29.1 Arthropods

- Not EVERY species has each feature, but these are features of the phylum as a whole

- Jointed appendages
- Segmentation
- Distinct head, often with compound eyes
- Exoskeleton
- Respiration by gills, tracheae, or book lungs
- Open circulatory system
- Excretion through Malpighian tubules
- Wings on many arthropods
Segmentation

- Individual segments often exist only during the larval stage
  - **Butterfly larva – caterpillar – has segments. Adult butterfly has 3 distinct regions, not segments**
- In most, body segments fuse during development to form 3 distinct regions
  - The head
  - The thorax (midbody region)
  - Abdomen
- Some, like the crab, have a head that is fused with the thorax, cephalothorax
Dragonfly segments

- Abdomen
- HEAD
- Thorax
Jointed Appendages

- Appendage – structure that extends from the arthropod’s body wall
  - Unlike parapodia and setae, they bend
- Arthropoda literally means “joint footed”
- Jointed appendages
  - Legs for walking
  - Antennae for sensing environment
  - Mouthparts for sucking, ripping, and chewing food
Exoskeleton

- Outer layer of arthropod – rigid – sometimes called a shell
- Composed primarily of chitin
  - Tough, but brittle and breaks easily
  - As animal increases in size, the exoskeletons become thicker
    - Increase in thickness add weight, restricting its size
      - *SO.. They shed (molt) → will discuss later….
- Provides protection from injury and helps prevent water loss
Respiration

- Many land arthropods respire through a network of fine tubes called trachea
  - Air enters through body structures called spiracles
    - passes into tracheae, delivering oxygen to body
- Others on land breath through book lungs
- Aquatic respire through gills
Circulation

- Open circulatory system
  - Which means? – blood is not contained in vessels
Feeding & Digestion

- Arthropods have varied mouthparts and appendages
  - Specialized to obtain food
- Intestinal tract extends from the mouth to the anus
  - Contains structures specialized for:
    - Storage
    - Mechanical and chemical digestion
    - Nutrient absorption
    - Elimination of digestive wastes
Excretion

- Excretory system that efficiently conserves water and eliminates metabolic wastes
- Composed of Malpighian tubules
  - Narrow extensions from arthropod’s lower intestinal tract
    - Bathed in blood
      - Water and small particles move in the blood through the tubules into the gut
        - Valuable resources are absorbed
        - Wastes are released through anus
  - So.. Terrestrial arthropods do not have to lose water to expel metabolic wastes
**Exoskeleton**

- **Advantages**
  - Protection
  - Muscle attachment
  - Reduction of water loss

- **Disadvantages**
  - Does not “stretch” for growth
  - Can be heavy
  - Can be vulnerable to breaking or cracking
**Compound Eyes**

- An eye composed of multiple individual visual units
  - Each has a lens and retina
  - Brain receives inputs from each unit
  - Not as clear of image, but see motion much more quickly

- Some have simple, single-lens eyes that can’t form images, but distinguish between light and dark

- Insects – most have compound and simple eyes
Compound Eyes

- Compound eyes
- Lens
- Facet
- Crystalline cone
- Pigment cells
- Visual cells
- Rhabdom
- Ommatidium
- Optic nerve fibers
Arthropod Life Cycle

- Most reproduce only sexually
  - Some can produce offspring from unfertilized eggs
- Fertilization is internal
  - More efficient than external – prevents gametes from drying out
- Many have specialized reproductive organs
  - Male and female fit together similar to lock and key
    - Ensure mating does not occur between different species
- Eggs are usually laid outside of female’s body
  - Immature animals hatch and generally receive no parental care
Molting

- Exoskeleton protects, but cannot grow larger
- Molting, or ecdysis, arthropods shed and discard their exoskeletons periodically
  - Triggered by release of certain hormones
  - New exoskeleton forms beneath the old one before it molts
  - When new one is formed, the old one breaks and the species emerges
  - The new exoskeleton will harden within a few hours or a few days, depends on the species
**Molting**

- Problems…..
  - Can be hazardous because they are more vulnerable to predators and environment because the new exoskeleton has not hardened yet
  - Most will HIDE until their new exoskeleton has hardened

- ALBINO roaches?
  - People claim they have seen albino roaches
    - Not really albinos, but have recently shed exoskeleton and haven’t returned to their full coloration yet
Groups of Arthropods

- Divided into two groups:
  - With jaws
    - Subphyla – Hexapoda (insects), Myriapoda (millipedes & centipedes), and Crustacea (lobsters & shrimp)
  - With fangs or pincers
    - Subphyla – Chelicerata (spiders)
Evolutionary Success of Arthropods

- Total # of arthropods exceeds that of all other kinds of animals combined
  - 5,000,000+ different species
- Factors contributing to success….
  - Exoskeleton for life on land
  - Small
  - Show wide range of adaptations (food & habitat)
1. Describe the arthropod life cycle.

2. Describe the molting process.

3. How is the exoskeleton of a growing arthropod similar to a balloon that is inflated inside a soft drink can? How does molting get around this limitation of the exoskeleton?

4. Which of the following structures takes in oxygen to deliver it to cells in arthropod bodies?
   - Blood, malpighian tubules, spiracles, tracheae

5. How are annelids and arthropods similar? Different?
29.2 Arachnids and Crustaceans

- **Arthropods (the animals of Arthropoda)**
  - Subphyla – Chelicerata
    - Class: arachnids – Spiders
  - Subphyla – Crustacea
    - Crustaceans
**NO other group of animals is probably more disliked and feared by humans than the arachnids**

- Spiders
- Scorpions
- Ticks
- Mites
- Daddy longlegs

**Actually do more good than harm**

- Some are venomous, but not all
- Major predator of insect pest
Arachnids are from the subphylum Chelicerata

- Members of this class have chelicerae
  - Mouthparts that are modified into pincers or fangs

- Made up of a cephalothorax and abdomen
  - No antennae
  - First pair of appendages are chelicerae
  - Second pair are pedipalps – modified to catch and handle prey (sometimes modified for sensory or reproductive functions)
  - Then, 4 pairs of appendages called walking legs
All except mites are carnivores
  • More are terrestrial
Some have no jaw, can only consume liquid
  • Injects prey with enzymes that cause the cells to liquidify
Spiders

- Chelicerae are modified into fangs
  - Poison glands are located in the spider’s anterior end – secrete toxin through fangs
  - Toxin kills or paralyzes prey
    - Then, injects enzyme to liquefy tissue and then sucks up the liquid food
- Important predators of insects
Spiders, cont.

- Only 2 species in the US are dangerous to humans
  - The black widow and the brown recluse
- Not all build webs – most secrete sticky strands of silk from appendages called **spinnerets** located at the abdomen
Locations of Brown Recluse

Range of recluse (genus Loxosceles) spiders in the United States

Rick Vetter, University of California Riverside
**Brown Recluse Spider**

- During the day, they hide in corners or other dark areas such as old boxes that are seldom opened
- Active at night
- Should wear gloves when opening boxes that have been left unattended for some time
- Extremely shy and non-aggressive
- Bite can cause mild irritation to an slow-healing open sore
  - After 24 hours, the cells around the bite begin to die and will slough off for several weeks - necresis
  - Healing can take several months
- No anti-venom, but there is medicine to treat symptoms
Brown Recluse Bites

Brown Recluse Bite Symptoms

- Rarely any pain when bitten.
- Bite site becomes reddened.
- Painful ulceration develops.
- Skin and muscle tissue dies, leaving a deep, infected wound that enlarges, fails to heal or heals quite slowly.
Anatomy of Brown Recluse
**Black Widow Spider**

- Extremely poisonous
- Will attempt to escape, not bite
  - Unless guarding eggs
- Found through US, but most often in the South
- Found in barns, sheds, stones, woodpiles, porch furniture
- Some do not even feel the actual bite, but without hours a dull pain spreads throughout the entire body
- Pregnant women often go into premature labor after being bitten
- Headache, profuse perspiration, anxiety, nausea, increased blood pressure
- Go to doc immediately for medicine
Black Widow Spider

Look for Red hour glass shape
They’re Not What You Think!

- Common daddy longlegs is NOT a spider
  - Member of scorpion, mite, and tick group
- Also, spiders are NOT insects and NOT bugs…
  - A “bug” insect has 3 pairs of legs
  - A spider has 4 pairs of legs
Scorpions

- Long, slender, segmented abdomens that end in a venomous stinger
  - Used to stun prey
- Stinger-tipped abdomen is usually folder over the rest of the body
- Pedipalps are large, grasping pincers, which are used for seizing food and during sexual reproduction
Scorpion
Mites & Ticks

- Largest group of arachnids
- Chiggers and ticks cause irritating bites
- Easily recognized
  - Head is fused into a single, unsegmented body
- Most are quite small, less than 1mm
  - Ticks can grow larger
- Aquatic mites = herbivores, terrestrial mites = predators
- Most aren’t harmful, but some can be plant pests
  - Can pass viral infections to plant
- Lyme disease is spread by bites from blood-sucking ticks
Ticks and Lyme Disease

- Lyme diseased caused by bacterium carried by 2 varieties of ticks
  - Found in humid, wooded areas
- Bite of an infected deer tick transfers bacterium to humans
  - Deer and other mammals are not affected by bacterium
    - Causes humans to become seriously ill
- Symptoms: target-like inflammation/rash at site of bite, flu-like symptoms like fever, pain, and extreme fatigue
- Can be treated with antibiotics
  - Difficult to diagnose
Horseshoe Crabs

- More closely related to spiders than crabs
  - Have chelicerae and pedipalps
- Hard exoskeleton
Stop and Think

1. How many pairs of appendages does an arachnid have? List these appendages.
   - 1 pair chelicerae, 1 pair pedipalps, 4 pairs walking legs

2. What are the functions of pedipalps?
   - To catch and handle prey

3. The arachnid body lacks
   - A. antennae
   - B. Jaws
   - C. A distinct thorax
   - D. All of the above

Answer: D
Crustaceans

- Primarily marine, some are also found in fresh water and a few are terrestrial species
- Include crabs, lobsters, crayfish, shrimps, barnacles, water fleas (Daphnia), and pill bugs
- Characteristics:
  - Most have cephalothorax and abdomen
    - Segments hardened into carapace
  - Have appendages on their abdomen
  - Have mandibles that are adapted for feeding
  - Two pairs of antennae
  - Breathe by using gills
Naupilis

- Distinctive larval form called a naupilis
  - Three pairs of branched appendages
  - Undergoes a series of molts before it takes on adult form
Terrestrial Crustaceans

- **Pill bugs and sow bugs (Isopods)** – live in leafy ground litter
- **Sand fleas** – several 1000 species – found along beaches
- **Land crabs** – live in damp areas
  - Only partly adapted to land living
  - Active at night when air is moist
  - Life cycle tied to ocean where larvae live until maturity
Aquatic Crustaceans

- Major food source for humans
- Copepods are among most abundant multicellular organisms on Earth
  - Key food source in the marine food chain
  - KRILL – chief food source for many marine species
    - Swarms in huge groups
Barnacles are sessile as adults
- Free-swimming larvae attach themselves to a rock, post, or some other submerged object, where they remain.
- Unlike most crustaceans, barnacles are hermaphrodites.
  - Do not usually fertilize their own eggs.
Decapods

- Large marine crustaceans
- Shrimps, lobsters, crabs, freshwater crayfish
- Five pairs of legs
- Includes ¼ of crustaceans
- Head and thorax fused into cephalothorax
  - Covered by protective shield – carapace
- In crayfish and lobster, anterior legs are modified into pincers called chelipeds
- Swimmerets are attached to abdomen and are used in swimming and reproduction
External Anatomy of Crayfish

(a) Cephalothorax (head and thorax)
- Cheliped
- Antennules
- Antennae
- Uropod
- Telson
- Walking legs

(b) Antenna
- Maxilla
- Mandible
- Maxillipeds
- Mouth
Internal Anatomy of Crayfish
29.3 Insects

- Diversity of Insects – NUMEROUS
  - Ants, mosquitoes, gnats, flies, bees, crickets, etc.
- Belong to arthropod subphylum Uniramia
  - Mostly terrestrial
- Most have mandibles (jaws)
- Uniramians
  - Three classes
    - Insecta (insects)
    - Diplopoda (millipedes)
    - Chilopoda (centipedes)
Insect Diversity, cont.

- Insects - Largest group of organisms on Earth
  - 700,000+ named species
    - Scientists believe most are unnamed species which live in the tropics
- More than 50% of all named animal species are insects
  - 90% of these belong to one 4 orders
Four Orders of Insects

- **Coleoptera** “shield winged”
  - Beetles, weevils
  - 350,000 species
- **Diptera** “two winged”
  - Flies, mosquitoes
  - 120,000 species
- **Lepidoptera** “scale winged”
  - Butterflies, moths
  - 120,000
- **Hymenoptera** “membrane winged”
  - 100,000
Insect Body Plan

- All insects share same general body plan, made up of three body sections:
  - **HEAD** – includes mandibles, specialized mouthparts, and one pair of antennae.
  - **THORAX** - composed of three fused segments, has three pairs of walking legs.
  - **ABDOMEN** - composed of 9 to 11 segments.
Insect Mouthparts

Grasshopper (adapted for biting and chewing)

Mosquito (adapted for piercing and sucking)

Fly (adapted for sponging and lapping)
Insect Life Cycle

- Complex, and often several molts are required before the adult stage is reached.
- During last molt, insect undergoes dramatic physical change called metamorphosis.
Complete Metamorphosis

- Almost all insect species
- Wingless, wormlike larva enclose itself within protective capsule called a chrysalis
- Passes into a pupa stage, in which it changed into an adult
- Larvae can exploit different habitats and food sources than adults
  - Butterfly that eats nectar, caterpillar eats leaves!
    - Increases chance of survival for each phase
      - Less competition
Complete Metamorphosis

Egg

Young larva

Older larva

Pupa in chrysalis

Adult emerging from chrysalis

Adult
Incomplete Metamorphosis

- Few insect species
- Less dramatic
- Egg hatches into juvenile, or nymph
  - Looks like a small, wingless adult
- After several molts, then nymph develops into adult
Complete vs. Incomplete Metamorphosis

- Complete
  - Egg
  - Larva
  - Pupa
  - Adult

- Incomplete
  - Egg
  - Nymph
  - Adult
Flight

- Insects first animals to have wings
- Great evolutionary innovation
- Allowed insects to reach previously inaccessible food sources and to escape quickly from danger
- Wings are composed entirely of chitin
  - strengthened by a network of tubes called veins (which carry air, not blood).
- In most insects, the power stroke of the wing during flight is downward, and it is produced by strong flight muscles.
- Wingless insects – fleas and lice
Social Insects

- Two orders, Hymenoptera (ants, bees, and wasps) and Isoptera (termites) have elaborate social systems
- Live in highly organized “societies” of genetically related individuals
- Marked division of labor
- Caste – role played by a social insect
  - Determined by heredity, diet, hormones, and chemical substances used for communication
Honeybees

- Hive contains queen, workers, and drone males
- Queen is usually the only reproductive female in the hive
- Workers care for eggs, the larvae, the queen, and the drones
  - Also forage for food and maintain and defend the hive
Small, active members are called workers and gather food, raise the young, and excavate tunnels.

Solders – defend the colony

Both are sterile

Reproduction is function of only the queen and king.
Insect Relatives

- Centipedes and millipedes
- Head region followed by numerous leg segments
  - Centipedes – one pair of legs per segment, up to 173 segments
    - carnivores
  - Millipedes – most have two pairs of legs per segment, from 11 to 100 or more body segments
    - herbivores
29.4 Echinoderms

**About 7,000 species organized into 5 classes**

- Fossil records show at least 15 additional classes of about 13,000 now extinct species
Echinoderm Characteristics

- Recognized by spines that project from their internal skeleton through their outer covering
  - Echinoderm means “spiny skinned”
- Unlike arthropods, are deuterostomes (mouth develops 2\textsuperscript{nd})
- All share 4 basic characteristics
  - Internal skeleton
  - Five-part radial symmetry
  - Water-vascular system
  - Ability to breath through skin
Endoskeleton

- Calcium-rich composed of individual plates called ossicles
  - In young, they are enclosed in living tissue
  - In adults, appears to be external, but are covered by a thin layer of skin
    - Sometimes this skin is worn away
- In adults, can be fused together to form what functions like an arthropod exoskeleton
  - Provide sites for muscle attachment
Five-Part Radial Symmetry

- Bilaterally symmetrical as larvae
- As adults, five-part radial symmetry
  - Have arms that radiate from a central point
    - Number of arms can vary
- Have no brain or head
  - Nervous system consists of ring of nerves that branch into each arm
    - Each arm acts, for the most part, independently
- Many can regenerate lost or broken pieces
Water Vascular System

- Interconnected canals and thousands of tiny hollow tube feet
  - Some tube feet extend outward through openings in ossicles to help them move across ocean floor
  - Can use tube feet to open up a bivalve
- Also functions in feeding and gas exchange
Body cavity (coelom) serves as simply circulatory and respiratory system

Some have skin gills which aid in respiration and waste removal

Skin gills – small, fingerlike projections that grow among the echinoderms spine’s

- Increase surface area for respiratory gases
- Also function as excretory structures
Echinoderm Diversity

- Living classes include:
  - Sea stars
  - Brittle stars & basket stars
  - Sea lilies and feather stars
  - Sea urchins & sand dollars
  - Sea cucumbers
**Sea Stars**

- Almost all are carnivores
  - Among most important predators in marine ecosystem
  - In 1 year, a single crown-of-thorns can consume up to 6 m² of reef
    - Can destroy entire reef ecosystem
  - Some prey on mollusks – open bivalve with tube feet
  - Ossicles can serve as pincerlike structures called pedicellaria
    - Can snap at anything that touches them
Brittle Stars

- Sea star relative
- Brittle stars and sea baskets make up largest class of echinoderm
- Have slender, branched arms that move in pairs to row across ocean floor
- Arms break off easily, hence brittle stars
- Live primarily on ocean bottom, hide under rocks
- Some are predators, but most are filter feeders
**Sea Lilies & Feather Stars**

- Most ancient and primitive living echinoderms
- Mouth is located on their upper, rather than lower, surface
- Sea lillies are sesile, attached to ocean floor by stalk that is about 23 inches long
- Feather stars use hooklike projections to attach themselves directly to ocean bottom
  - Can sometimes crawl or swim for short distances
Sea Urchins and Sand Dollars

- Lack distinct arms, but have basic 5-part body plan
- Have hard, somewhat flattened endoskeleton of fused plates covered with spines
  - In sea urchins, spines provide protection, and in some species, contain a venom that causes severe burning sensation
- Sea urchins – ocean bottom
- Sand dollars – live in sandy areas near the coast
**Sea Cucumbers**

- Soft-bodied, sluglike animals without arms
- Ossicles are small and not fused together
- Body can have tough, leathery exterior
- Sexes are usually separate, but some are hermaphrodites
- Feed by trapping tiny organisms present in the sea water using tube feet modified into tentacles
  - Covered in sticky mucus
- When threatened, the sea cucumber releases sticky threads from its anus to entrap attackers
**Sea Daisies**

- Discovered in 1986
- Strange, disk-shaped little animals
- Less than 1cm in diameter
- Only a few species are known
- Tube feet are located around the edges of the disk rather than along the radial lines