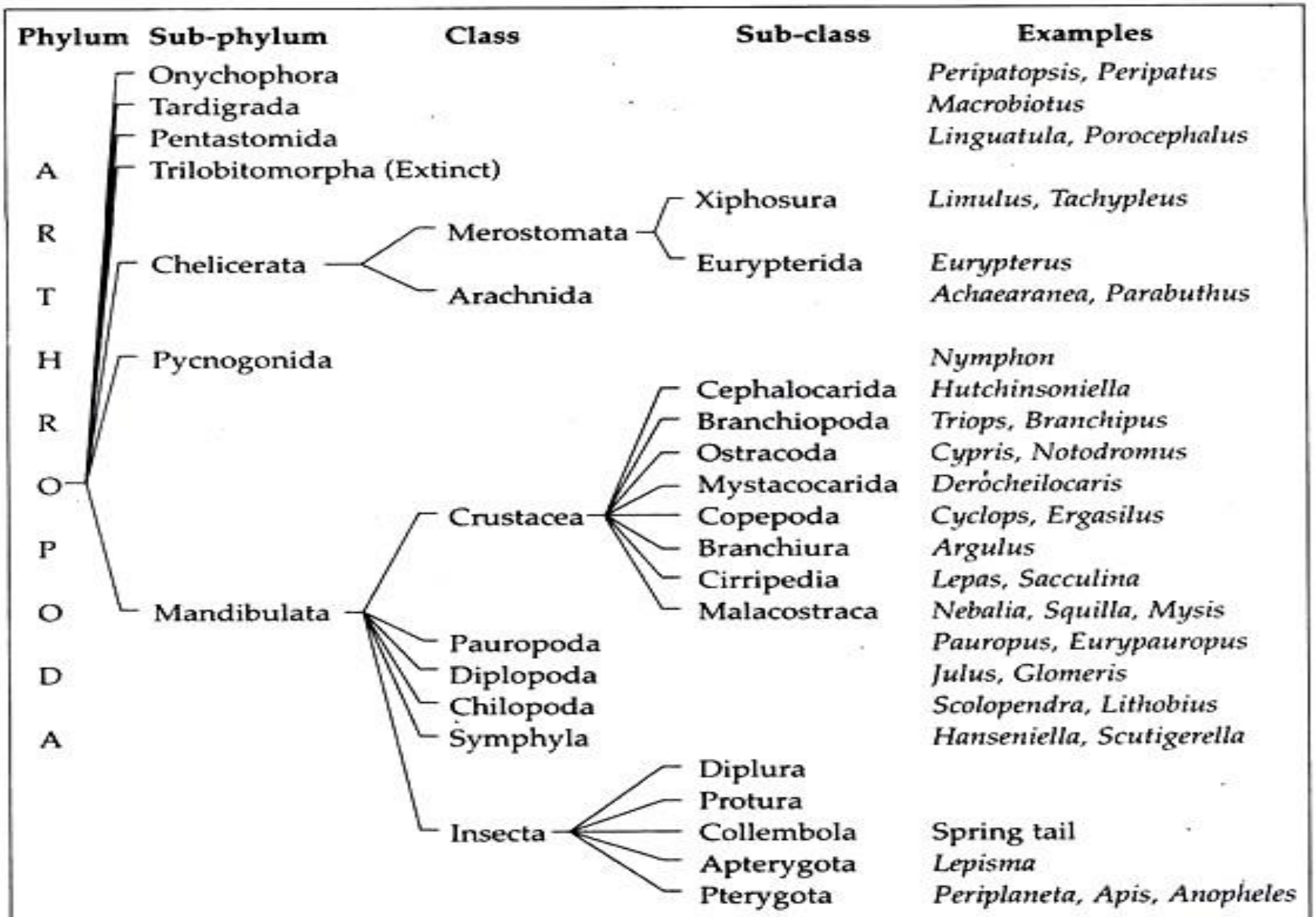
THE ARTHROPODS:

- Metamerism and Tagmatization
- The Exoskeleton Metamorphosis
- Subphylum Chelicerata
  - Class Arachnida (general characteristics)
- Subphylum Crustacea
  - Class Malacostraca
  - Class Branchiopoda
  - Class Copepoda
  - Class Cirripedia
  - Class diplopoda
  - Class chilopoda



Box. 1.7 : Scheme of classification Phylum Arthropoda as in 'Text book of Zoology — Invertebrates' by Parker and Haswell (eds. Marshall and Williams, 1972).

Metamerism and Tagmatization

❖ **Three aspects of arthropod biology have contributed to their success.**

1) Metamerism

- **Metamerism of arthropods is most evident externally because the arthropod body is often composed of a series of similar segments, each bearing a pair of appendages.**
- **Internally, however, septa do not divide the body cavity of an arthropod, and most organ systems are not metamerically arranged.**

2) tagmatization

- **Metamerism permits the specialization of regions of the body for specific functions. This regional specialization is called tagmatization.**
- **In arthropods, body regions, called tagmata are specialized for feeding and sensory perception, locomotion, and visceral functions.**

3) THE EXOSKELETON

THE EXOSKELETON

Cuticle:

- An external, jointed skeleton, called an exoskeleton or cuticle, encloses arthropods.
- It provides structural support and protection
- It provides impermeable surfaces for the prevention of water loss, and
- It provides a system of levers for muscle attachment and movement.
- The exoskeleton covers all body surfaces and invaginations of the body wall
- It is nonliving.
- secreted by a single layer of epidermal cells.

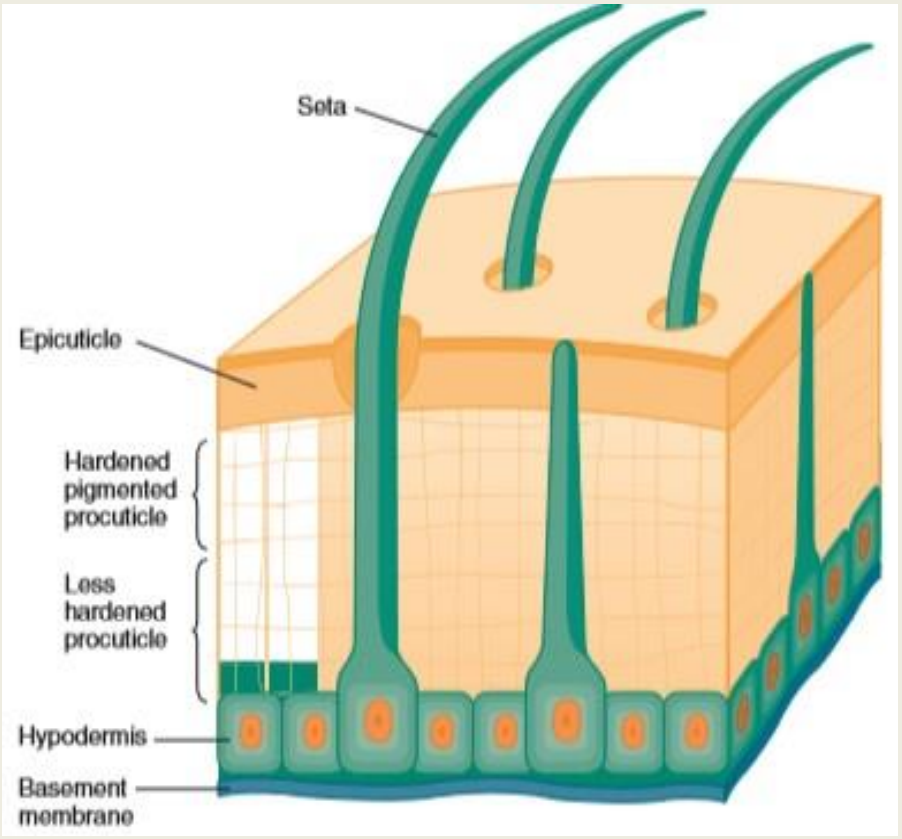


Fig: Arthropod Exoskeleton. The epicuticle is made of a waxy lipoprotein and is impermeable to water. Calcium carbonate deposition and/or sclerotization harden the outer layer of the procuticle. Chitin, a tough, leathery polysaccharide, and several kinds of proteins make up the bulk of the procuticle. The hypodermis secretes the entire exoskeleton

Epidermal layer

- The epidermal layer is sometimes called the hypodermis.
- It is covered on the outside by exoskeleton, rather than being directly exposed to air or water.

❖ The exoskeleton has two layers → i) epicuticle ii) procuticle

Epicuticle

- The epicuticle is the outermost layer.
- Made of a waxy lipoprotein.
- Impermeable to water and a barrier to microorganisms and pesticides.

Procuticle

- The bulk of the exoskeleton is below the epicuticle and is called the procuticle.
- Composed of chitin, a tough, leathery polysaccharide, and several kinds of proteins.
- It hardens through a process called sclerotization and sometimes by impregnation with calcium carbonate.

Sclerotization

- It is a tanning process in which layers of protein are chemically cross-linked with one another—hardening and darkening the exoskeleton.
- The exoskeleton of crustaceans hardens by sclerotization and by the deposition of calcium carbonate in the middle regions of the procuticle.

Advantages of Exoskeleton:

- Some proteins give the exoskeleton resiliency. Distortion of the exoskeleton stores energy for such activities as flapping wings and jumping.
- Hardening in the procuticle provides armorlike protection for arthropods.

Modification of the exoskeleton

- Another modification of the exoskeleton is the formation of joints.
- Other modifications of the exoskeleton include sensory receptors, called sensilla, in the form of pegs, bristles, and lenses, and modifications of the exoskeleton that permit gas exchange.

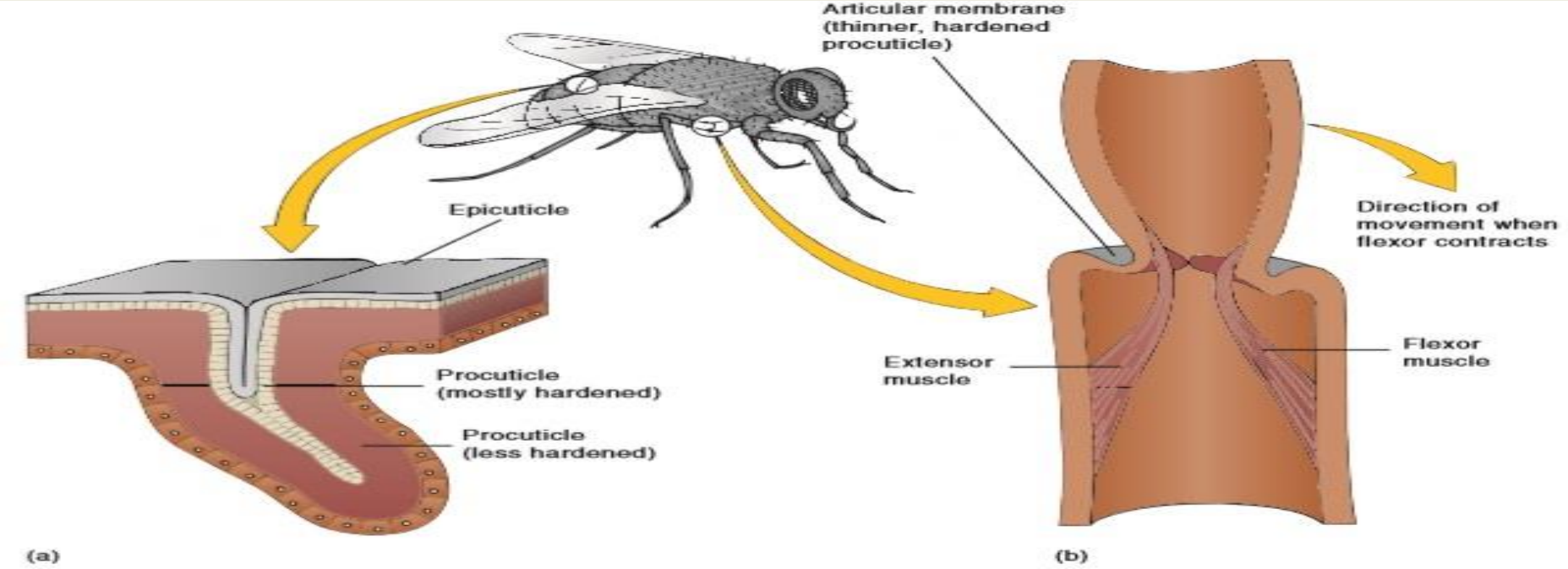


Fig: Modifications of the Exoskeleton. (a) Invaginations of the exoskeleton result in firm ridges and bars when the procuticle in the region of the invagination remains thick and hard. These are muscle attachment sites. (b) Regions where the procuticle is thinned are flexible and form membranes and joints.

Ecdysis

The growth of an arthropod would be virtually impossible unless the exoskeleton were periodically shed, such as in the molting process called ecdysis.

Ecdysis is divided into four stages:

1) **Enzymes, secreted from hypodermal glands, begin digesting the old procuticle to separate the hypodermis and the exoskeleton.**
2) **new procuticle and epicuticle are secreted.**
3) **the old exoskeleton splits open along predetermined ecdysal lines when the animal stretches by air or water intake; pores in the procuticle secrete additional epicuticle.**
4) **finally, calcium carbonate deposits and/or sclerotization harden the new exoskeleton.**

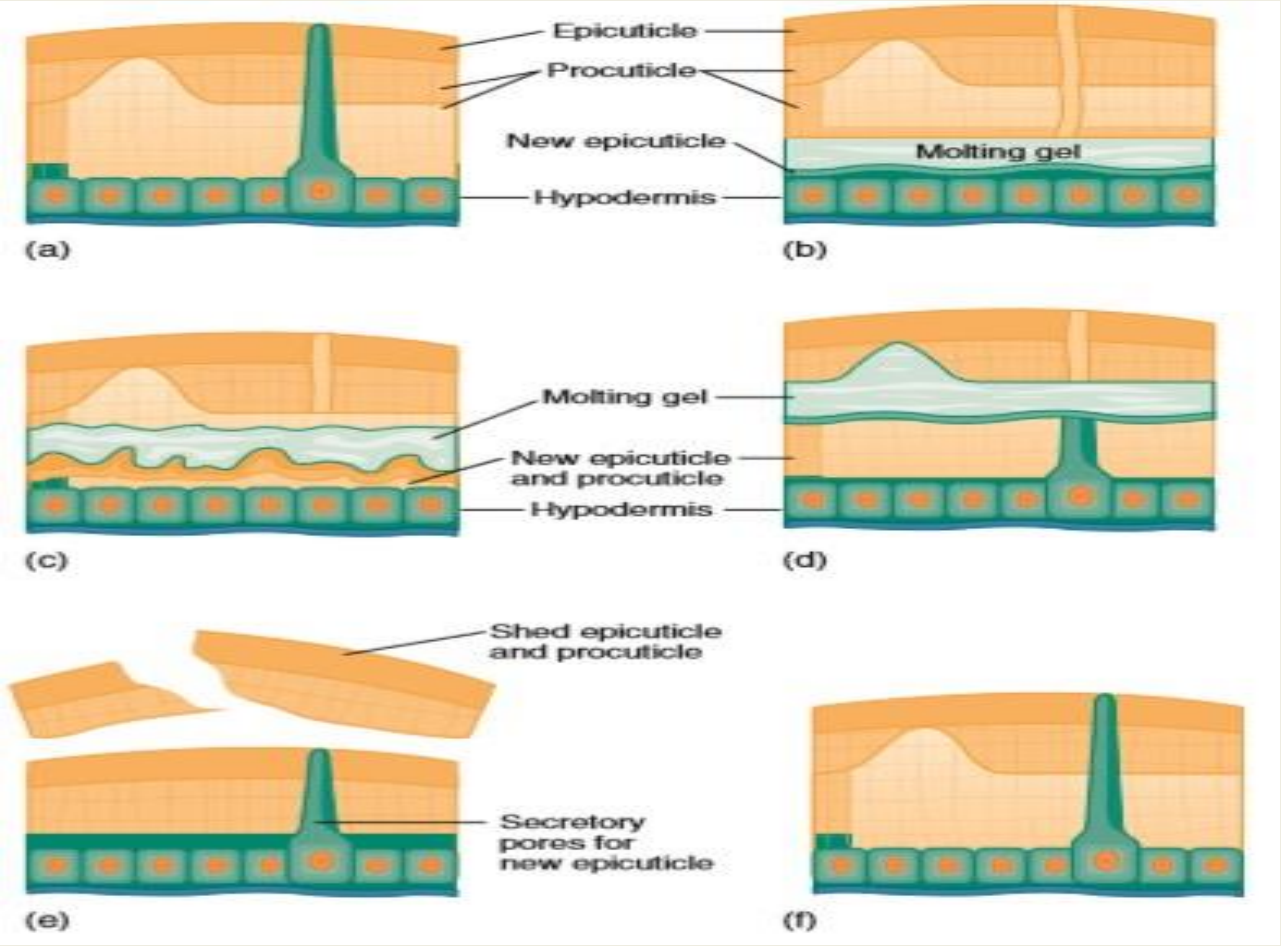


Fig: Events of Ecdysis. (a,b) During preecdysis, the hypodermis detaches from the exoskeleton, and the space between the old exoskeleton and the hypodermis fills with a fluid called molting gel. (c,d) The hypodermis begins secreting a new epicuticle, and a new procuticle forms as the old procuticle is digested. The products of digestion are incorporated into the new procuticle. Note that the new epicuticle and procuticle are wrinkled beneath the old exoskeleton to allow for increased body size after ecdysis. (e) Ecdysis occurs when the animal swallows air or water, and the exoskeleton splits along predetermined ecdysal lines. The animal pulls out of the old exoskeleton. (f) After ecdysis, the new exoskeleton hardens by calcium carbonate deposition and/or sclerotization, and pigments are deposited in the outer layers of the procuticle. Additional material is added to the epicuticle

3) Metamorphosis

- Reduction of competition between adults and immature stages because of metamorphosis.
- Metamorphosis is a radical change in body form and physiology as an immature stage, usually called a larva, becomes an adult.
- The evolution of arthropods has resulted in an increasing divergence of body forms, behaviors, and habitats between immature and adult stages.

Example:

- Adult crabs, for example, usually prowl the sandy bottoms of their marine habitats for live prey or decaying organic matter, whereas larval crabs live and feed in the plankton.
- The caterpillar that feeds on leafy vegetation eventually develops into a nectar-feeding adult butterfly or moth.

SUBPHYLUM CHELICERATA

- Includes familiar animals, such as spiders, mites, and ticks, and less familiar animals, such as horseshoe crabs and sea spiders.
- These animals have two tagmata. i) Prosoma or Cephalothorax ii) Opisthosoma.

(i) Prosoma or Cephalothorax

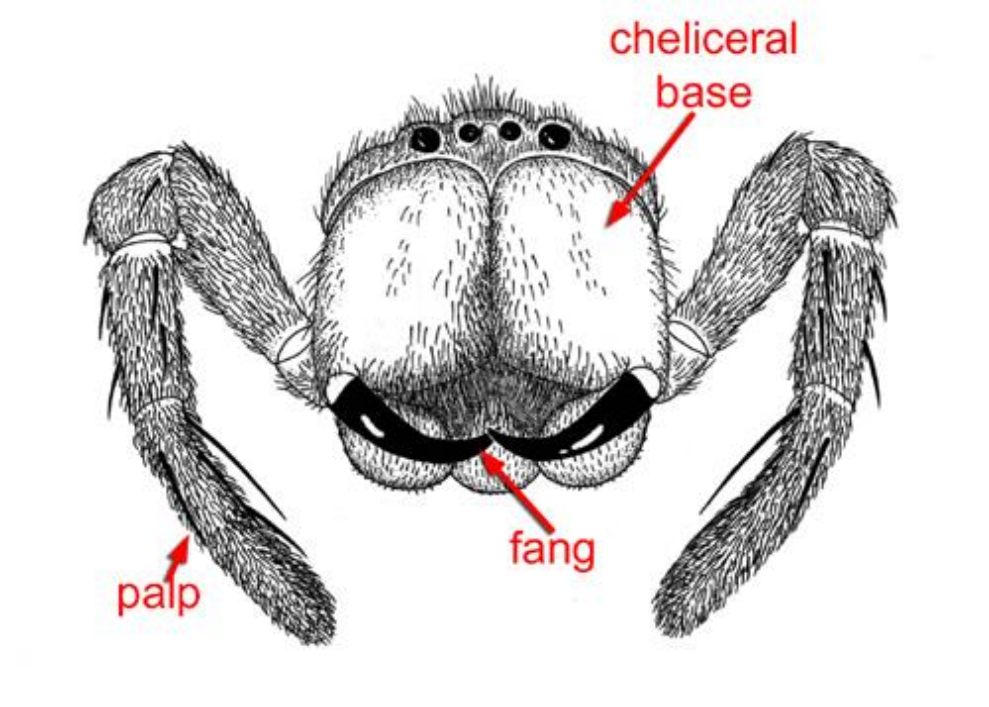
- Sensory, feeding, and locomotor tagma.
- It usually bears eyes, but unlike other arthropods, never has antennae.
- Paired appendages attach to the prosoma.

Chelicerae:

- The first pair, called chelicerae.
- Often pincerlike or chelate, and are most often used in feeding.
- They may also be specialized as hollow fangs or for a variety of other functions.

Pedipalps:

- The second pair, called pedipalps.
- Usually sensory but may also be used in feeding, locomotion, or reproduction.


cheliceral
base
fang
palp


Abdomen
Spinnerets
Cephalothorax
Pedipalps
Chelicerae
Eyes

Spiders

(ii) Opisthosoma

- Posterior to the prosoma is the opisthosoma.
- It contains digestive, reproductive, excretory, and respiratory organs.

CLASS ARACHNIDA

- The majority of spiders, mites, ticks, scorpions, and related forms are either harmless or very beneficial to humans.
- Most zoologists believe that arachnids arose from the eurypterids and were early terrestrial inhabitants.
- The earliest fossils of aquatic scorpions date from the Silurian period (405 to 425 million years ago),
- Fossils of terrestrial scorpions date from the Devonian period (350 to 400 million years ago), and
- Fossils of all other arachnid groups are present by the Carboniferous period (280 to 345 million years ago).

Preadaptation

- **Impermeable exoskeleton** preadapted ancestral arachnids for terrestrialism.
- Preadaptation is when a structure present in members of a species proves useful in promoting reproductive success when an individual encounters new environmental situations.

Adaptations

- Later adaptations included the evolution of efficient excretory structures.
- Internal surfaces for gas exchange.
- Appendages modified for locomotion on land.
- Greater deposition of wax in the epicuticle.

Form and Function

- Most arachnids are carnivores.
- They hold small arthropods with their chelicerae while enzymes from the gut tract pour over the prey.
- Partially digested food is then taken into the mouth.
- Others inject enzymes into prey through hollow chelicerae (e.g., spiders) and suck partially digested animal tissue.

GUT TRACT OF ARACHNIDS

Foregut

- ✓ Anterior portion
- ✓ Develop as infoldings of the body wall.
- ✓ Lined with cuticle.
- ✓ A portion of the foregut is frequently modified into a pumping pharynx.

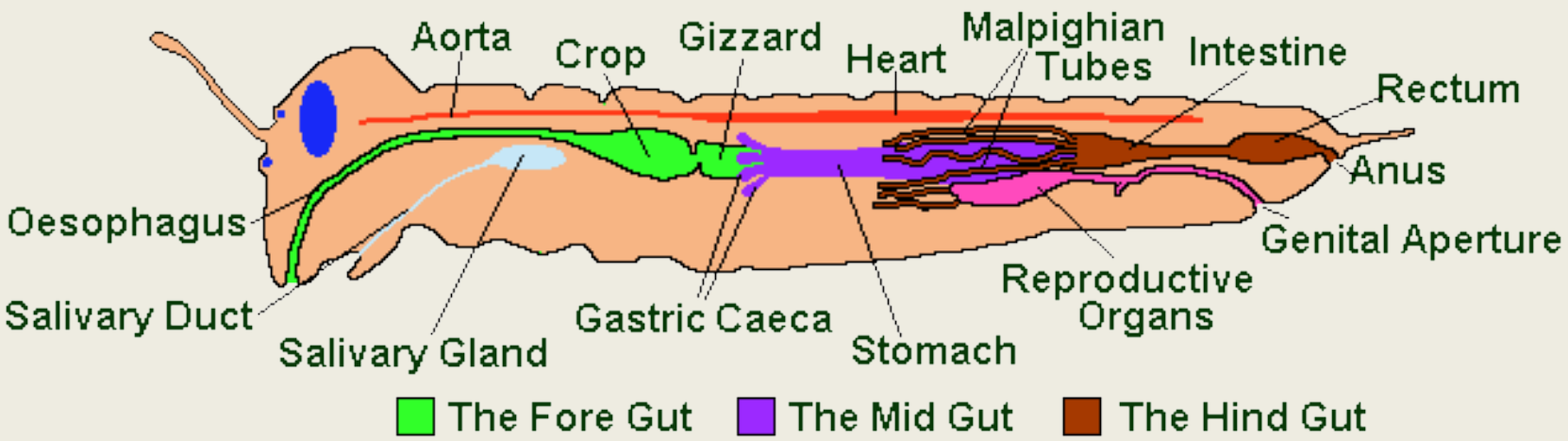
Midgut

- ✓ Between the foregut and hindgut.
- ✓ Noncuticular
- ✓ Lined with secretory and absorptive cells.

Hindgut

- ✓ posterior portion
- ✓ Develop as infoldings of the body wall.
- ✓ Frequently a site of water reabsorption.

The Insect Gut (Digestion and Reproduction)

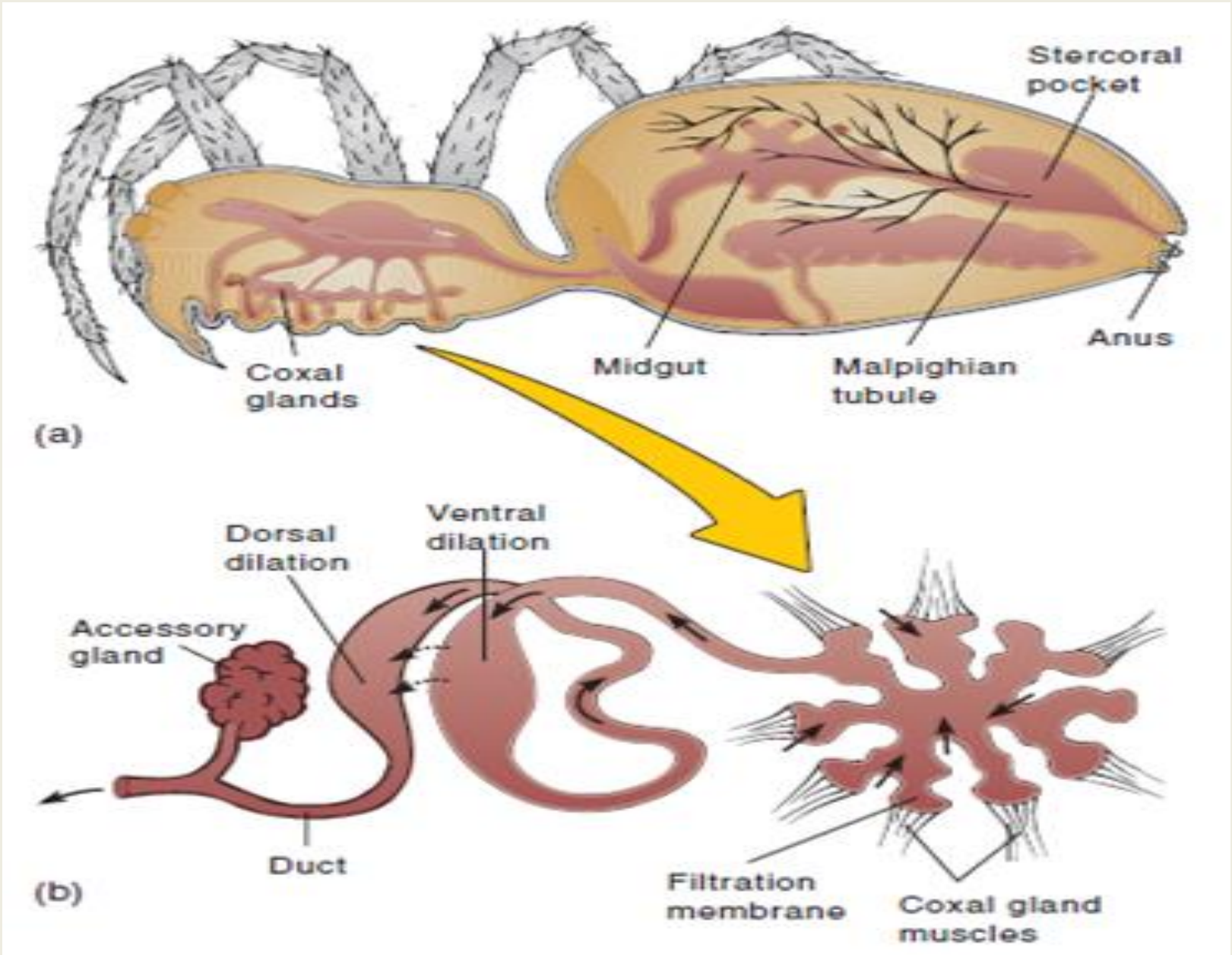


Coxal glands

- For excreting nitrogenous wastes.
- Paired, thinwalled, spherical sacs bathed in the blood of body sinuses.
- Nitrogenous wastes are absorbed across the wall of the sacs, transported in a long, convoluted tubule, and excreted through excretory pores at the base of the posterior appendages.

Malpighian tubules

- Arachnids that are adapted to dry environments possess blind-ending diverticula of the gut tract that arise at the juncture of the midgut and hindgut.
- These tubules, called Malpighian tubules, absorb waste materials from the blood and empty them into the gut tract.
- Excretory wastes are then eliminated with digestive wastes.
- The major excretory product of arachnids is uric acid.


Stercoral pocket
Anus
Coxal glands
Midgut
Malpighian tubule
(a)
Ventral dilation
Dorsal dilation
Accessory gland
Duct
(b)
Filtration membrane
Coxal gland muscles

Respiratory System:

Book lungs:

- Paired invaginations of the ventral body wall that fold into a series of leaflike lamellae.
- Air enters the book lung through a slitlike opening and circulates between lamellae.
- Respiratory gases diffuse between the blood moving among the lamellae and the air in the lung chamber.

Tracheae:

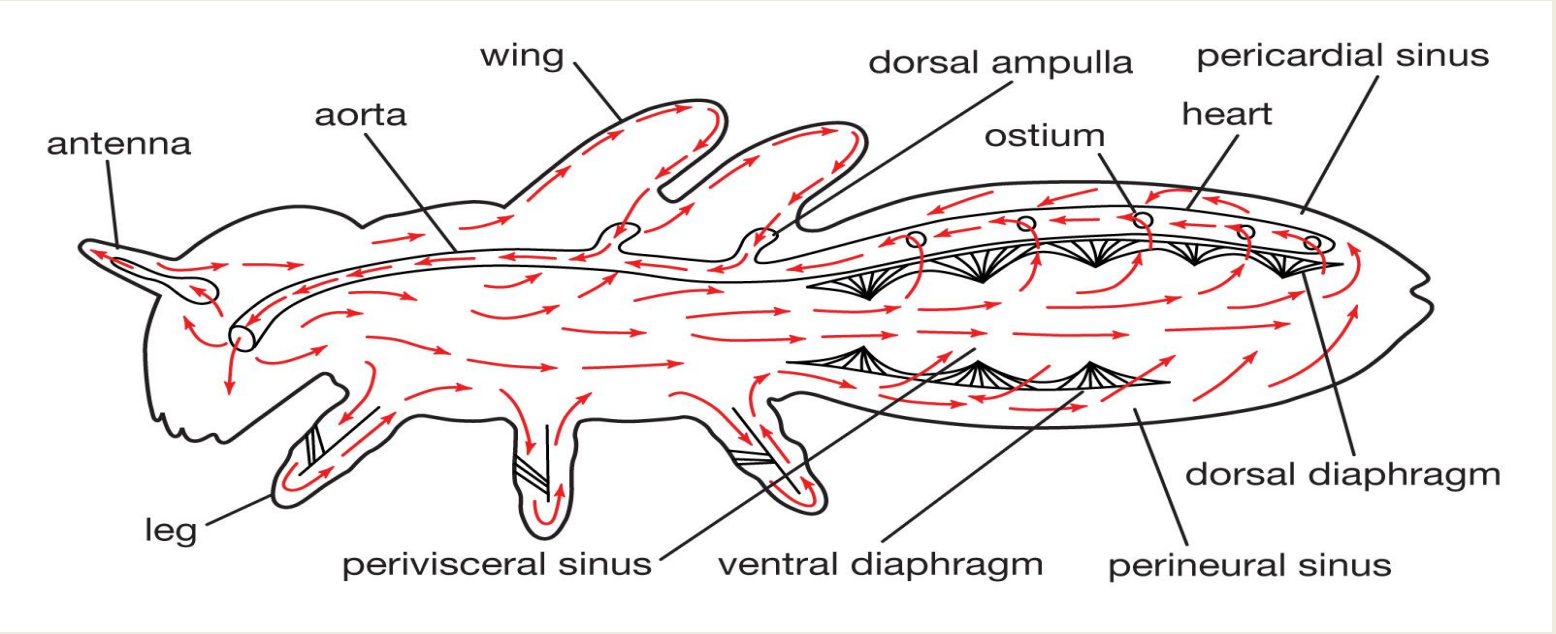
- Other arachnids possess a series of branched, chitin-lined tubules that deliver air directly to body tissues.
- These tubule systems, called tracheae.
- Open to the outside through openings called spiracles along the ventral or lateral aspects of the abdomen.

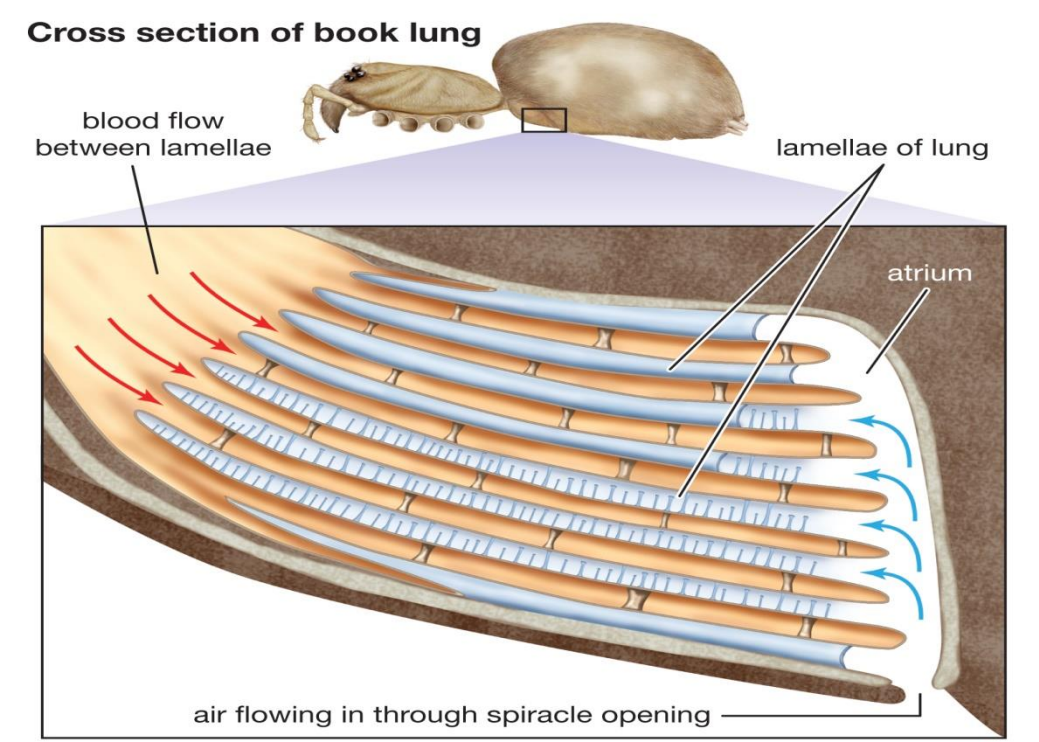
Circulatory system

- an open system in which a dorsal contractile vessel pumps blood into tissue spaces.
- In arthropods, the coelom is reduced to cavities surrounding the gonads and sometimes the coxal glands.
- Blood bathes the tissues and then returns to the dorsal aorta through openings in the aorta called ostia.
- Arachnid blood contains the dissolved respiratory pigment hemocyanin and has amoeboid cells that aid in clotting and body defenses.

Nervous system

- The nervous system of all arthropods is ventral.
- With the exception of scorpions, the nervous system of arachnids is centralized by fusion of ganglia.


wing
dorsal ampulla
pericardial sinus
aorta
heart
antenna
ostium
dorsal diaphragm
leg
perivisceral sinus
ventral diaphragm
perineural sinus


Cross section of book lung
blood flow
between lamellae
lamellae of lung
atrium
air flowing in through spiracle opening

Sensory Structures

- The body of an arachnid has a variety of sensory structures.
- Most mechanoreceptors and chemoreceptors are modifications of the exoskeleton, such as projections, pores, and slits, together with sensory and accessory cells.
- Collectively, these receptors are called **sensilla**.

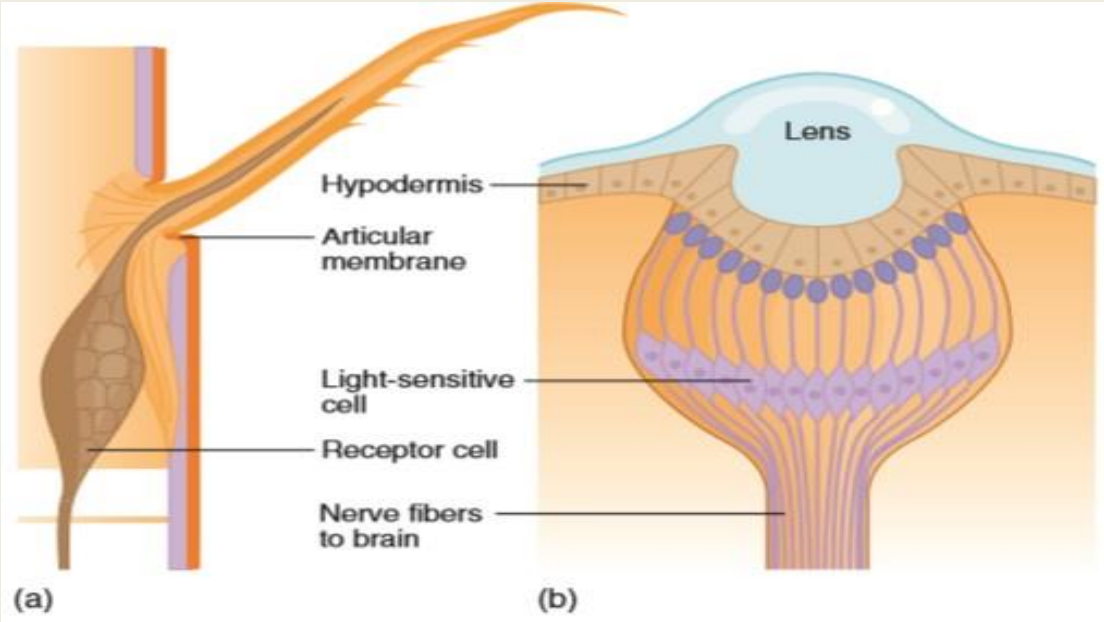


Fig: Arthropod Seta and Eye (Ocellus). (a) A seta is a hairlike modification of the cuticle set in a membranous socket. Displacement of the seta initiates a nerve impulse in a receptor cell (sensillum) associated with the base of the seta. (b) The lens of this spider eye is a thickened, transparent modification of the cuticle. Below the lens and hypodermis are light-sensitive sensillae with pigments that convert light energy into nerve impulses.

Sensory Structures

- The chemical sense of arachnids is comparable to taste and smell in vertebrates.
- Small pores in the exoskeleton are frequently associated with peglike, or other, modifications of the exoskeleton, and they allow chemicals to stimulate nerve cells.
- Possess one or more pairs of eyes primarily for detecting movement and changes in light intensity.
- The eyes of some hunting spiders probably form images.

REPRODUCTION AND DEVELOPMENT

- Arachnids are **dioecious.**
- **Paired genital openings** are on the ventral side of the second abdominal segment.
- The male often packages sperm in a **spermatophore**, which is then transferred to the female.
- In some taxa (e.g., spiders), copulation occurs, and sperm is transferred via a modified **pedipalp** of the male.
- Development is direct.
- The young hatch from eggs as **miniature adults.**
- Many arachnids tend their developing eggs and young during and after development.

GENERAL CHARACTERISTICS:

- Food usually consists of small arthropods, earthworms, and snails.
- Some centipedes feed on frogs and rodents.
- Poison claws (modified first-trunk appendages called maxillipeds) kill or immobilize prey.
- Male lays down a silk web using glands at the posterior tip of the body.
- places a spermatophore in the web, which the female picks up and introduces into her genital opening.
- Eggs are fertilized as they are laid.
- A female may brood and guard eggs by wrapping her body around the eggs, or they may be deposited in the soil.
- Young are similar to adults except that they have fewer legs and segments.
- Legs and segments are added with each molt.