Chapter 18
Phylum Arthropoda

Anthropodization
• The soft cuticle of the ancestors of arthropods was stiffened by deposition of protein and inert polysaccharide chitin.
• Joints had to provide flexibility and a sequence of molts was necessary to allow for growth.
• Molting required hormonal control.
• The hydrostatic skeleton function was lost, the coelom regressed and open sinuses replaced them.
• Motile cilia were lost.
• If this were not a monophyletic group, these features would all have to arise independently.

Phylum Arthropoda
• This contains over 3/4ths of all known species.
• The phylum has a rich fossil history dating to the late Precambrian.
• They are eucoelomate protostomes with well-developed organ systems.
• Similar to annelids, they have distinct metameres.
• Sizes range from the Japanese crab (four meters in leg span) to the 0.1 mm long follicle mite.
• Their abundance and wide ecological distribution makes them the most diverse animal group.
• Some arthropods are serious disease agents and compete with humans for food; others are beneficial.
• All modes of feeding occur among arthropods but most are herbivorous.

Exoskeleton
• The primitive pattern is a linear series of similar somites with jointed appendages.
• Many somites may be fused or combined into specialized groups called tagmata.
• Appendages are often highly specialized for division of labor.

Versatile Exoskeleton
• The cuticle highly protective but is jointed, providing mobility.
  – It consists of an inner thick procuticle and an outer thin epicuticle.
  – Procuticle has an exocuticle secreted before a molt and an endocuticle secreted after molting.
  – Both layers of procuticle contain chitin bound with protein.
  – Thus the procuticle is lightweight, flexible, and provides protection against dehydration.
• Chitin varies from composing 40% of the procuticle in insects to as much as 80% in crustaceans.

Figure 29.1a
Versatile Exoskeleton

- Impregnation with calcium salts makes the procuticle very hard in lobsters and crabs.
- The cuticle is laminated and further hardened by tanning, a chemical process.
- As the cuticle is thin between segments, it allows movement at the joints.
- Cuticle also folds inward to line the foregut, hindgut and trachea.
- Ecdysis, or molting, is the process of shedding its outer covering and growing a new, larger one.
  - Arthropods typically molt 4 to 7 times
  - Weight is a limit to ultimate body size.

Molting

- The epidermal cells divide by mitosis.
- Enzymes secreted by the epidermis digest most of the procuticle; digested materials are absorbed.
- In the space beneath the old cuticle, a new epicuticle and procuticle are formed.
- After the old cuticle is shed, the new cuticle is thickened and calcified or sclerotized.

Segmentation and Appendages for Efficient Locomotion

- Usually each somite bears a pair of jointed appendages.
- Segments and appendages are then modified for various adaptive functions.
- Limb segments are hollow levers with internal striated muscles.
- Appendages may function in sensing, food handling, walking, or swimming.

Air Piped Directly to Cells

- Terrestrial arthropods use an efficient tracheal system that delivers oxygen directly to cells.
- Aquatic arthropods respire via various forms of efficient gills.
- We will discuss respiration in more detail within each group.

Highly Developed Sensory Organs

- Eyes vary from simple light sensitive ocelli to a compound mosaic eye.
- Other senses accomplish touch, smell, hearing, balancing and chemical reception.

Complex Behavior Patterns

- Arthropods surpass most other invertebrates in complex and organized activities.
- Most behavior is innate or unlearned but some is learned.

Source: http://www.learnenglish.org.uk/magazine/magazine_home_fleacircus.html
Use of Diverse Resources through Metamorphosis

- Many arthropods have metamorphic changes that result in different larval and adult stages.
- Larvae and adults eat different foods and occupy different habitat and avoid competition.

More About Trilobites

- Their exoskeleton contained chitin strengthened by calcium carbonate.
- The body was divided into a cephalon, trunk, and pygidium.
- The cephalon was a fusion of segments, trunk varied in somites, and the pygidium was fused.
- The cephalon bore antennae, compound eyes, mouth, and jointed appendages.
- Each body somite except last bore a pair of biramous appendages.
- One of the branches of the biramous appendage was fringed and may have been a gill.

Subphylum Trilobita

- History of an Ancient Group
  - Trilobites arose before the Cambrian, flourished, and then became extinct 280 million years ago.
  - They have a trilobed body shape due to a pair of longitudinal grooves.
  - They were bottom dwellers and probably were scavengers.
  - Ranging from 2 to 67 centimeters long, they could roll up like pill bugs.

Subphylum Chelicerata

Characteristics

- Chelicerates have six pairs of cephalothoracic appendages including chelicerae, pedipalps and four pair of legs.
- They lack mandibles and antennae.
- Most suck liquid food from prey.

Class Merostomata

Horseshoe Crabs

- The modern horseshoe crab is nearly unchanged from ancestors in the Triassic period.
- Five species in three genera survive.
- Most live in shallow water.

Structures

- An unsegmented shield or carapace covers the body in front of a broad abdomen and a telson.
- The cephalothorax has five pairs of walking legs and a pair of chelicerae.
- The abdomen bears six pairs of broad, thin, appendages fused in the median line.
- Book gills are exposed on some of the abdominal appendages.
Horseshoe Crabs continued

- The carapace has two compound and two simple eyes.
- They walk with their walking legs and swim with abdominal plates.
- They feed at night on worms and small molluscs.

Reproduction

- During the mating season, they come to shore at a very high tide to mate.
- Females burrow into sand to lay eggs; males follow to add sperm before she covers the eggs.
- The young larvae hatch and return to the sea at the next very high tide.
- Larvae are segmented and resemble trilobites.

Class Pycnogonida

Sea Spiders

- Sea spiders vary from a few millimeters to larger sizes; all have small, thin bodies.
- Some species duplicate the somites, and they may have five or six pairs of legs.
- Some males may have a subsidiary pair of legs (ovigers) to carry developing eggs.
- Many also have chelicerae and palps.

Sea Spiders - continued

- The mouth, at the tip of a proboscis, sucks juices from cnidarians and soft-bodied animals.
- Most have four simple eyes.
- There is a simple dorsal heart but excretory and respiratory systems are lacking.
- The digestive system sends branches into the legs; most gonads are also in the legs.
- Sea spiders occur in all oceans but are most common in polar waters.
- Evolutionary relationship is uncertain; some place them nearer crustaceans, others place them nearer arachnids.

Class Arachnida

- There is a great diversity among scorpions, mites, ticks, daddy longlegs, and others.
- Most are free living and more common in warm, dry regions.

Structures

- Arachnids are divided into a cephalothorax and an abdomen.
- The cephalothorax bears a pair of chelicerae, a pair of pedipalps and four pairs of walking legs.
- Antenna and mandibles are lacking.
- Most are producous and have claws, fangs, poison glands, or stingers.
Structures - continued

- Sucking mouthparts ingest the fluids and soft tissues from bodies of their prey.
- Spiders have spinning glands.
- A few spiders have a segmented abdomen (primitive).
- Pedipalps of males are modified, sometimes elaborately, for sperm transfer.

Diversity

- Over 70,000 species have been described.
- Scorpions appeared on land in the Silurian; mites and spiders were found by the end of the Paleozoic Era.
- Most are harmless to humans and provide essential control of injurious insects.
- Some spiders are venomous and can cause pain or death in humans; ticks may carry human diseases; mites can be crop pests.

Order Araneae: Spiders

- About 35,000 species of spiders are known.
- The body consists of an unsegmented cephalothorax and abdomen joined by a slender pedicel.
- The anterior appendages are a pair of chelicerae with terminal fangs.
- A pair of pedipalps has basal parts that help them handle food.
- Four pairs of walking legs terminate in claws.

Nutrition

- All spiders are predaceous, mostly on insects, which are dispatched by poison and fangs.
- The injected venom liquefies and digests the tissues; this is sucked into the spider’s stomach.

Source: http://science.howstuffworks.com/spider6.htm

Respiration

- Spiders breathe by book lungs and/or tracheae.
  - Book lungs are unique to spiders; parallel air pockets extend into a blood-filled chamber.
  - Air enters the chamber through a slit in the body wall.
  - The tracheae system is less extensive than in insects; it carries air directly to tissues.

Excretion

- Spiders and insects have Malpighian tubules for an excretory system.
  - Potassium, other solutes and waste molecules are secreted into the tubules.
  - Rectal glands reabsorb the potassium and water, leaving wastes and uric acid for excretion.
  - This conserves water and allows the organisms to live in dry environments.
  - Many spiders have coxal glands that are modified nephridia at the base of some legs.
Malpighian Tubules

- Insects and spiders use this system.
- The thin, elastic, blind Malpighian tubules are closed and lack an arterial supply.
- Secretion of salt creates an osmotic drag that pulls water, solutes and wastes into the tubule.
- Uric acid enters the upper end of the tubule as soluble potassium urate and precipitates as insoluble uric acid in the proximal end of the tubule.

Malpighian Tubules

- When the solution reaches the rectum, rectal glands reabsorb water and potassium.
- Uric acid and other wastes continue out in the feces.

Toxicity of Nitrogenous Wastes

- Uric acid is relatively nontoxic.
- But unlike either ammonia or urea, uric acid is largely insoluble in water and can be excreted as a semisolid paste with very small water loss.
- While saving even more water than urea, it is even more energetically expensive to produce.

Toxicity of Nitrogenous Wastes

- Another alternative is urea which is synthesized in the liver by combining ammonia with carbon dioxide.
- The main advantage is low toxicity, about 100,000 times less than that of ammonia.
- Urea can be transported and stored safely at high concentrations.
- This reduces the amount of water needed for nitrogen excretion when releasing a concentrated solution of urea rather than a dilute solution of ammonia.

Toxicity of Nitrogenous Wastes

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- Urea can be transported and stored safely at high concentrations.
- This reduces the amount of water needed for nitrogen excretion when releasing a concentrated solution of urea rather than a dilute solution of ammonia.
- The main disadvantage of urea is that animals must expend energy to produce it from ammonia.
Sensory Systems
• Most spiders have eight simple eyes, each with a lens, optic rods and a retina.
• They detect movement and may form images.
• Sensory setae detect air currents, web vibrations and other stimuli.
• A spider’s vision is usually poor and its awareness of its environment depends largely on cuticular mechanoreceptors such as sensory setae, trichobothria, and slit sense organs.

Web-Spinning Habits
• Spinning silk is a critical ability for spiders and some other arachnids.
• Two or three pairs of spinnerets contain microscopic tubes that run to silk glands.
• A liquid scleroprotein secretion hardens as it is extruded from the spinnerets.
• Silk threads are very strong and will stretch considerably before breaking.
  – Its tensile strength comparable to high-grade steel
  – Able to stretch up to 40% of its length without breaking
• Silk is used for orb webs, lining burrows, forming egg sacs and wrapping prey.

Reproduction
• Before mating, the male stores his sperm in his pedipalps.
• Mating involves inserting the pedipalps into the female genital openings.
• A courtship ritual is often required before the female will allow mating.
• Eggs may develop in a cocoon in the web or may be carried by the female.
• The young hatch in about two weeks and may molt before leaving the egg cocoon.

Are spiders really dangerous?
• Most people fear spiders without good reason.
• Spiders are allies of humans in our battle with insects.
• American tarantulas rarely bite, and the bite is not dangerous.
• Species of black widow spiders are dangerous; the venom is neurotoxic.
• The brown recluse spider has hemolytic venom that destroys tissue around the bite.
• Some Australian and S. American spiders are the most dangerous and aggressive

Order Scorpionida: Scorpions
• Scorpions are more common in tropical and subtropical zones but do occur in temperate areas.
• They are nocturnal and feed largely on insects and spiders.
• The cephalothorax has the appendages, a pair of medial eyes and 2-5 lateral eyes.
• The preabdomen has seven segments.
• The postabdomen has the long, slender tail of five segments that ends in a stinging apparatus.
• The stinger on the last segment has venom that varies from mildly painful to dangerous.

Scorpions - continued
• Scorpions are ovoviviparous or viviparous and produce from six to 90 young.
• Scorpions perform complex mating dances, and in some species the male stings the female on her pedipalp or on the edge of her cephalothorax.
Order Opiliones: Harvestmen

- Harvestmen or daddy longlegs are common, particularly in tropical regions.
- Unlike spiders, their abdomen and cephalothorax join broadly without a narrow pedicel.
- They can lose most of their eight long legs without ill effect.
- Their chelicerae are pincerlike and they feed more as scavengers than do spiders.

Order Acari: Ticks and Mites

- Acari are medically and economically the most important arachnids.
- About 30,000 species have been described, many more are estimated to exist.
- They are both aquatic and terrestrial, and inhabit deserts, polar areas and hot springs.
- Most mites are less than 1 millimeter long; ticks may range up to 2 cm.

Reproduction

- Acarines may transfer sperm directly or by spermatophores.
- The egg hatches, releasing a six-legged larva; eight-legged nymphal stages follow.

Human Impact

- House dust mites are free-living and often cause allergies.
- Spider mites are one of many important agricultural pest mites that suck out plant nutrients.
- Chiggers are larval Trombicula mites; they feed on dermal tissues and cause skin irritation.
- The hair follicle mite Demodex is harmless but other species cause mange in domestic animals.
- The human itch mite causes intense itching.

Disease Vectors

- Tick species of Ixodes carry Lyme disease.
- Tick species of Dermacentor transmit Rocky Mountain spotted fever.
- The cattle tick transmits Texas cattle fever.

http://uts.cc.utexas.edu/~gilbert/bites/
Adaptive Radiation

- In contrast to annelids, arthropods have pronounced tagmatization by fusion of somites.
- Those with primitive characters have appendages on each somite; derived forms are specialized.
- Modification of exoskeleton and appendages allowed variation in feeding and movement.