Phylum Arthropoda

“joint-footed” animals
Phylum Arthropoda

- the largest phylum
- comprises ~80% of all known animals
Arthropoda Characteristics

- Triploblastic
- Organ level of organization
- Bilateral Symmetry
- Cephalization
- Eucoelomate
- Protostome
protostomes

- Annelida
- Mollusca
- Arthropoda

deuterostomes

- Echinodermata
- Chordata

- eucoelomates
Similarities Between Arthropods and Annelids

1. Segmentation: Arthropods and Annelids are both segmented
Similarities Between Arthropods and Annelids

1. Segmentation

   Segmentation is reduced in Arthropods through:

   1. Disappearance of segments
   2. Fusion of segments
   3. Structural and functional differentiation of segments
Tagmatization: The fusion and specialization of metameric segments.
A developing Arthropod embryo
Similarities Between Arthropods and Annelids

2. Nervous system: The nervous systems of Arthropods and Annelids consist of a dorsal brain (cerebral ganglion) and a ventral nerve cord with ganglia in every segment.
Annelid Nervous System

- cerebral ganglion
- segmental nerve
- ventral nerve cord
- segmental ganglion
- mouth
Arthropod Nervous System

Segmental ganglion

cerebral ganglion

ventral nerve cord
Similarities Between Arthropods and Annelids

3. Primitive Arthropods have one pair of appendages per segment

Andelid

Arthropod

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Similarities Between Arthropods and Annelids

- These appendages are said to be **serially homologous** to one another.
- Serial homology: the correspondence (in the same individual) of repeated structures having the same origin and development.
Examples of homologous characters: Vertebrate forelimbs
Examples of analogous characters: bat wings and insect wings

Bat wing

Fly wing
serially homologous structures
<table>
<thead>
<tr>
<th>Homology</th>
<th>Serial Homology</th>
<th>Analogy</th>
</tr>
</thead>
</table>
| - 2 individuals  
- structures have same developmental origin and same or different functions | - 2 structures on 1 individual | - 2 individuals  
- structures have different developmental origins but same function |
| bat wing & hand | cheliped & swimmeret | bat wing & insect wing |
Similarities Between Arthropods and Annelids

1. Segmentation
2. Nervous system
3. Paired appendages
Similarities Between Arthropods and Annelids

• Despite these similarities Arthropods are a much more successful group of animals than Annelids.
• Over 1 million described species of Arthropods (probably 10 million undescribed) compared to 15,000 Annelids.
What characteristics have enabled Arthropods to achieve such great diversity and abundance?
1. **Exoskeleton**

- hardened external cuticle secreted by the epidermis
- composed of chitin; has internal ridges/projections called apodemes to which muscles attach
- benefits: protection without loss of mobility
- limits growth → must be “molted”
- limits ultimate body size because of weight
Ecdysis (molting)

- Epicuticle
- Exocuticle
- Endocuticle

Under hormonal control

- Molting fluid dissolves old endocuticle
- New exocuticle is secreted
- New endocuticle forms under exocuticle
- Exocuticle hardens

- Old exocuticle ruptures
- Ecdysis → the animal backs out of old exoskeleton

J. Soucie, © BIODIDAC.
2. Tagmatization and jointed appendages

• The fusion of segments into blocks called tagmata (sing: tagma) that are specialized for certain functions
head composed of 3 segments

head composed of 5 fused segments
2. Tagmatization and jointed appendages

• usually each tagma has a pair of jointed appendages
• appendages may be highly modified with tagmata being specialized for certain functions (e.g. feeding, moving, sensory)
• appendages are essentially hollow levers that are moved by well-developed striated muscles (flexors and extensors) and are capable of fast, powerful movement
Raptorial leg
Swimming leg
Leg of diving beetle
Jumping leg
Digging leg
Honey bee leg
3. Respiratory System

• on land: most have a respiratory system that consists of tubes that deliver air directly to tissues and cells (tracheal system)
• in water: most have gills
• these systems allow for a higher metabolic rate and level of activity
Insect tracheal system

- spiracle
- trachea

Ivy Livingstone © BIODIDAC
Insect tracheal system

Ivy Livingstone © BIODIDAC

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4. Sensory System

• similar to Annelida
  (ventral nerve cord, cerebral ganglia/brain…)
• possess a variety of sensory organs
  (e.g. simple and compound eyes, antennae, chemoreceptors, sensory hairs…)
5. Complex Behavior

- have complex innate behaviors and some are capable of learning
- some even show communication and cooperation

Dr. Herrnkind: http://bio.fsu.edu/~herrnlab/
6. Metamorphosis

• most have a larval stage that differs morphologically and behaviorally from the adult

• reduces competition between larvae and adults by allowing them to occupy different ecological niches
Arthropoda Characteristics

Feeding and Digestion

- Free living and parasitic forms
Cymothoa exigua

The only known case of a parasite substituting itself for a host's organ.
Arthropoda Characteristics

Digestive System

• complete with regional specialization
Generalized Arthropod Digestive System

- foregut (lined with cuticle)
- midgut
- hindgut (lined with cuticle)
- mouth
- anus
Arthropoda Characteristics

Circulatory System

• open circulatory system consisting of a hemocoel (main body-cavity) filled with hemolymph (blood)
Arthropoda Characteristics

Excretion

• usually glands, some classes have specialized excretory systems

Reproduction

• usually sexual and dioecious
• usually internal fertilization
Subphylum Trilobita
(Class Trilobitomorpha)

• all are extinct
• the most diverse of the extinct arthropod groups (~5000 genera)
Subphylum Chelicerata

- no antennae
- 6 pairs of appendages:
  - 1\(^{st}\) pair = pincer, fang-like chelicerae
  - 2\(^{nd}\) pair = pedipalps
  - 3\(^{rd}\) – 6\(^{th}\) pair = walking legs
- body divided into 2 tagmata

[Image of a spider with prosoma and opisthosoma labeled]

- prosoma: consists of the head and all the legs
- opisthosoma: consists of the abdomen
Body Plan

- chelicerae
- pedipalps
- prosoma
- walking legs
- opisthrostoma
Subphylum Chelicerata

Class Merostomata

Horseshoe crabs have been essentially unchanged for ~250 million years
Class Merostomata

telson

opisthosoma prosoma

carapace

compound eye

chelicerae

book gills

walking legs
Class Merostomata
Subphylum Chelicerata

Class Arachnida
Class Arachnida
spiders, scorpions, ticks, mites, chiggers, daddy longlegs

They usually have several adaptations for life on land:
  • book lungs or tracheal system or both
  • waxy cuticle

pedipalps
Class Arachnida

- arachnids as parasites
- chiggers (mites) and ticks
Class Arachnida

- arachnids as disease vectors
- Lyme disease is caused by infection with a bacteria that is transmitted by tick bites

Deer tick

Borellia
Subphylum Chelicerata

Class Pycnogonida

- sea spiders
- ~1000 marine species
- males carry the eggs
Subphylum Crustacea

- most are marine, some terrestrial and freshwater
- head has 2 pairs of antennae
- appendages are primitively biramous
  (have 2 major branches)
- body divided into 2 tagmata:

  cephalothorax:
  consists of the head and the thorax

  abdomen

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Subphylum Crustacea

- have mandibles, 2 pairs of maxillae, and 1 pair of legs per segment

- cephalothorax:
  - 2 pairs of antennae
  - mandibles
  - 1\(^{\text{st}}\) and 2\(^{\text{nd}}\) maxillae
  - 3 pairs of maxillipeds
  - 5 pairs of walking legs

- abdomen
  - usually has 6 segments
  - # 1-5 have pairs of swimmerets
  - last segment has a pair of uropods and a telson
Subphylum Crustacea

Class Branchiopoda

- sea monkeys and water fleas
- marine and freshwater
- important zooplankton
Subphylum Crustacea

Class Ostracoda

- have a bivalved carapace
- marine and freshwater
- reduced number of appendages
Subphylum Crustacea

Class Copepoda

- mainly marine, some freshwater and terrestrial (e.g. mosses...)
- usually the most abundant animal in the plankton
- median eye
- Extremely long first antennae
Subphylum Crustacea

Class Cirripedia

- acorn barnacles and gooseneck barnacles
- marine and sessile as adults
- feed with modified appendages called cirri
Class Cirripedia

- modified body form

- Cirri (legs)
- penis
- mouth
- anus
- Peduncle (absent in stalkless barnacles)
- ovary
- Adhesive gland
Class Cirripedia

- often form dense mats
- hermaphroditic with long extendable penis to reach neighbors
Subphylum Crustacea

Class Malacostraca

- largest class of Crustacea (23,000 species)
- marine, freshwater, terrestrial
- shows great diversity
Class Malacostraca

Class Malacostraca contains the largest Arthropods
Who are the Arthropods closest relatives?

• Traditionally, Arthropods were thought to have derived from an Annelid-like ancestor.

• This hypothesis was based mainly on morphological similarities.
Neilson 2001
• A new phylogeny based on RNA sequence data has changed our view of the relationship between Arthropods and Annelids (and many other taxa).
• According to this new view, Arthropods are more closely related to some of the pseudocoelomates (e.g. nematodes) than Annelids.
Deuterostomia (vertebrates, echinoderms, tunicates, etc.)
  Arthropoda (insects, spiders, crabs, etc.)
    Onychophora (velvet worms)
    Tardigrada (water bears)
    Nematoda (roundworms)
    Nematomorpha (horsehair worms)
    Kinorhyncha
    Loricifera
    Priapulida (penis worms)
      Platyhelminthes (flatworms, tapeworms, flukes)
      Chaetognatha (arrow worms)
      Gastrotricha
      Rotifera (rotifers)
      Gnathostomulida (jaw worms)
      Micrognathozoa
      Cyclophora
      Mesozoa
    Annelida (bristleworms, ragworms, earthworms, leeches and their allies)
      Sipuncula (peanut worms)
      Mollusca (snails, clams, squids, etc.)
      Nemertea (ribbon worms)
      Bryozoa (moss animals)
      Entoprocta (kamptozoans)
      Phoronida (horseshoe worms)
      Brachiopoda (lamp shells)