

Classification of Phylum ARTHROPODA

Phylum Arthropoda is the largest phylum of the animal kingdom. The word comes from Greek *arthron* (≡ joint) and *podos* or *pous* (≡ foot) i.e. “animals with jointed legs”. This represents approximately three-quarters of all known biological organisms, living or extinct. They are one of the chief divisions of animal kingdom both as regards to diversity of organization and the number of genera and species. They are adapted to different types of environmental conditions.

Time of origin: From the study of fossil record, it can be said that the origin of the phylum was *Cambrian* period about more than 500 million years ago.

Numerical strength: There are well over *one million* described *species* till date.

Definition: Arthropods are *bilaterally symmetrical, segmented, coelomate* animals having *jointed appendages* and *haemocoelom* and the body covered by exoskeleton formed of *chitinous cuticle*, respire by gills or trachea or book gill or book lung or body surface and undergo moulting periodically.

Reasons for establishing arthropods as the dominant biologically successful group of animals

1. Highest number of genera, species and individuals.
2. Stretches of territory occupied & variety of habitats- aquatic, terrestrial, semi terrestrial i.e. living in different environmental conditions.
3. Excellent adaptive features.
 - a] Respiration by gills in aquatic forms, by trachea or air tubes in terrestrial forms and in some cases, special types of respiratory structures like book lung or book gill also serve the function of respiration.
 - b] Excretion is performed by antennary glands or green glands in the second antenna maxillary gland or shell gland in second maxilla. In terrestrial forms, Malpighian tubules and coxal gland perform the function of excretion.
 - c] Circulatory system open, in which the heart is long, situated on the dorsal surface of the body and extends from the head right upto abdomen. It pumps blood through haemocoel which is the major body cavity.
 - d] Nervous system consist of a brain, united by oesophagial connectives with ventral nerve cord, formed of a double chain of ganglia joined together by connectives and commissures.
4. Amount and kinds of food consumed.
5. Capabilities of defending against enemies.

General Characters

1. Presence of externally jointed appendages.
2. Body covered by an exoskeleton formed of chitinous cuticle.
3. Presence of haemocoelomic body cavity.
4. Respiration by gills, trachea, book gill or book lung and other types.
5. Excretion by antennary glands or green glands, maxillary gland or shell gland, Malpighian tubules and coxal gland.

6. Heart is represented by slender, elongated dorsal vessel and perforated by small apertures called ostia.

N.B. In addition to the above points, arthropods also show some features which may be common with some other groups. These include-

- i) Bilaterally symmetrical and segmented body.
- ii) Mouth and anus are at opposite ends.
- iii) Sexes are separate or united, sexual dimorphism is common.

Note: (i) An appendage is an external body part that projects from the body while limb is a major appendage of animal, used for locomotion. Foot (plural: feet) is the terminal part of the limb that bears weight & allows locomotion.

(ii) An exoskeleton is a hard covering that supports and protects the bodies of some animals. The cuticle is the outer covering of arthropod and is its exoskeleton to which the muscles are attached. The cuticle in arthropod is made of chitin.

(iii) When the animal grows, its soft inside parts also grow but not the exoskeleton. So, its soft body gets too big for the exoskeleton, and the exoskeleton splits open and falls away. This process is called moulting (or, molting) which is regulated by hormone.

Basis of classification: The following characters have immense and considerable classificatory values like: (i) Presence or absence and the structure of antennae & antennules (ii) Presence or absence and the structure of caudal styles (iii) Number, structure and arrangements of appendages on head, thorax and abdomen (iv) Nature of eyes (v) Presence or absence of mandibles (vi) Types of excretory organ (vii) Nature of respiratory organ (viii) Structure of heart

Classificatory Scheme

[After Rupert and Barnes, 1994 (as mentioned in the book Invertebrate Zoology, 6th. Edition): upto class only]

Phylum ARTHROPODA			
I. Sub phylum TRILOBITA	II. Sub phylum CHELICERATA	III. Sub phylum CRUSTACEA	IV. Sub phylum UNIREMIA
Extinct	1. Class Merostomata	1. Class Remipedia	1. Class Chilopoda
	2. Class Arachnida	2. Class Cephalocarida	2. Class Diplopoda
	3. Class Pycnogonida	3. Class Branchiopoda	3. Class Symphyla
		4. Class Ostracoda	4. Class Pauropoda
		5. Class Copepoda	5. Class Insecta
		6. Class Mystacocarida	
		7. Class Tantulocarida	
		8. Class Pentastomida	
		9. Class Branchiura	
		10. Class Cirripecta	
		11. Class Malacostraca	

Characters of Different Living Subphyla and Classes

Sub phylum Trilobita

The trilobites are an extinct group of arthropods (e.g., *Elrathia* sp) that lived in the seas of the world for about 380 million years, from the Precambrian 610 million years ago to around the end of the Permian.

Sub phylum Chelicerata

1. Body divisible into anterior *prosoma* (cephalothorax) and posterior *opisthosoma* (abdomen).
2. Prosoma with six pairs of appendages - the first pair is pre-oral and known as 'chelicerae', the second pair is pedipalps and the last four pairs are walking legs.
3. Neither mandible, nor antenna.
4. Respiration by book gill, book lung, trachea or cutaneous.

Note: (i) The group is an ancient group of Arthropod that evolved about 500 million years ago. (ii) The name chelicerata comes from chelicerae (singular chelicera), which act as jaw. The chelicerae and pedipalps are mouthparts.

(iii) The early members were all predatory, but the modern chelicerates have diversified to take advantage of a variety of feeding strategies. Members of this group are herbivores, detritivores, predators, parasites and scavengers.

(iv) The living animals include horse shoe crabs, scorpions, mites, ticks, harvestmen, spiders and marine spiders and also fossilized forms namely Eurypterida, which were the largest arthropods.

Class Merostomata

1. Presence of both simple and compound eyes, arranged in pairs.
2. Opisthosoma is divided into mesosoma with five to six pair of lamelliform or leaf like biramous appendages and a metasoma without appendage but with a spine like telson.
3. Aquatic and mostly marine, showing external fertilization.
4. Branchial respiration usually by book gill.

Example: *Limulus* sp. *Carcinoscorpius* sp., *Tachypleus* sp.

N. B. There are only four living species under the three genera. (i) *Limulus polyphemus* - known as King crab or American or Atlantic horse shoe crab. (ii) *Carcinoscorpius rotundiculata* - known as Mangrove horse shoe crab, found in India. (iii) *Tachypleus gigas* - known as Indo-Pacific horse shoe crab, found in India. (iv) *Tachypleus tridentatus* - known as Tri-spine horse shoe crab.

Note: The class includes the extinct eurypterids (e.g., *Jaekelopterus* sp.) and the living xiphosurans. The latter is commonly called horse shoe crabs as the upper surface of the prosoma is covered by a semicircular or horse shoe shaped carapace.

Class Arachnida

1. Body divisible into cephalothorax and abdomen.
2. Cephalothorax with two pairs of jointed appendages and four pairs of walking legs.
3. Eye sessile, usually simple.
4. Respiration by trachea or book lung.

5. Heart tubular, sex separate.

Example: *Buthus* sp., *Palamnaeus* sp. (these are two genera of Scorpion), *Araneus* sp. *Nephila* sp. (these are two genera of Spider), *Haemaphysalis* sp. (Tick), *Acarus* sp. (Mite), *Leiobunum* sp. (Harvestmen or Opiliones)

Class Pycnogonida (also known as Pantopoda which means all legs)

1. Marine, spider like animals having body with cephalothorax or prosoma and a rudimentary abdomen or opisthosoma.
2. Cephalothorax with four dorsal simple eyes and four pairs of appendages of which the first two pairs are chelophore (chelated) and palpi respectively, and the rests are walking legs.
3. Anterior end with snout like process bearing mouth (proboscis) and four projections bearing claws.
4. No respiratory or excretory system.
5. Heart tubular with two to three pairs of ostia.

Example: *Nymphon* sp.

Sub phylum Crustacea

1. Body is divided into six segmented head, thorax and abdomen; in most cases, thoracic segments fuse together with head to form cephalothorax.
2. The head has two compound eyes; two pairs of antennae; one pair of mandible and two pairs of maxillae.
3. A pair of 'green glands' excretes wastes near the base of antennae.
4. Swimming appendages are biramous and abdominal.
5. The circulatory system is open; heart may or may not be present and the 'blood' is pumped by vessels into sinuses.
6. The nervous system consists of a primitive ventral nerve cord and ganglia system.

Note: The following features of crustacean are very important.

(i) Eyes usually compound and many are 'satlked' in nature.

(ii) Mandibles and maxillae form mouth parts. Mandible helps in crushing food; Maxilla helps in holding the solid food & passing it to mouth; The second pair of maxilla helps in respiration.

(iii) Among the antennae, the pair attached to the first segment of the head is called primary antennae or antennules. This pair is generally uniramous, but is biramous in crabs and lobsters and remipedes. It is usually smaller, acts as organ of balance, touch & taste. The pair attached to the second segment is called secondary antennae or simply antennae. The second antennae are larger & biramous, but many species later evolved uniramous pairs (Boxshall and Jaume, 2013), or reduced in remipedes, absent in barnacles or modified in some lobsters. It acts as an organ of touch, smell & taste.

(iv) The thoracic appendages are may be of two types: (a) Maxillipeds- appendages modified to function as mouthparts. (b) Pereiopods- the primarily walking legs, also used for gathering food.

(v) The abdominal appendages may be of two types: (a) The primarily swimming legs are called Pleopods (also called *swimmerets*). (b) The appendages from the last pair of body segment, usually before anus, known as uropods or caudal rami.

(vi) The posterior most body part is known as telson. It is not considered as a true segment by some scientists, and does not carry any appendages; however, a forked tail or caudal furca may be present.

(vii) Mostly aquatic; woodlice and a few crabs live on land. Majority are marine although some species live in freshwater. Barnacles live attached to rocks, walls etc.

(viii) The sexes are separate. Eggs are attached to the swimmerets or swimming legs of the female. The first pair is enlarged in the male which is used to pass sperm to the female.

Class Remipedia (only known venomous crustaceans)

1. Long segmented worm like body.
2. Each segment bears a pair of biramous appendages.
3. Inhabitants of marine caves.

Example: *Lasioneectes* sp., *Speleonectes* sp.

Class Cephalocarida (known as horse shoe shrimp)

1. Horse shoe shaped small structure with large head.
2. Eye absent, the second pair of antennae is located behind the mouth.
3. Only first 8 segments with appendages, out of 19-20 segments.
4. Live in marine surface sediments, i.e. benthic.

Example: *Hutchinsoniella* sp.

Class Branchiopoda

1. Body and appendages leaf like and latter contain gills.
2. Body may or may not be enclosed by carapace and antennae may help in locomotion.
3. Telson ramified mostly.
4. Mainly found in fresh water, few are marine.

Example: *Triops* sp.(tadpole shrimp), *Daphnia* sp.(water flea), *Artemia* sp.

Class Ostracoda (known as seed shrimp)

1. Body flattened from side to side and is fully covered by a bivalve carapace.
2. Segmentation not clear, trunk or abdomen reduced.
3. Two pairs of antennae help in swimming.
4. Number of appendages two pair, rarely four pair.
5. No gills, instead branchial plates present on the body surface.

Example: *Cypris* sp., *Vargula hilgendorffii* (bioluminescent species, known as sea firefly)

Class Copepoda

1. Body elongated with five to six pairs of thoracic appendages but none in abdomen except tail like remi.
2. Presence of single median compound eye.
3. The first pair of thoracic appendages is modified to form maxillipeds, which assist in feeding.
4. Heart and gill absent mostly.
5. Antennae large, especially the first pair.

Example: *Cyclops* sp. (water flea), *Mesocyclops* sp. (feeds on mosquito larva and used in biological control of mosquito), *Pennella* sp. (largest copepod and parasitic)

Class Mystacocarida

1. Small cylindrical body with five thoracic and five abdominal segments.
2. Head relatively large, mandibles limb like, antennae long.
3. Presence of single naupliar eye.
4. Found in the intertidal zones of sandy beaches.

Example: *Derocheilocaris* sp., *Ctenocheilocharis* sp. These are the only two genera with eight and five species respectively.

Class Tantulocarida

1. Minute, marine, ectoparasites.
2. Body unsegmented, thorax sac like, abdomen much reduced, no heart.
3. Trunk appendages absent.
4. The mature adult actually develops within an attached parasitic tantulus larva (Boxshall and Lincoln, 1987).

Example: *Tantulacus dieteri*

N. B. It is the world's smallest arthropod.

Class Pentastomida

1. Body worm or fluke like, cylindrical, superficially annulated, parasites.
2. Presence of two pairs of rudimentary limbs bearing claws apically.
3. No respiratory, excretory or circulatory system.
4. Nervous system consists of a circum oesophageal ring, a suboesophageal ganglia and a simple nerve cord.

Example: *Linguatula* sp. (Tongue worm), *Porocephalus* sp.

Class Branchiura (known as fish louse)

1. Body compressed dorsoventrally and covered by shield shaped or oval carapace.
2. One pair of sessile compound eye present.
3. Ectoparasite and abdomen unsegmented.
4. First maxilla with sucker, in most cases.

Example: *Argulus* sp., *Dolops* sp., *Chonopeltis* sp., *Dipteropeltis* sp.

Class Cirripedia (known as barnacle)

1. Marine, tend to live in shallow or tidal water.
2. Sessile, remain attached with substrate directly or by a stalk; larvae - active swimmers.
3. Free living, suspension feeders or parasitic forms.
4. Body encased in calcified plates, segmentation indistinct usually.
5. Adult with single cephalic appendage or antenna and maximum eight pairs of feathery thoracic legs or cirri.

Example: *Balanus* sp., *Sessilia* sp. (rock barnacle or acorn barnacle - two genera), *Lepas* sp., *Pedunculata* sp. (goose barnacle - two genera), *Sacculina* sp. (parasite on crab)

Class Malacostraca

1. Body segments conspicuous usually 20-21 in number, of which head 5 or 6 segmented.

2. Trunk with 14 segments and all bear appendages - 8 pair thoracic and 6 pairs abdominal; abdomen also bears telson usually.
3. Usually each abdominal segment except the last carries a pair of biramous pleopods which are similar types and used for swimming, burrowing etc.
4. The appendages of the last segment are typically flattened into uropods, which together with the terminal telson, make up the "tail fan".
5. Digestive gland hepatopancreas; heart tubular and respiratory pigment is haemocyanin mostly.
6. Eye stalked.

Example: *Macrobrachium rosenberghii* (giant fresh water prawn), *Penaeus monodon* (giant tiger prawn), *Squilla* sp. (mantis shrimp), *Panulirus* sp. (lobstar), *Eupagurus* sp. (hermit crab), *Scylla serrata* (mud crab), *Carcinus maenas* (shore crab - one invasive species)

Note: This is the largest class of crustacea, containing about 40,000 living species. The class displays a great diversity of body forms and include crabs, lobsters, crayfish, shrimp, krill, woodlice, amphipods, mantis shrimp and many other less familiar animals.

Sub phylum Uniremia

1. Appendages uniramous, i.e. unbranched.
2. Mostly terrestrial, some are aquatic.
3. One pair of mandibles and one pair of antennae present.
4. Respiration by trachea; excretion by Malpighian tubule.

Note: (i) This is the largest subphylum with maximum species including millipeds, centipeds, symphyla, pauropods and insects.

(ii) The first four classes i.e. Chilopoda, Diplopoda, Symphyla and Paropoda are commonly called Myriapoda and some Scientists considered these four altogether in a separate taxon. It also includes Arthropleurida (that contains some giant herbivores like *Arthropleura* sp.) which is extinct now.

(iii) Unusual sense organs found in some centipede, millipede and symphyla are the 'organs of Tömösváry'. These are located at the base of the antennae, and consist of a disc-like structure with a central pore surrounded by sensory cells. They are probably used for sensing vibrations, and may even provide a sense of hearing.

(iv) The centipede has some similarities with symphyla, whereas pauropods share some similarities with millipeds.

Class Chilopoda (centipeds)

1. Elongated dorsoventrally flattened body.
2. Presence of a pair of long filiform (long and thin with uniform cross section) antennae, a pair of mandibles and two pairs of maxillae.
3. Trunk with many somites, each bearing one pair of legs.
4. The appendages of the first trunk segment modified into prehensile (grasping) claw or pincer, known as forcipules.
5. Eye, if present usually compound without true vision or absent in many.
6. Live in soil, bark and log or beneath the stone; usually predatory and mostly venomous.

Example: *Scolopendra* sp.

Class Diplopoda (milliipeds)

1. Tube like body with distinct head and trunk (consists of more than 100 segments).
2. Presence of double trunk segments or diplosegments derived from the fusion of 2 originally separate somites.
3. Each diplosegment bears two pairs of legs.
4. Antennae club shaped and seven segmented.
5. Eye simple; consist of several simple flat-lensed ocelli arranged in a group or patch (ocellaria) on each side of the head.
6. A pair of mandible and maxillae present.
7. The first trunk segment is apodous (without feet).
8. Slow moving; live in leaf litter, dead wood or soil with humid condition; detritivore mostly, some feed on fungi or plant fluid, a few are predatory.

Example: *Julus* sp.

N. B. The species, *Illacme plenipes*, has the greatest number of legs (750) among the entire animal kingdom (Marek and Bond, 2006).

Class Symphyla (also known as garden centipede or pseudocentiped)

1. Body small, divided into head and trunk without eye and pigment.
2. Maxillae two pairs and the second pair united to form labium.
3. Trunk usually 14 segmented, which are protected by overlapping dorsal plates and usually first 12 segments bear legs.
4. Last segment bears a pair of sensory hair (trichobothria) or cerci.
5. Head bears a pair of spiracles and a pair of segmented antennae.
6. Rapid runners; live in deep soil, under stone, decaying wood or other moist places; herbivore or detritivore.

Example: *Scutigera* sp.

Class Pauropoda

1. Small, elongated, cylindrical, soft bodied animal, pale in colour and there are long sensory hairs located throughout the body segments.
2. Body 11-12 segmented, partially fused, nine of which bear a pair of legs.
3. The first instar has three pairs of legs, but that number increases with each moult.
4. Head is tiny, with large, branched, triflagellate or biramous antennae; deep-set mandibles; and two pairs of maxillae (accessory jaws).
5. Eye and heart absent, a pair of vibration-sensitive organs (pseudoculi) present.
6. The body segments have ventral tracheal or spiracular pouches, trachea absent in most.
7. Presence of distinct anal plate or pygidium.
8. Live under dead leaves, stones, and rotten wood and feed chiefly on fungi and decaying organic matter.

Example: *Pauropus* sp., *Decapauropus* sp.

Class Insecta (also known as hexapoda)

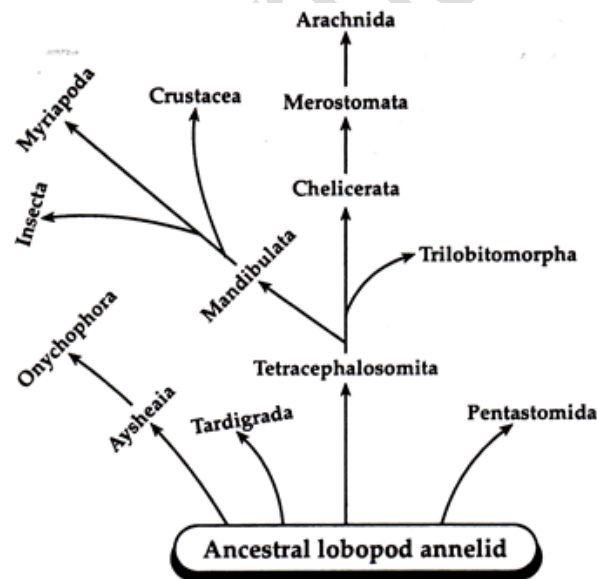
1. Body divided into head, thorax and abdomen.
2. Three pairs of thoracic legs are present.
3. Head with a pair of antennae, a pair of mandible and two pairs of maxillae.
4. Presence of one or two pairs of wings which may be absent in some.

5. Each segment has four basic regions. The dorsal surface is called the tergum (or *notum*), the two lateral regions are called the pleura (singular: pleuron) and the ventral aspect is called the sternum.

Example: *Lepisma* sp. (silver fish), *Podura* sp.(springtail, wingless), *Musca domestica*, *Apis* sp., *Bombyx mori*, *Phyllium* (leaf insect), *Gesonula* sp. (grasshopper), *Phasmatodea* sp.(stick insect), *Coccinella* sp. (lady bird beetle), *Anax* sp. (dragonfly)

Remark

The classification of arthropoda is not only a huge task, but also differs greatly from author to author. The classification followed here excludes the detail characters of extinct group and is restricted upto class level, which may not be sufficient for understanding the diversity of the group, especially for distinction between scorpions and spider, prawns and crabs, winged insects from wingless forms, insects from myriapods and many others. Lar, in 1904, separated Myriapods under a separate subphylum Myriapoda and considered Hexapoda i.e. insect as another subphyla. Parker and Haswell (1972) classified the phylum into seven subphyla, which further subdivided into eight classes. The classification was lucid but includes onychophora under the phylum. Now a days, onychophora is considered as a separate phylum. Meglitsch, Barrington, Anderson and others have classified in their own way. Thus, for simplicity, the scheme of Ruppert and Barnes can be followed.



Phylogeny of Arthropoda, after Anderson, 1998

Reference

Barnes, R.D. and Rupert, E. 1994. Invertebrate Zoology, 6th.ed. Brooks/Cole.