Chapter 31 Introduction to Animals

I. 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. (**Fig. 31.1**)
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 drug testing and genetic studies are done on other mammals.

II. How Do Biologists Study Animals?

A. How do biologists define what an animal is?
1. They are a monophyletic group of multicellular eukaryotes.
2. They move on their own, and are heterotrophs.
3. Their cells lack walls, but have a supportive extracellular matrix.
4. No other lineage has members with muscle and nervous tissue.
5. They can reproduce sexually and asexually, but do not exhibit alternation of generations.
6. They are extremely diverse, with 34 phyla having distinct morphological features. (**Table 31.1**).

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. (**Fig. 31.2**)
   b. However, the basic animal body plan is remained relatively unchanged and is defined by:
      (1) Number and 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; they have specialized cell types, but lack tissues.
   b. All other animals are eumetazoans; they have at least two different types of tissues.
   c. Diploblasts have two tissue layers.
      (1) Embryonic endoderm gives rise to the gut.
      (2) Ectoderm gives rise to the skin and nervous system.
      (3) Only cnidarians and ctenophorans are diploblastic. (**Fig. 31.3**)
      (4) Cnidaria have been important model organisms for the study of animal development. (**Box 31.1, Fig. 31.4**)
   d. Triploblasts have three tissue layers.
      (1) Endoderm and ectoderm are similar to diploblasts.
      (2) Mesoderm gives rise to muscles and circulatory system.
      (3) All other animals have three tissue layers.
3. Symmetry and cephalization
   a. Sponges are asymmetrical (**Fig. 31.5a**)
   b. Some animals have radial symmetry. (**Fig. 31.5b**)
      (1) These animals have at least two planes of symmetry.
      (2) Most of them float in the water or are attached to a substrate.
      (3) They capture prey or react to predators from more than one direction.
      (4) Echinoderms are the only triploblastic animals with radial symmetry.
   c. The rest of animal phyla have bilateral symmetry. (**Fig. 31.5c**)
      (1) These animals have only one plane of symmetry.
      (2) Bodies tend to be long, narrow cylinders with a distinct head region.
      (3) Cephalization refers to the evolution of a head region that contains sensing and processing structures such as eyes and a brain.
         (*a*) The opposite end of the animal, the posterior region, is specialized for movement.
         (*b*) This is an efficient way to hunt and capture prey.

    (4) All triploblastic organisms are bilaterally symmetrical.
4. Evolution of a body cavity
    a. Many animals have a fluid-filled internal cavity called a coelom.
    b. Diploblasts do not have a coelom. (**Fig. 31.6a**)
        (1) They have a central canal for digestion and respiration.
        (2) Because they lack a coelom, they are called acoelomates.
    c. In some animals the cavity forms between the endoderm and mesoderm. (**Fig. 31.6b**)
        (1) Roundworms and rotifers are examples.
        (2) These are called pseudocoelomates, because their coelom forms differently than that of other animals.
    d. The rest of the triploblasts have a true coelom. (**Fig. 31.6c**)
        (1) A true coelom develops within and is encased by the mesoderm.
        (2) The coelom is surrounded by circulatory vessels and muscles.
        (3) It contains the internal organs.
        (4) The coelom serves as a hydrostatic skeleton that facilitates movement in some animals (earthworms).
            (*a*) The coelom is filled with incompressible watery fluid.
            (*b*) When muscles surrounding the coelom contract, the water moves to a different part of the body.
            (*c*) These coordinated contractions allow for writhing and swimming motions. (**Fig. 31.7**)
5. The protostome and deuterostome patterns of development.
    a. Bilaterans (triploblastic, bilaterally symmetrical animals) can be split into two subgroups.
        (1) Protostomes include arthropods, mollusks, and annelids.
        (2) Deuterostomes include chordates and echinoderms.
    b. The difference between protostomes and deuterostomes is in how they develop.
        (1) Differences in cleavage patterns (**Fig. 31.8a**)
            (*a*) Most protostomes exhibit spiral cleavage—a pattern that results in a helical arrangement of cells.
            (*b*) Many deuterostomes exhibit radial cleavage, resulting in cells that are stacked onto one another.
        (2) Differences in gastrulation (the cell movements that result in the formation of three tissue layers) (**Fig. 31.8b**)
            (*a*) Gastrulation begins when cells invaginate and move toward the inside of the ball of cells.
            (*b*) In protostomes, the pore resulting from invagination becomes the mouth.
            (*c*) In deuterostomes, the pore becomes the anus.
        (3) Differences in coelom formation (**Fig. 31.8c**)
            (*a*) In protostomes, the coelom forms from a split in a block of mesoderm.
            (*b*) In deuterostomes, the coelom forms when mesoderm cells pinch off from the gut.
6. Most bilaterally symmetrical triploblastic animals have the same tube-within-a-tube body design.
    a. The inner tube is the gut, while the outer tube forms the body wall. (**Fig. 31.9a**)
    b. The mesoderm forms between the tubes.
    c. Worms are the classic, simplest tube-within-a-tube animals; however, more complex animals have the same basic structure. (**Fig. 31.9b**)
    d. Once the tube-within-a-tube body plan evolved, the diversification of animals was fueled by the evolution of specialized structures for moving, capturing food, and sensing the environment.
7. A phylogeny of animals based on morphology
    a. The phylogenetic tree of animals is based on the assumption that more complex body plans were derived from simpler ones. (**Fig. 31.10**)
    b. Choanoflagellates are the closest living relatives of animals.
    c. Porifera and sponges, are the most basal, ancient phylum of animals.
    d. Choanoflagellates and sponges are sessile, feed in the same way (**Fig. 31.11**), and lack tissues and symmetry.
    e. Radially symmetrical, diploblastic animals likely evolved from sponges.
    f. Bilaterally symmetrical, triploblastic animals evolved in the following order; acoelomates, pseudocoelomates, and coelomates.
    g. Coelomates split into protostomes and deuterostomes, and then . . .
        (1) Radial symmetry evolved in adult echinoderms.
        (2) Segmentation evolved independently in protostomes and deuterostomes.
    h. Vertebrates are a monophyletic group that is defined by the presence of a skull.
    i. Invertebrates are a paraphyletic group encompassing all animals that are not vertebrates.

C. Using the Fossil Record
1. The earliest animal fossils are the Duoshantuo microfossils; date to 570 mya, include sponges and early embryos of more complex animals. (**Fig. 31.12a**)
2. The Ediacaran fossils (565–544 mya) include sponges, small cnidarians, and ctenophorans. (**Fig. 31.12b**)

3. The Burgess Shale fossils (525–515 mya) contain many examples of bilaterally symmetrical, large-bodied species from most animal phyla, including chordates. (**Fig. 31.12c**)

D. Evaluating Molecular Phylogenies
1. In 1997 Aguinaldo used gene sequence data for the rRNA from the small ribosomal subunit to estimate the phylogeny of 14 animal phyla. (**Fig. 31.13**)
2. This revised phylogenetic tree highlights several important observations:
   a. The most ancient triploblasts, Acoelomorpha, lack a coelom entirely; 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 the size of their skeletons.
   c. Segmentation evolved independently in annelids, arthropods, and vertebrates.
   d. The acoelomate condition in Platyhelminthes involved the loss of a coelom because Platyhelminthes are lophotrochozoa.
   e. Nematodes and rotifers, both pseudocoelomates, arose from ancestors that had coeloms.

III. What Themes Occur in Diversification of Animals?

A. Feeding
1. Suspension (filter) feeding (**Fig. 31.14**)
   a. These animals capture food by filtering particles out of water or air.
   b. Sessile filter feeders: clams (**Fig. 31.14a**)
      (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 out of the water as it passes over the gills and is swept to the mouth.
   c. Mobile filter feeders: krill (**Fig. 31.14b**)
      (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 (**Fig. 31.14c**)
      (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. They belong to a number of taxonomic groups.
2. Deposit feeding
   a. These animals eat their way through a substrate.
   b. They may be detrivores that eat dead or partially decayed organic matter—Earthworms. (**Fig. 31.15a**)
   c. They may be herbivores that eat through plant leaves or stems—insects. (**Fig. 31.15b**)
   d. All have simple mouthparts, and a wormlike body shape. (**Fig. 31.15**)
   e. They belong to several different taxonomic groups.
3. Herbivory
   a. Many animals from different phyla eat algae or plants.
   b. They have complex mouths with structures that allow for biting, chewing, sucking, and grinding.
      (1) The radula of mollusks scrapes material away from a plant or alga. (**Fig. 31.16a**)
      (2) Long, hollow proboscis of a moth sucks nectar from flowers. (**Fig. 31.16b**)
      (3) Mandibles of grasshoppers and molars of horses chew and grind leaves and stems. (**Fig. 31.16c, d**)
4. Predation
   a. Animals that eat other animals employ different strategies to find and capture their prey.
   b. Sit-and-wait predators: frogs (**Fig. 31.17a**)
      (1) Sit completely still, waiting for a worm or insect to move close.
      (2) Use a quick extension of their tongue to capture the prey.
   c. Stalkers: wolves (**Fig. 31.17b**)
      (1) Locate their prey and run it down during a long-distance chase.
      (2) Live and hunt in packs.
      (3) Other stalkers, like mountain lions, are solitary hunters that wait and pounce on their unsuspecting prey.
5. Parasitism
   a. Parasites are 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 in shape, they live in the gut of their host.
      (2) Example: Platyhelminthes have no digestive system; they hook onto their hosts' digestive tract to absorb the nutrients directly. (**Fig. 31.18a**)
      (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 the host's skin and suck the nutrient-rich fluid from inside.
            (2) Lice, ticks, and mosquitoes are ectoparasites. (**Fig. 31.18b**)

B. Movement
    1. Even some sessile animals move at some point during their lives.
        a. Sea anemone eggs swim via cilia to disperse. (**Fig. 31.19a**)
        b. Then, as adults, they attach to rocks. (**Fig. 31.19b**)
    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. Limbs in the ecdysozoans and vertebrates
            (1) Onychophorans (velvet worms) have unjointed, saclike limbs. (**Fig. 31.20a**)
            (2) Arthropods and vertebrates have jointed, more complex limbs. (**Fig. 31.20b**)
        b. Jointed limbs allow for fast, coordinated movement.
        c. Jointed limbs of arthropods and vertebrates work the same; limbs move when attached muscles are contracted or relaxed.
        d. Main difference between arthropod and vertebrate limbs is the skeleton.
            (1) Ecdysozoans have a hard, outer skeleton called the exoskeleton.
            (2) Vertebrates have a rigid internal skeleton, called an endoskeleton.
            (3) In both cases, the skeleton serves as a rigid structure that resists the force of the muscle.
    5. Are all animal appendages homologous? (from a common ancestor)
        a. Biologists have hypothesized that the answer is no; 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 (**Fig. 31.20c**)
            (4) Tube feet of echinoderms (**Fig. 31.20d**)
            (5) The diversity in structure led biologists to hypothesize that there was little to no genetic homology.
        c. Recent data challenges this view, implies all animal limbs are homologous.
            (1) The gene *Dll* (distal-less) encodes for a protein that controls limb growth during development.
                (*a*) Fruit flies with mutant *Dll* develop only limb buds.
                (*b*) The *Dll* protein seems to tell the embryo to "Grow appendage out this way."
            (2) Carroll et al. did experiments to determine if *Dll* was involved in limb development in other species. (**Fig. 31.21**)
                (*a*) They used a fluorescent protein that sticks to the *Dll* protein to show where it is expressed.
                (*b*) They found the *Dll* protein in annelids, arthropods, echinoderms, and chordates.
                (*c*) *Dll* localized to cells involved in limb formation in all these phyla.
                (*d*) *Dll* was also shown to be important in vertebrate limb formation.

C. Animal reproduction and life cycles are as diverse as their habitats and lifestyles.
    1. Some animal phyla, such as rotifers, reproduce only asexually. (**Fig. 31.22**)
    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. (**Fig. 31.23a**)
            (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 the eggs directly with sperm, (**Fig. 31.23b**)
            (2) Or shed sperm directly into the 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. (**Fig. 31.24a**)
        b. Oviparous animals lay fertilized eggs. (**Fig. 31.24b**)
        c. Ovoviviparous animals retain eggs that are nourished by a yolk.
    4. Metamorphosis is a spectacular 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. (**Fig. 31.25a**)

(2) During pupation, the juvenile body is remodeled into the adult form. (**Fig. 31.25b**)
(3) The nymph is the sexually immature young adult form.
(4) Adults are sexually mature, and are morphologically distinct from larvae or nymphs. (**Fig. 31.25c**)

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. (**Fig. 31.26a**)
(*b*) This also occurs in cnidaria. (**Fig. 31.27**)
(2) Incomplete or hemimetabolous metamorphosis: when the animal experiences a gradual change in form (grasshoppers) (**Fig. 31.26b**)

IV. Key Lineages of Animals

A. Choanoflagellates (**Fig. 31.28**)
1. Feeding: Suspension feed by using flagella that beat to create water currents to draw food toward the cell
2. Movement: Adults are sessile; individual cells can swim via flagella.
3. Reproduction: Simple fission

B. Porifera (**Fig. 31.29**)
1. Feeding:
a. Suspension feeders
b. Cells move within the sponge to move water through pores and chambers to bring food to feeding cells.
2. Movement:
a. Adults are sessile.
b. Larvae can swim via flagella.
3. Reproduction:
a. Asexual reproduction occurs via fragmentation; sponge cells are totipotent.
b. All species have hermaphroditic individuals that produce both egg and sperm, but generally cross-fertilize.
c. Fertilization usually takes place in the water.

C. Cnidaria (**Fig. 31.30; Essay, Fig. 31.33**)
1. Feeding:
a. Capture prey with a cnidocyte by ejecting a barbed spear called a nematocyst that poisons the prey.
b. The barbs hold prey and bring it to the mouth, where it is ingested.
c. Cnidocytes are usually found on tentacles.
2. Movement:
a. Both polyps and medusae have simple musclelike tissue even though they are diploblasts.
b. In polyps, gut acts as a hydrostatic skeleton to contract or extend the body.
c. In medusae, rhythmic, coordinated muscle contraction at the rim of its bell structure results in pulsating movement via jet propulsion.
3. Reproduction:
a. Polyps can reproduce asexually via . . .
(1) Budding
(2) Fission (adult dividing in half)
(3) Fragmentation
b. Sexual reproduction involves gametes that are released into the water where fertilization takes place.
c. Eggs hatch into the water and larva are part of the plankton until they grow into polyps.

D. Ctenophora (Comb Jellies) (**Fig. 31.31**)
1. Feeding:
a. Ctenophores are predators.
b. Some species catch prey with tentacles covered with adhesive cells.
c. Some trap prey in a mucus coating on the body.
2. Movement: Adults move by beating cilia.
3. Reproduction:
a. Most species are hermaphroditic and self-fertilize.
b. Fertilization is external.
c. Larvae are free swimming.

E. Acoelomorpha (**Fig. 31.32**)
1. Feeding: They feed on detritus or small animals and protists that live in the mud or sand.
2. Movement: Swim, glide or burrow with the aid of cilia
3. Reproduction:
a. Can reproduce asexually via fission or budding.
b. Sexual reproduction occurs via hermaphroditic individuals that can produce both egg and sperm.
c. Fertilization is internal, and eggs are laid outside the body.

Chapter Vocabulary

heterotrophs
primary producers
consumers
predators

animals
phyla

tissues
parazoans
eumetazoans

diploblasts
triploblasts

germ layers
ectoderm
endoderm
mesoderm
epithelium

Hydra
regenerate

symmetry
asymmetrical
radial symmetry
bilateral symmetry
pentaradial symmetrycephalization
head

body cavity
coelom
acoelomates
coelomates
pseudocoelomates

protostome
deuterostome
bilateria
cleavage
spiral cleavage
radial cleavage
gastrulation

worms
tub-within-a-tube design
sessile
segmentation
vertebrates
invertebrates

Ecdysozoa
Lophotrochozoa

metamorphosis
suspension feeders
deposit feeders
foot
siphon
gills

herbivores
detrivores

radula
mandibles
predator
endoparasites
ectoparasites

hydrostatic skeleton
limbs
exoskeleton
endoskeleton

oviparious
viviparious
ovoviviparious
larva/larvae
nymph
pupa/pupae
pupation
holoetabolous metamorphosis
hemimetabolous metamorphosis
polyp
medusa/medusae

Choanoflagellates/Collar flagellates
Porifera/Sponges
Cnidaria
Ctenophora
Acoelomorpha