

(3) Differences in coelom formation

(*a*) Protostomes- coelom forms from split in block of mesoderm.

(*b*) Deuterostomes- coelom forms when mesoderm cells pinch off gut.

6. Most bilaterally symmetrical triploblasts have **tube-within-a-tube body design**

a. Inner tube is the gut, outer tube forms the body wall.

b. mesoderm forms between the tubes.

c. Worms are classic, simple tube-within-a-tube animals

d. Evolution of the tube-within-a-tube body plan drives the diversification of animals

d. Choanoflagellates & sponges are sessile, feed the same way & lack tissues & symmetry.

e. Radially symmetrical, diploblastic animals likely evolved from sponges.

f. Bilaterally symmetrical, triploblastic animals evolved as follows; acoelomates, pseudocoelomates, & coelomates.

g. Coelomates split into protostomes and deuterostomes, and
(1) Radial symmetry evolved in adult echinoderms.
(2) Segmentation evolved independently in protostomes & deuterostomes.

h. Vertebrates - monophyletic group defined by presence of a skull.

i. Invertebrates - paraphyletic group of all invertebrates.

C. Using the Fossil Record

1. The earliest animal fossils are the Duoshantuo microfossils; date to 570 mya, include sponges & early embryos of more complex animals.
2. The Ediacaran fossils (565–544 mya) include sponges, small cnidarians, and ctenophorans.
3. The Burgess Shale fossils (525–515 mya) contain examples of bilaterally symmetrical, large-bodied species from most animal phyla, including chordates.

D. Evaluating Molecular Phylogenies

1. Gene sequence data for the rRNA used to estimate the phylogeny of 14 animal phyla.
2. Revised phylogenetic tree highlights several important observations:
    a. Most ancient triploblasts, Acoelomorpha, lack a coelom; supports hypothesis that more complex bodies evolved from simpler ones.
    b. An important split occurred within protostomates:
        (1) Ecdysozoa—arthropods and nematodes—grow by shedding their exoskeletons.
        (2) Lophotrochozoa—mollusks and annelids—grow by extending size of their skeletons.
    c. Segmentation evolved independently in annelids, arthropods, and vertebrates.
    d. Acoelomate condition in Platyhelminthes involved loss of a coelom because Platyhelminthes are lophotrochozoa.
    e. Nematodes and rotifers, both pseudocoelomates, arose from ancestors that had coeloms.

III. Diversification of Animals

A. Feeding

1. **Suspension (filter) feeding**

a. Capture food by filtering particles out of water or air.

b. Sessile filter feeders: clams

(1) Burrow into sediments using a muscular foot.

(2) Extend a siphon into the water.

(3) Use gills to pull water into the siphon.

(4) Filter food from water as it passes over the gills & is swept to the mouth.

c. Mobile filter feeders: krill

(1) Legs wave in and out as they swim forward.

(2) Projections on legs trap food particles.

(3) Food is moved up toward mouth and ingested.

d. Large suspension feeders: whales

(1) Have a series of plates extending from jaws made of baleen.

(2) Gulp water; squeeze water out through the plates, filtering out krill.

e. Belong to a number of taxonomic groups.

2. **Deposit feeders**

a. eat their way through a substrate.

b. may be detrivores that eat dead or partially decayed organic matter—Earthworms.

c. may be herbivores that eat plant leaves or stems—insects.

d. all have simple mouthparts, and a wormlike body shape.

e. belong to several different taxonomic groups.

3. **Herbivory**

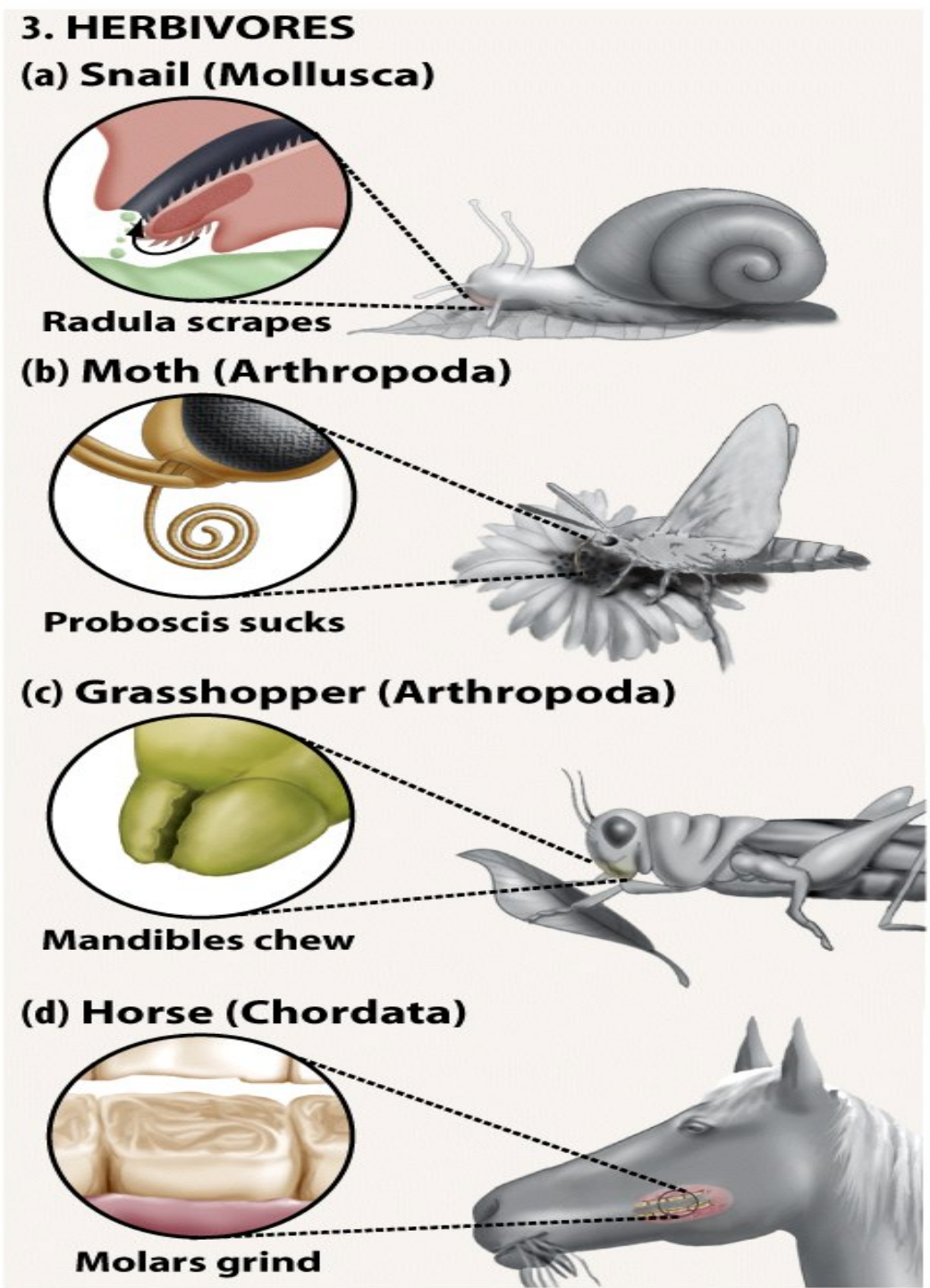
a. Many animals from different phyla eat algae or plants.

b. Have complex mouths with structures that support biting, chewing, sucking, & grinding.

(1) **Radula** of mollusks scrapes material away from a plant or alga.

(2) Long, hollow **proboscis** of a moth sucks nectar from flowers.

(3) **Mandibles** of grasshoppers & molars of horses chew & grind leaves and stems.



4. **Predators**

a. eat other animals different strategies to find & capture their prey.

b. Sit-and-wait predators: frogs

(1) Sit still, waiting for prey to move close.

(2) Use a quick reaction to capture the prey.

c. Stalkers: wolves

(1) Locate their prey and run it down.

(2) Live and hunt in packs.

(3) Other stalkers are solitary hunters that wait & pounce

5. **Parasitism**

a. Parasites - generally much smaller than their prey.

b. Often harvest nutrients from their prey without killing them.

c. **Endoparasites** live inside their hosts.

(1) Often wormlike shape, live in the gut of their host.

(2) e.g., Platyhelminthes - no digestive system; hook onto their hosts' digestive tract.

(3) Most other endoparasites have a mouth and a digestive tract.

d. **Ectoparasites** live outside their hosts.

(1) Usually have grasping mouth parts that pierce host's skin & suck nutrient-rich fluid from inside.

(2) Lice, ticks, and mosquitoes are ectoparasites.

B. **Movement**

1. Even some sessile animals move at some point during their lives.
    a. Sea anemone eggs swim via cilia to disperse.
    b. Then, as adults, they attach to rocks.
2. Locomotion has three main purposes:
    a. To find food
    b. To find mates
    c. To escape from predators
3. The structures that power movement:
    a. Cilia, flagella
    b. Muscles attached to a hydrostatic skeleton
    c. Muscles that power limbs

4. Types of limbs: Jointed and unjointed

a. 2 major limb lineages - ecdysozoans and vertebrates

(1) Onychophorans (velvet worms) have unjointed, saclike limbs.

(2) Arthropods and vertebrates have jointed, more complex limbs.

b. Jointed limbs allow for fast, coordinated movement.

c. Jointed limbs of arthropods and vertebrates work the same;

d. Difference between arthropod & vertebrate limbs- skeleton.

(1) Ecdysozoans - hard, outer skeleton called the exoskeleton.

(2) Vertebrates have a rigid internal skeleton, called an endoskeleton.

(3) Skeleton a rigid structure that resists muscle force in both.

5. Are all animal appendages homologous? (from a common ancestor)
   a. It is hypothesized; animal limbs have evolved independently several times.
   b. Consider the variety in limb types
      (1) Arms and legs of vertebrates, arthropods, etc.
      (2) Wings of vertebrates, arthropods, etc.
      (3) Parapodia of earthworms
      (4) Tube feet of echinoderms
      (5) Diversity in structure led biologists to hypothesize that there was little to no genetic homology.

Recent data challenges this view, implies all animal limbs have some degree of homology

C. Animal reproduction and life cycles are diverse

1. Some animal phyla (e.g. rotifers) only reproduce asexually
2. During sexual reproduction, fertilization may be internal or external.
    a. During internal fertilization, males usually insert a sperm-transfer organ into the female, where the egg is fertilized.
    (1) Sometimes sperm packets are picked up by the females.
    (2) In sea horse, eggs are inserted into the male, fertilized by sperm there.
    b. During external fertilization, the egg is fertilized outside the female's body.
    (1) Males either cover eggs directly with sperm
    (2) Or shed sperm directly into water that also contains the eggs.

3. During sexual reproduction eggs and embryos may be retained in the body of the female, or may be deposited by the mother.
   a. **Viviparous** animals give birth to live young.
   b. **Oviparous** animals lay fertilized eggs
   c. **Ovoviviparous** animals retain eggs that are nourished by a yolk.

4. **Metamorphosis** is a type of life cycle that involves a dramatic change from juvenile to adult.
   a. In species that undergo metamorphosis, each stage is distinct.
      (1) The larva is the sexually immature juvenile form.
      (2) During pupation, the body is remodeled into adult form.
      (3) The nymph is the sexually immature young adult form.
      (4) Adults are sexually mature, and are morphologically distinct from larvae or nymphs.

b. Metamorphosis can be complete or incomplete.

(1) **Complete or holometabolous** metamorphosis occurs when the animal experiences a dramatic change in form

(*a*) This occurs in mosquitoes.

(*b*) This also occurs in cnidaria.

(2) **Incomplete or hemimetabolous** metamorphosis: when the animal experiences a gradual change in form (grasshoppers)