

# Rotifera

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Rotifera are minute, bilaterally symmetrical, unsegmented animals that live predominantly in freshwaters. The phylum name (Latin, *rota*, wheel; *ferre*, to bear) was first used by Cuvier in 1798; this refers to the anterior end which, in many species, resembles a rotating wheel due to the sequential beat of its cilia.

## Basic Design

Rotifera is a moderately sized phylum of fewer than 2000 species of minute ( $\approx 100\text{--}1500\ \mu\text{m}$ ), bilaterally symmetrical pseudocoelomates, having two distinctive features (Figure 1). (1) At the anterior end is a ciliated or setous field called the corona; this is used in locomotion and/or food gathering. (2) The pharynx, termed the mastax, is very muscular and is equipped with a complex set of jaws called trophi. Rotifers are sacculate to cylindrical animals possessing a spacious pseudocoelom in which are suspended the internal organs, but respiratory and circulatory systems are absent (Figure 2). The typical rotiferan body has four regions (head with corona, neck, trunk and foot), but to make this simple generalization is to dismiss a high degree of diversity within the phylum.

## Corona

The corona is a ciliated field at the anterior end of rotifers, but distribution of the cilia, presence of various lobes and knobs, and location of the mouth make this structure highly variable. For many species the corona comprises two ciliated rings (trochus and cingulum) that produce water currents used in locomotion and/or feeding (Figure 1). In some cases the corona is elaborated into two or more lobes or ear-like expanses (auricles) (Figure 3). Not all rotifers possess an extensive ciliary field; in some, cilia are nearly or completely lacking, in which case long setae surround the rim of a funnel-shaped corona (Figure 4).

## Neck and trunk

The neck region is hardly noticeable in most species (Figures 1 and 2). When distinct it is usually seen as a minor constriction separating the corona and trunk (Figure 4). The trunk exhibits a remarkable diversity within the group. In some species it is a large, smooth sac-like structure, whereas in others it is flattened like a dinner plate or long and worm-like resembling a telescope that collapses into itself.

## Body wall

The body wall or integument of rotifers is a syncytium in which is embedded a layer of filamentous proteins. This

## Introductory article

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layer, called the intracytoplasmic lamina (ICL), is shared with the parasitic phylum Acanthocephala, thereby indicating an evolutionary relationship. If major portions of the body wall are thickened by the ICL the rotifer is said to be loricate. However, if the integument is not thickened the body wall remains thin and flexible and the rotifer has no lorica (illoricate). Because extremes may be found even within a single genus, thickness of the body wall is of little taxonomic significance.

## Foot

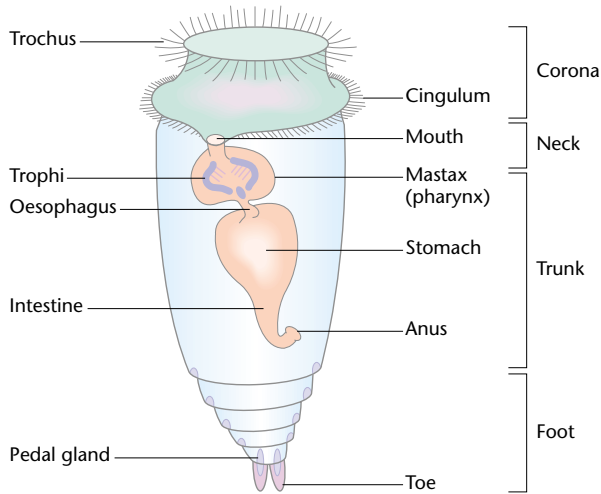
When present, the foot extends ventrally from the body. It may be very short or quite long (i.e. twice the body length) and it may or may not possess a few toes. In some forms the foot houses pedal glands, which secrete an adhesive that permits a temporary attachment to surfaces in free-swimming rotifers (Figure 1). However, in the juveniles of sessile rotifers, the adhesive forms a bond with the substratum that is not easily detached.

## Musculature

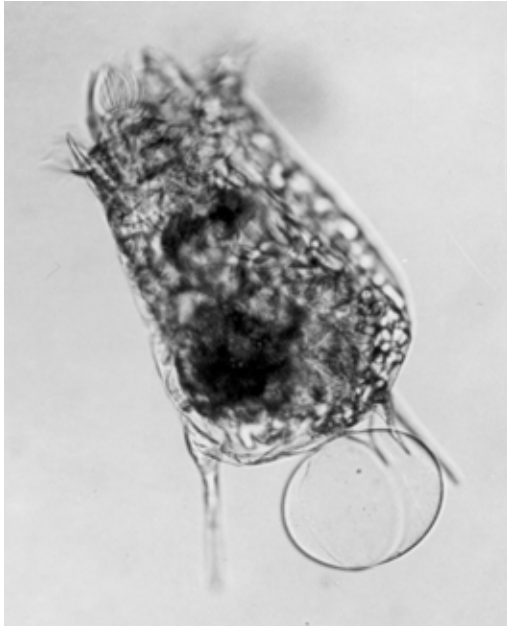
Rotifers possess bands of longitudinal and circular muscles inserted at various points on the body wall or between the body wall and internal organs. When muscles contract in the so-called loricate species the pressure within the pseudocoel is increased, allowing it to act as a hydrostatic skeleton. In some forms the hydrostatic skeleton aids in achieving movements that resemble those of an inch worm, whereas in others this pressure merely expands flaccid portions of the body wall or causes flexible spines or feather-like appendages that articulate with the body to swing outward.

## Digestive system

The gut is an uncomplicated structure generally differing only in the form of the jaws (trophi). In herbivorous rotifers small particulate food (captured by feeding currents generated by the corona) enters the mouth and then passes into the mastax or pharynx. Here the trophi crush the food before it is passed to the stomach. In some raptorial species the trophi are used more like ice tongs to

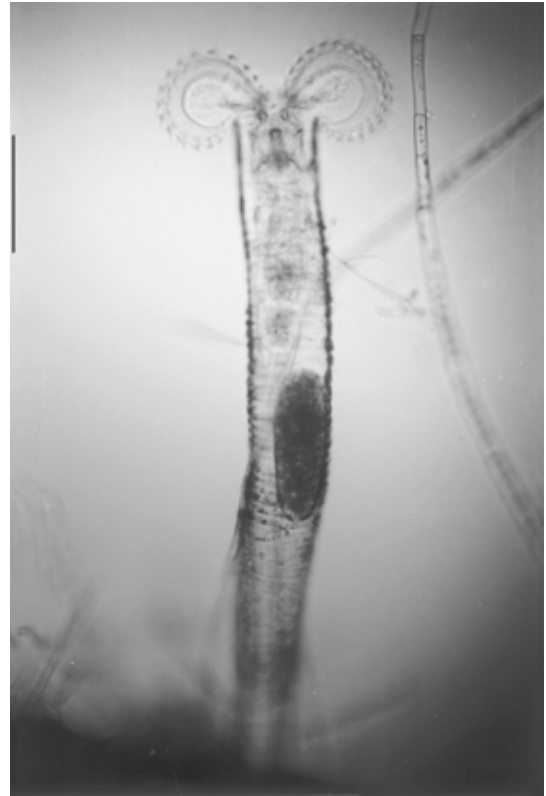


**Figure 1** Anatomy of a generalized rotifer. (Reproduced with permission from: Barnes RSK, Calow P and Olive PJW (1993) *The Invertebrates: a New Synthesis*, 2nd edn. London: Blackwell Scientific Publications.)



**Figure 2** *Brachionus*, an abundant, freshwater monogonont rotifer. Bar, 100  $\mu\text{m}$ .

grasp the prey and push it into the stomach. Stomach, intestine, rectum and anus are usually present. In those with a complete gut, the end of the intestine acts as a cloaca (Latin, sewer), receiving eggs, fluid from paired protonephridia, and indigestible food. Often algae or other strongly pigmented foods colour portions of the gut a bright green or brown.



**Figure 3** *Limnias*, a common, freshwater, sessile rotifer of class Monogononta. Bar, 100  $\mu\text{m}$ .

## Nervous system

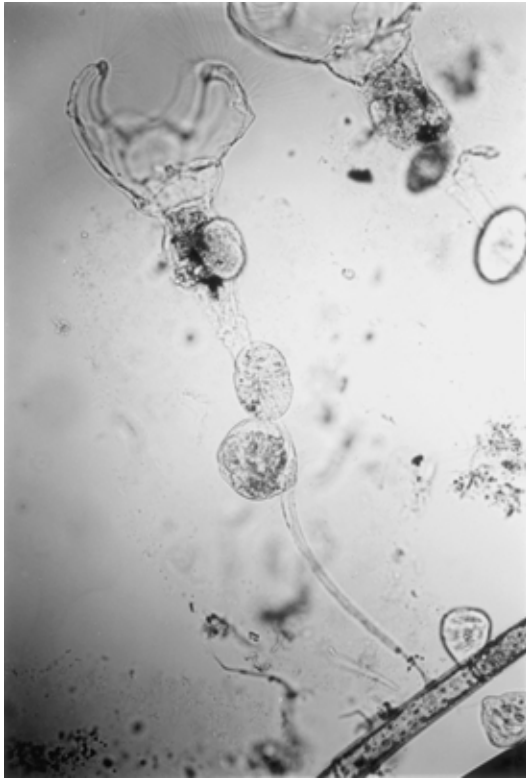
The nervous system is simple comprising a dorsal brain, a few ganglia, and sensory receptors. An interesting structure, of unknown function, found in the apical region of many species is the retrocerebral organ. It consists of paired glands and an unpaired sac. Ducts from the retrocerebral organ lead to the surface of the corona.

## Excretory system

All rotifers possess a paired protonephridial system that consists of tubules and flame cells which function in excretion of wastes and osmoregulation. Normally, the tubules drain into a urinary bladder which leads to the cloaca, but the bladder is absent in some species and a contractile cloaca assumes its function.

## Reproductive system

Major differences in the reproduction system are used to separate the three classes. Two classes possess paired gonads, whereas a third has only one. In females the ovary



**Figure 4** *Collotheca*, a sessile rotifer lacking the typical ciliated corona of rotifers. Bar, 100  $\mu\text{m}$ .

(usually with a yolk gland or vitellarium) leads to an oviduct and then to the cloaca.

### Body cavity

The fluid-filled body cavity of rotifers is usually spacious, but it contains no blood cells. Nevertheless, it probably functions as a kind of circulatory system as well as a hydrostatic skeleton. Because there is no peritoneal layer lining either the inner body wall or the internal organs, this cavity qualifies as a pseudocoelom. This allies the rotifers with other wormlike animals often referred to as the pseudocoelomates or aschelminths (e.g. Acanthocephala, Loricifera, Kinorhyncha).

## Diversity and Life Styles

There are three classes of rotifers: Seisonidea, Bdelloidea and Monogononta. With one genus and only two species, Seisonidea is the smallest of the three classes. This class, which lives on a type of marine crustacean, has paired gonads and both sexes are always present. There are about 400 species of Bdelloidea, a class comprising mainly



**Figure 5** *Macrotrachella*, bdelloid rotifer. (Reproduced with the kind permission of Giulio Melone, University of Milan.) Bar, 100  $\mu\text{m}$ .

swimming and crawling forms (Figure 5); many, however, inhabit the film of water that covers soil particles and small plants such as mosses. Only females with paired ovaries are known in this class. The third and largest class is Monogononta with some 1600 species; these rotifers have single gonads and two curious features regarding the males. They are sometimes structurally reduced, and they are more often not present at all. In fact, in some species males have never been seen. Thus, reproduction for the monogononts is, in the main, parthenogenetic, with sexual reproduction occurring only rarely. The majority of monogononts swim or crawl over plants or live within the sediments. However, some 200 species live a sessile life, usually permanently attached to a freshwater plant (Figures 3 and 4). While the vast majority of rotifers are solitary, some 25 species form colonies of various sizes (Figure 6).

### Life styles

Typically rotifers inhabit freshwater where their abundance ranges up to about 1000 individuals per litre or more when food is abundant. Rotifers live in other environments besides freshwaters: about 50 species are exclusively marine whereas some live within the films of water found in soils or covering mosses and other small terrestrial plants. Most freshwater rotifers live their brief lives in the plankton, while others crawl over aquatic plants or creep within the benthos. Nearly all rotifers are free-living herbivores or raptorial predators; very few are parasitic.

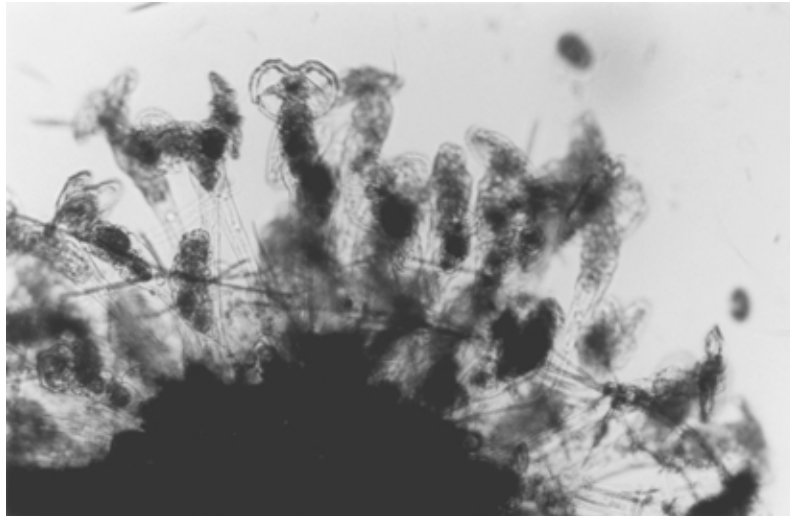


Figure 6 *Sinantherina*, a colonial rotifer. Bar, 100  $\mu\text{m}$ .

## Life cycle

Reproduction varies among the classes. At the two extremes are the Seisonidea, which always reproduce sexually, and the Bdelloidea, which always reproduce asexually via parthenogenesis. Class Monogononta exhibits a combination of the two. In this class parthenogenetic reproduction, termed the amictic cycle, prevails for most of the year with sexual reproduction, termed the mictic cycle, occurring only rarely, if at all. Control of when the males appear is complex and probably specific to each species. The outcome of sexuality is a resting egg (diapausing embryo).

## Anhydrobiosis

Some bdelloid rotifers are capable of being desiccated and then revived by rehydration some weeks or even years later. This feature, called anhydrobiosis, has been known since the time of Leeuwenhoek when he observed rehydration of rotifers found in the dry sediments from rain gutters. Phylum Tardigrada (the water bears) are also capable of anhydrobiosis.

## Fossil History and Phylogeny

There are only a few fossils of rotifers, and these are all bdelloids that have been found in amber. The phylogenetic position of rotifers is not completely clear. On the basis of recent work on the genetic sequences of nuclear and mitochondrial DNA, rotifers appear to be very closely related to the parasitic phylum Acanthocephala. In fact, some scientists argue that acanthocephalans are rotifers,

whereas others maintain that there is just a close relationship. In either case, the acanthocephalans and rotifers are traditionally grouped with the aschelminths or pseudo-coelomates, but the status of that entire group is suspect.

## Further Reading

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