Flatworms and Ribbon Worms

Note: These links do not work. Use the links within the outline to access the mages in the popup windows. This text is the same as the scrolling text in the popup windows.

Why is bilateral symmetry important? (Page 1)

Bilatera:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/bilatera.html

The Bilateria constitute the major branch of true multicellular animals. Animals in this lineage not only developed bilateral symmetry, but also a definite head and a third tissue layer from which more complex tissues and organs could form.

Three Layers:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/three_layers.html

His cross section of the simple flatworm body illustrates a major difference between the Radiata and the Bilateria. Whereas the Cnidarians and comb jellies had an inert layer of mesoglea between the epidermis and gastrodermis, The Bilateria have a region of packed cells that constitutes a third cell layer. From these cells, muscle tissue developed as well as a variety of specialized organs. Such structures could not form from pidermis, which is designed as an interface between the animal and its environment or from the gastrodermis that is specialized to keep digestive juices with the digestive cavity and to promote digestion and food distribution. A major step in establishing the Bilateria body plan occurred when the early embryo of these animals acquired a middle layer of mesoderm. The outer embryonic layer, ectoderm, developed into the pidermis and the inner endoderm layer into the gastrodermis as occurs in all Eumetazoans, but the mesoderm give rise to the all important third layer of cells that is not present in the Radiata.

Protostomia:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/protostomia.html

The Protostomia lineage of the Bilateria contains many familiar animals. For the next 10 days we will concentrate on three Phyla: Platyhelminthes, the flatworms, Mollusca, the molluscs, and Annelida, the segmented worms. We will discuss the embryological differences that separate the Protostomia and Deuterostomia lines when we begin our study of Deuterostome animals later.

I. What is a flatworm? (Page 2)

Wormlike:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/wormlike.html

Any soft bodied animal that is elongated and lacks appendages is usually called a worm. The flatworms meet his definition, but are much more flattened than the worms of other Phyla. The typical flatworms shown here are crawling across the glass in an aquarium.

Digestive Cavity:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/digestive_cavity.html

The digestive cavity of flatworms is typically large and branched. The branching is more extensive in some species as depicted in the right-hand diagram. The only opening to this cavity is the mouth which is located on the ventral side of the body posterior to the head. The mouth, like that of Cnidarians serves as an anus to eliminate solid wastes as well as an entry point for food.
The mesodermal region of flatworms contributes tissue to form two layers of muscle that underlie the epidermis.
Complex Epidermis:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/complex_epidermis.html

His diagram of a flatworm cross section illustrates the location of mucus glands. These glands are part of the epidermis, but have increased their size by penetrating inward through the muscle tissues. Copious mucus is secreted from these glands to the body surface.

Freshwater Planaria:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/freshwater_planaria.html

Freshwater planaria are small, rarely exceeding one centimeter in length. They are abundant in streams and ponds, but usually hide from site in crevices or beneath rocks. A piece of raw meat left in the water can attract a large number of planaria in a short period of time. The two species shown here are typical and probably look familiar to you.

Biology Courses:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/biology_courses.html

The freshwater planaria are easy to handle and have become popular specimens in introductory biology laboratories. Their locomotion and behavior are readily visible to the naked eye, but observation of their anatomy requires a microscope.

Regeneration:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/regeneration.html

The regenerative capacity of flatworms has been known since the 19th century. These diagrams are from a paper published in 1897 by Harriet Randolph at Bryn Mawr College. She first cut planaria in half either lengthwise or across the center and found that each half grew back the missing part. In the figures on the right, she cut each planarian into 8 pieces. All pieces from both planaria were able to regenerate an entire worm.

Experiments:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/experiment.html

These diagrams were posted on the Internet by a biology class. As in historical experiments, each piece of a cut planarian began to regenerate, with the anterior pieces being the first to restore a head. The bottom panel illustrates the ever popular experiment of creating a two-headed animal.

Marine Planaria:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/marine_planaria.html

Marine planaria are also common, but less well known due to their small size and tendency to avoid light. Their shape is often broad, but very flat. Brilliant color patterns are typical.

Some Species:
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/flatworms/flatworms_popups/some_species.html

Here we see three species of terrestrial planarians. They are generally larger than the aquatic planaria; the one at the top is 10 centimeters in length. Although the soft bodies of flatworms are subject to drying out, a mucus coat allows these species to survive on land as long as their environment is moist and humid. The upper planarian
The long planarian on the right was recently found in North Carolina where it is rarely seen. It is a species introduced from Australia and lacks the characteristic wedge-shaped head of most terrestrial planaria.

Gardeners:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/gardeners.html

Here is a question posed to a gardening expert at a horticulture website. The answer was not to worry, planarians are carnivorous and never eat plants.

II. How do free-living flatworms perform the basic life processes? (Page 3)

Flatworm Locomotion:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/move_across.html

Note the changes in body shape as this freshwater planarian glides across the surface of a petri dish. Muscle contractions elicit barely perceptible undulations of the body as well as obvious contractions, extensions and ending movements. The muscle tissue of flatworms is much more powerful than the tiny contractile fibers of cnidarians and provides stronger, faster contractions.

Cilia:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/cilia.html

The planarian body is covered with cilia which create turbulence in the surrounding water when the animal is active. This observation gave rise to the class name Turbellaria for the free-living flatworms. In this video of a highly magnified planarian body, the rapidly beating cilia can be seen.

Swim:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/swim.html

Some marine planarians have a broad, extremely flattened body and swim by undulations of the body edges.

Pharynx:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/pharynx.html

The pharynx of planarians is a muscular tube connected to the digestive cavity. It is housed within the cavity when not in use and extended out through the mouth during feeding.

Pharynx Extended:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/pharynx_extended.html

This diagram illustrates the pharynx extended out through the mouth on the ventral side of the planarian’s body. The opening within the pharynx leads into the digestive cavity. This allows enzymes to be secreted into foodstuffs outside of the body. Partially digested bits of food are then sucked up by muscular contractions of the pharyngeal wall.

Predators:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/predators.html

Planaria will eat almost any animal small enough to subdue. Here, the planarian on the left has mounted a nudge. On the right, a planarian has extended its pharynx to feed on Daphnia, a small crustacean. In the bottom panel, the planarian has captured a small segmented worm.

Branched Cavity:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/branched_cavity.html
In most groups of free-living flatworms, the digestive cavity is highly branched to provide increased surface area.
Green Flatworm:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/green_flatworm.html

Planarians that lack a digestive cavity are called Acoels. The species shown here is abundant along the northern coast of France. At low tide, these flatworms can often be found by the millions gathered into patches on the beach. Note the symbiotic algae living in tissues throughout the worm’s body.

Excretory System:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/excretory_system.html

The excretory system consists of a network of small canals that extend from the head to the tail along both sides of the body. As shown in the magnified portion, the tips of most canals end in oval structures called flame bulbs that are embedded within the mesodermal tissues. Water collects within the flame bulbs and is transported through the canal system until arriving at one of the many excretory pores where it exits the body.

Flame Bulb:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/flame_bulb.html

Each flame bulb, like the one illustrated here, contains a tuft of long flagella. Beating of the flagella propels water into the connecting canal and throughout the canal system. The beating flagella resemble flickering lames, giving “flame bulbs” their name.

V. How do free-living flatworms reproduce? (Page 4)

ermaphroditic:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/hermaphroditic.html

The planarians contain both male and female sex organs. To reproduce sexually, two worms must copulate and exchange sperm. Sperm cells produced by the testes move through the sperm duct and are injected into the body of the mate by inserting a muscular penis into the genital pore. Sperm are stored in a seminal receptacle by the receiving worm until eggs are released from the ovaries. Sperm then travel through the oviduct to fertilize the eggs. As fertilized eggs move down the oviducts, they are surrounded by yolk and finally by a protective capsule before being shed through the genital pore. This complex system assures that eggs will be fertilized, provides nutrients for prolonged development, and gives the developing embryos some protection from potential predators.

Fertile Eggs:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/fertile_eggs.html

Most free-living flatworms produce a small number of rather large eggs. In this acoel planarian, five eggs are waiting release from the body.

Larvae:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/larvae.html

On the left, we see the typical larva of a marine flatworm. Larvae swim and feed by means of cilia for several days. Then, they begin a metamorphic change to the adult body form as can be seen in the larva on the right.

/. Does the flatworm nervous system differ from that of Cnidarians? (Page 5)
Cephalization:
Most flatworms have a distinguishable head end. The free-living forms usually have one or more pairs of eyes and there are often small lobes projecting from the sides of the head.

**Ganglia:**  
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/ganglia.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/ganglia.html)

At the anterior end of flatworms, nerve cells have clumped together forming large ganglia. There are usually two head ganglia and they often fuse as in the example shown here. Note that the eyes are positioned directly over the ganglia and that short nerve tracts run to the lobes of the head where cells sensitive to chemicals and touch are concentrated. This arrangement allows sensory stimuli to be transmitted directly to the ganglia where an appropriate response is generated.

**Eye Cups:**  
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/eye_cups.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/eye_cups.html)

The eye cups of planarians are somewhat advanced over the light sensing structures found in jellyfish. As shown in this diagram, the light sensing cells are surrounded by a cup of darkly pigmented cells. There is only one opening into the cup for light penetration, thus the worms can determine both intensity and direction of the light source. Most planarians respond negatively to light by moving away from the light source and attempting to hide in dark places.

**Sensing Chemicals:**  
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/sensing_chemicals.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/sensing_chemicals.html)

The head region of free-living flatworms is well endowed with sensory cells that can distinguish chemicals dissolved in the water. These enable planarians to locate food and to recognize potential mates. Both chemosensory and touch-sensitive cells are highly concentrated on the lobes extending from the sides of the head. These lobes are more prominent in freshwater and terrestrial species, shown in the top panels, than in marine flatworms, as depicted below.

**Nerve Cords:**  
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/nerve_cords.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/nerve_cords.html)

The nervous system of planarians is distinguished by the presence of longitudinal nerve cords that connect to the head ganglia and receive input from the lateral nerve nets. Some freshwater species have cross connections between the two nerve cords which facilitate coordination between right and left sides.

**Response to Stimuli:**  

As this planarian travels around the bottom of a dish, its head touches bits of debris that cause it to quickly turn and try a new direction. Notice how quickly the worm responds to these touch stimuli. The planarian is also responding to light from the microscope by moving toward a shaded area at the edge of the dish.

/1. Are the ribbon worms related to flatworms? (Page 6)

**Ribbon Worms:**  
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/ribbon_worms.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/ribbon_worms.html)

Observe the long, flat bodies of these typical ribbon worms. The ribbon worm group (Phylum Nemertea) has been considered a “minor phylum” due to the small number of species and relative obscurity of these worms. Now though, some biologists consider them a neglected phylum worthy of study due to the advanced features of
of ribbon worms and more are being found at a rapid rate. These worms arose at least 500 million years ago and are among the first animals in the Bilateria line.

**Proboscis:**
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/proboscis.html

The ribbon worms have a long, muscular proboscis that is everted from the head of the worm to capture prey. It can be seen both retracted and extended in the worms shown here. Unlike the extensible pharynx of flatworms, the proboscis is not connected to the digestive cavity. The proboscis is flexible enough to wrap around small animals and in some worms is armed with sharp stylets.

**Giant Ribbon Worm:**
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/flatworms/flatworms_popups/giant_ribbonworm.html

We don’t usually think of worms as candidates for size competitions, but all ribbon worms can greatly increase their length by thinning the body. Giant Ribbon Worms have been measured at over 30 meters when relaxed and one is reported to have extended to a length of 60 meters while thinning to a few millimeters in diameter. If this is true, ribbon worms hold the record for longest living animal.