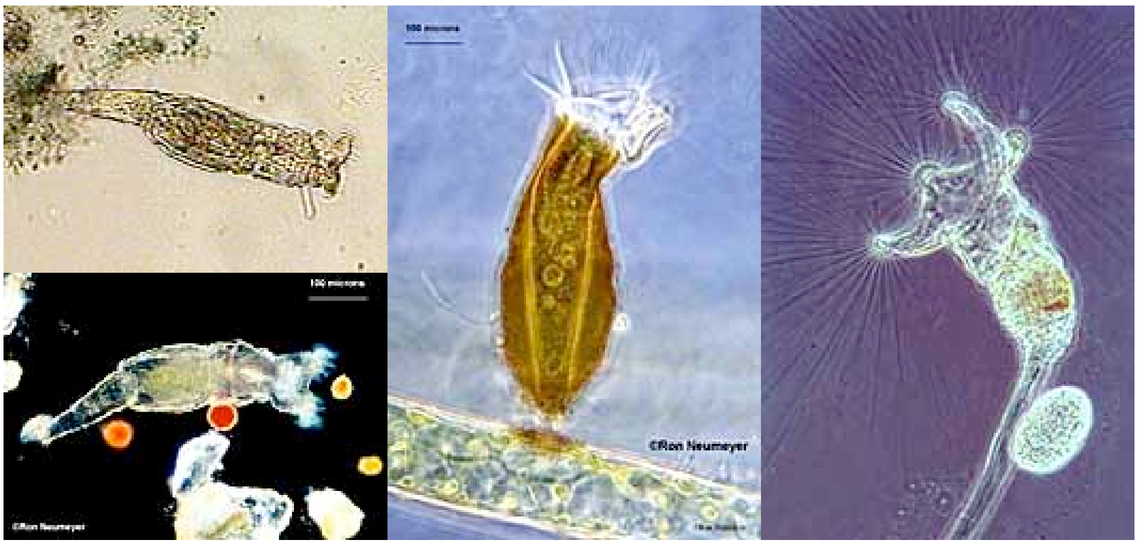
Introduction to the Rotifera

Rotifers : the "wheel animalcules"

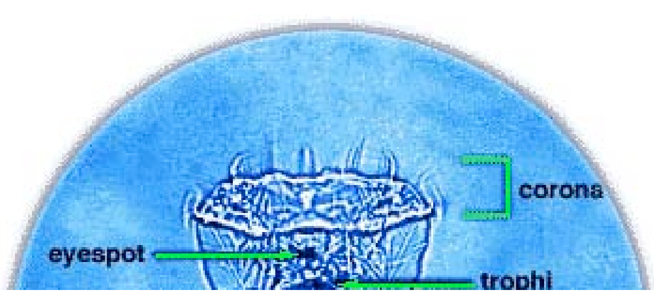
Rotifers are microscopic aquatic animals of the phylum Rotifera. Rotifers can be found in many freshwater environments and in moist soil, where they inhabit the thin films of water that are formed around soil particles. The habitat of rotifers may include still water environments, such as lake bottoms, as well as flowing water environments, such as rivers or streams. Rotifers are also commonly found on mosses and lichens growing on tree trunks and rocks, in rain gutters and puddles, in soil or leaf litter, on mushrooms growing near dead trees, in tanks of sewage treatment plants, and even on freshwater crustaceans and aquatic insect larvae. (Örstan, 1999)

Because of their very small size and mostly soft bodies, rotifers are not commonly favored for fossilization. Their only hard parts, their jaws, might be preserved in the fossil record, but their tiny size makes detection a serious challenge (Örstan, 1999). However, fossils of the species *Habrotrocha angusticollis* have been found in 6000 year old Pleistocene peat deposits of Ontario, Canada (Warner et al., 1988). The oldest reported fossil rotifers have been found in Dominican amber dating to the Eocene (Waggoner & Poinar, 1993).



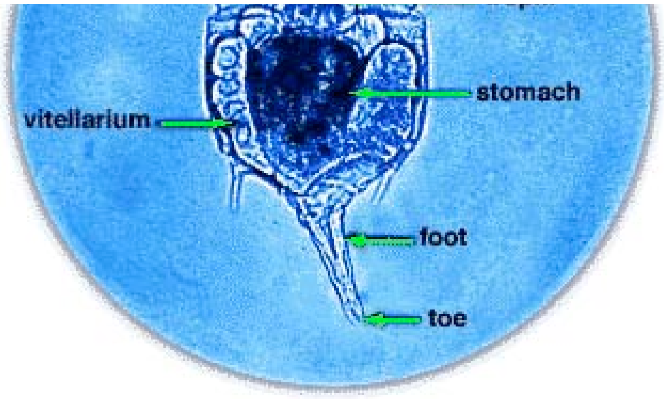
Rotifers : The rotifers are microscopic animals, and under high magnification will look something like the picture at upper left, for most perople using a light microscope. Those with more sophisticated microscopes and lighting techniques can give rotifers such as *Philodina*, grazing at lower left, a beautiful glow. But not all rotifers swim freely; some like the Floscularaiacean rotifer above at center, will cement themselves by their foot to a handy alga or bit of dirt and sift the water for food. At right, *Collotheca* is another monogonont rotifer, shown here bearing an egg on its stalk end. Notice the extemely long coronal cilia this rotifer uses to catch food. (Click on any of the pictures above for a larger image).

Rotifers are multicellular animals with body cavities that are partially lined by **mesoderm**. These organisms have specialized organ systems and a complete digestive tract that includes both a mouth and anus. Since these characteristics are all uniquely animal characteristics, rotifers are recognized as animals, even though they are microscopic. Most species of rotifers are about 200 to 500 micrometers long. However a few species, such as *Rotaria neptunia* may be longer than a millimeter (Orstan 1999). Rotifers are thus multicellular creatures who make make their living at the scale of unicellular protists.



The name "rotifer" is derived from the Latin word meaning "wheel-bearer"; this makes reference to the crown of **cilia** around the mouth of the rotifer. The rapid movement of the cilia in some species makes them appear to whirl like a wheel.

At left, you can see a photomicrograph identifying basic anatomical features of *Epiphanes brachionus*. The general body plan of a rotifer consists of four basic regions: head, neck, trunk (body), and the foot. In most species, the head carries a **corona** (crown) of



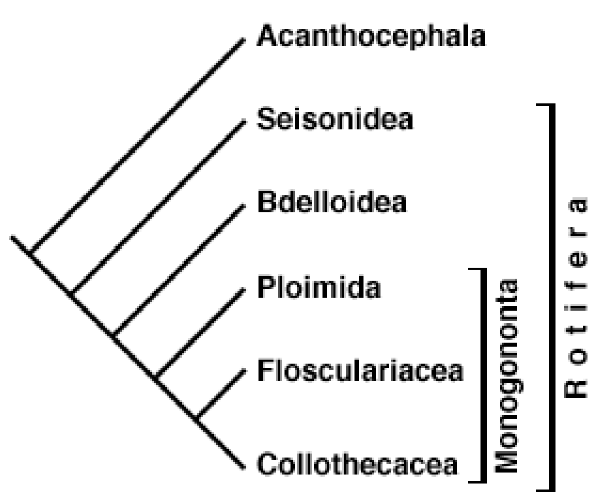
cilia that draws a vortex of water into the mouth, which the rotifer sifts for food. The food itself is ground by the **trophi** (jaws), located just behind the mouth in the **pharynx** (throat). Trophi are found in almost all rotifers, and are characteristic organs of the phylum Rotifera. The body of the rotifer is externally but not internally segmented. The body is telescopic, with a semi-flexible, extendible, transparent **cuticle** covering. It is the cuticle that suggests rotifers are close relatives of roundworms and arthropods. Within the body are the stomach and reproductive organs. The final region of the rotifer body is the foot; this foot ends in a "toe" containing a cement gland with which the rotifer may attach itself to objects in the water and sift food at its leisure.

As rotifers are microscopic animals, their diet must consist of matter small enough to fit through their tiny mouths during filter feeding. Rotifers are primarily omnivorous, but some species have been known to be cannibalistic. The diet of rotifers most commonly consists of dead or decomposing organic materials, as well as unicellular algae and other phytoplankton that are primary producers in aquatic communities. Such feeding habits make some rotifers primary consumers. Rotifers are in turn prey to carnivorous secondary consumers, including shrimp and crabs.

As well as their morphology and feeding habits, reproduction in rotifers is rather unusual. Several types of reproduction have been observed in rotifers. Some species consist only of females that producetheir daughters from unfertilized eggs, a type of reproduction called **parthenogenesis**. In other words, these parthenogenic species can develop from an unfertilized egg, asexually. Other species produce two kinds of eggs that develop by parthenogenesis: one kind forms females and the other kind develops into degenerate males that cannot even feed themselves (**sexual dimorphism**). These individuals copulate resulting in a fertilized egg developing within the rotifer. The males survive long enough to produce sperm that fertilize eggs, which then form resistant zygotes that can survive if the local water supply should dry up. The eggs are released and hatch in the water. If the egg develops in the summer, the egg may remain attached to the posterior end of the rotifer until hatching.

A particular class of rotifers called bdelloids can be found living in almost all freshwater environments, and occasionally in brackish and marine waters. Bdelloids are known for their remarkable ability to survive drying through a process known as **cryptobiosis**. Factors determining the duration of time that a rotifer is able to withstand desiccation include the humidity and temperature at which they are kept. Ideally, more humid conditions and mild to warm temperatures prevent the very dry conditions that are unfavorable to rotifers. Rotifer eggs can also withstand drying, with older embryos having a greater chance at survival (Örstan, 1999). The species *Brachonius calyciflorus* has been found to conserve energy when food is scarce by decreasing its respiration rate, while other species show no change in respiration rate. It is predicted that the ability of some rotifer species to adapt to resources with temporal variation in availability allows the coexistence of competing species of rotifers. Therefore, there is a tradeoff between the competitive ability of rotifers and the maximum population growth rate for a particular species. (Kirk, 1999).

Based on certain morphological similarities, rotifers and **acathocephalans** (the parasitic worms constituting the phylum Acanthocephala) have long been considered close relatives. Recent comparisons of 18S rRNA gene sequences provide further evidence of close relationship between these two groups. Rotifers and acanthocephalans have traditionally been classified as pseudocoelomates, along with a variety of other small worm-like animals. More recently, phylogenetic analyses have contradicted the hypothesis that Pseudocoelomata is a natural group. Instead, some pseudocoelomate animals, such as priapulids and nematodes, appear to be more closely related to arthropods, in a group termed Ecdysozoa. Other animals with a pseudocoel, such as rotifers and acanthocephalans, appear to be more closely related to Lophotrochozoa, a large alliance of protostomes that includes molluscs, annelids, brachiopods, etc.



Phylum Rotifera is divided into three classes: Monogononta, Bdelloidea, and Seisonidea. The largest group is the Monogononta, with about 1500 species, followed by the

Bdelloidea, with about 350 species. There are only two known species of Seisonidea, which is usually regarded as the most "primitive", and in morphological analyses it comes out in a basal position (see cladogram at right).

Observing rotifers is relatively uncomplicated with the correct procedure and equipment. When extracting rotifers from a sample, it is best to use a pipette, drawing water from the area around clumps of soil or plant matter in the sample. The sample should be quickly transferred to a slide so the rotifers do not adhere to the sides of the pipette. Additionally, cover-slips should not be used under a light microscope because rotifers are easily disturbed and may contract into an indiscernible ball. If food is added to the slide, rotifers can be observed swimming if they do not become stuck to the slide (Ricci, 1999). Thus, although rotifers are invisible to the naked eye, they can easily be watched in their exported natural environments with the help of a microscope.

For more information about Rotifera:

Visit Microscopy UK for a wealth of wonderful rotifer images and information, including:

- Gallery of Rotifers
- Wonderfully Weird World of Rotifers by Richard L. Howey
- The Rotifer Jaw by Mike Morgan
- Live Rotifer Birth, a movie filmed by amateur microscopist David Walker

Aydin Örstan has collected a wealth of bdelloid rotifer information for the web:

- An Introduction to Bdelloid Rotifers
- Microhabitats and Dispersal Routes of Bdelloid Rotifers
- LIBS - Literature Index for Bdelloid Rotifers

Additional sites rich in rotifer-nalia:

- International Association of Meiobenthologists, an organization for scientists who study the really tiny animals like rotifers.
- Laboratory Exercise on Bdelloid Rotifer Anatomy by Richard Fox. A step-by-step tecaching exercise involving rotifers.
- Population Dynamics study by James N. McNair, using rotifers in a chemostat.
- Rotifer Gallery by Ron Neumeyer, a talented photomicroscopist who has taken some very nice rotifer portraits.
- Rotifers Gallery, this time from Jerry Evans' information about Central Texas Natural History.
- Rotifer Study Methods, a wealth of free information on the collection, micromanipulation, and study of rotifers by Howard L. Taylor.
- Rotifer Systematic Database, coordinated by Elizabeth Walsh of the University of Texas at El Paso. The site includes morphological and molecular phylogenies, a database, references, and basic information.

Images of *Philodina* and Floscularíacean kindly provided by Ron Neumeyer. Image of *Epiphanes brachionus* internal anatomy prepared by Elizabeth Walsh, of the University of Texas at El Paso, and used with permission. Pictures of *Collotheca* and *Lecane* kindly supplied by Wim van Egmond from the "Gallery of Rotifers" listed above. Image of living rotifer by Molly McCarthy of Ohio University.

Sources:

- A. Jawahar Ali, S. S. S. Sarma, & H. J. Dumont, 1999. Cyst production in the fairy shrimp, *Streptocephalus proboscideus* (Anostraca) in relation to algal and loricated rotifer diet. Crustaceana (Leiden) 72(5): 517-530.
- Garey, J. R., Schmidt-Rhaesa, A., Near, T. J., Nadler, S. A. 1998. The evolutionary relationships of rotifers and acanthocephalans. Hydrobiologia 387-388: 83-91.
- Mary Jo Hartman & Stephen Sulkin, 1999. Effects of prior exposure to petroleum hydrocarbon contamination during brooding on the subsequent larval development of the brachyuran crab *Hemigrapsus oregonensis*. Journal of Crustacean Biology 19(4): 690-698.

- Kevin L. Kirk, et al., 1999. Physiological responses to variable environments: Storage and respiration in starving rotifers. Freshwater Biology 42 637–644.
- Thomas Nogrady, Robert L. Wallace, & Terry W. Snell. 1993. Rotifera, Vol. 1: Biology, Ecology and Systematics. The Hague: SPB Academic Publishing.
- Aydin Örstan, 1999. An Introduction to Bdelloid Rotifers. member.aol.com/bdelloid1/deloid.htm
- Claudia Ricci & Guilio Melone, 2000. Key to the identification of the genera of bdelloid rotifers. Hydrobiologia 418: 73–80.
- B. M. Waggoner & G. O. Poinar, Jr., 1993. Fossil habrotrochid rotifers in Dominican amber. Experientia (Basel) 49(4): 354–357.
- B. G. Warner, et al., 1988. Holocene fossil *Habrotrocha angusticollis* (Bdelloidea: Rotifera) in North America. Journal of Paleolimnology 1(2): 141–147.
- Wirz, A., Pucciarelli, S., Miceli, C., Tongiorgi, P., Balsamo, M. 1999. Novelty in phylogeny of Gastrotricha: Evidence from 18S rRNA gene. Molecular Phylogenetics and Evolution 13(2): 314–318.
- Xi Yilong & Huang Xiangfei. Effect of food supply in both food quality and quantity on the population dynamics of *Brachionus urceolaris*. Acta Hydrobiologica Sinica 23(3): 227–234.
