Introduction to Planaria

Planarians are free-living flatworms and form the class Turbellarians in the Phylum Platyhelminthes. The Other two classes of flatworms are parasitic (flukes and tape worms). Flatworms have three tissue layers, ectoderm, mesoderm, and endoderm. These tissues are organized into organs and organ systems. Thus, flatworms are the simplest animals with mesodermic layers and organ-system levels of organization. However they do not have body cavity. They are acoelomates.

Most planarians are freshwater worms and are commonly found in ponds and streams or under rocks. However terrestrial and marine species also exist. Planarians are mobile and use cilia on their ventral surface to glide over surfaces. Planarians can have different pigmentation such a light brown, dark brown, black, or white. The characteristic planarian triangular head has two auricles and two light-sensing eye spots (ocelli) which give the worm a “cross-eyed” appearance. The auricles contain chemoreceptors that are used to find food. The eye spots are connected to the cerebral ganglia and are used to detect and avoid sunlight (negative phototaxis) but do not detect images.

Planarians are predators and scavengers and eat live or dead animals using their muscular retractable pharynx which can extend out of the mouth opening on the ventral side up to half of their body length. The pharynx pins down the prey while enzymes secreted from the mouth soften the tissue. The digestion is completed inside the cells after the food has been sucked through the pharynx. The mouth is the only opening in planarian and undigested food must also exit the body through the mouth.

Planarians show bilateral symmetry, and form the simplest invertebrate group showing definite differentiation into head and tail parts. Planarians have very simple organ systems: The nervous system is made of a small brain beneath the ocelli (the cerebral ganglia) which is connected to two long parallel nerve cords running along the body to the tail. The two chords are connected by transversal nerves. The digestive system consists of a mouth, a pharynx, and a three-branched digestive cavity (triple guts) which makes planaria referred to as triclads. Planaria do not have a skeletal, circulatory or respiratory system.

Oxygen and carbon dioxide are transported into and out of individual cells by simple diffusion.
This is possible because of the high surface area to volume ratio in flatworms. The excretory system consists of a series of tubules that run the length of the body. These tubules have side branches with flame cells (protonephridia). Using cilia, the flame cells remove excess water (in freshwater planarian) and liquid wastes from the body and pass them into ducts. The contents of the ducts pass out of the worm through small excretory pores on the dorsal surface called nephridiopores. In the absence of a circulatory system and coleom, the excretory system plays an important role in osmotic regulation and protonephria, which are absent in marine planarians, are critical to the ability of planaria to live in freshwater.

Planarians have well developed reproductive systems. They are hermaphroditic, and have both ovaries and testes. They however do not self fertilize. They can also reproduce asexually by binary fission, by “pulling” away from their tail, which regenerates a full animal. You will probably be able to observe some binary fission in your planaria colony. The end of the tail will attach to the surface of the container and the planarian will pull away until the tail separates from the rest of the body.

Planarian Anatomy

Phylum Platyhelminthes, class turbellarian
- True tissues
- Bilateral symmetry
- Triploblastic (3 germ layers)
- Acoelomate: No cavity-no vascular system
- Only one body opening
- Some cephalization
- Genome size ~ 4.8x10^8 (Human genome size is 3.5X10^9)
Figure A  
**Dugesia tigrina**  
Diagrammatic representation of digestive system

Branched gastrovascular cavity with only one opening: the pharynx

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**Planarians’ excretion system**
Regeneration

Planarians have a highly robust regeneration system and in recent years have emerged as a model system for the study of stem cells and tissue regeneration. Some species can fully regenerate within a week. Pieces of planaria as small as $\frac{1}{270}$th of the body can regenerate a whole animal. Regeneration is due to the presence of totipotent adult somatic stem cells, called neoblasts which can make up as much as 30% of all cells in the adult worm. Neoblasts can give rise to any type of cells. They function in the animal i) to replace normal cell loss due to turnover ii) in wound healing and regeneration. After amputation the body around the wound contract rapidly and within a day a blastema, a structure made of rapidly dividing cells is formed at the amputation site (seen as a white colorless area at the tip of the growing tissue). The polarity of the body is kept with a tail regenerating a head and vice versa. However abnormal regeneration can occur and result in a planarian with two heads or two tails. There is no current clear understanding of how the body polarity is sensed and maintained during regeneration and how a tail or a head knows it needs to regenerate a head or a tail. Normal full regeneration requires preexisting cells to reprogram and acquire the right shape and size to form a functional and bilaterally symmetrical organism. Such reshaping and re-establishment of the proper form and function by these smaller fragments is what Morgan termed "morphallaxis".

Although they have a very primitive nervous systems, planaria are able to learn simple tasks such as traveling through a maze to find food, or reacting to a simple stimuli. It has been demonstrated in the lab that the flatworms can pass such conditioned responses on to "offspring" created by regeneration. After decapitation and full regeneration, both new worms, one with the original head and the other with the
original tail and a new head remember these simple tasks.

Regenerative capacity of the freshwater planarian *Dugesia tigrina* after transverse cutting.

From www.rzuser.uni-heidelberg.de/~bu6/Introduction03.html

**Collecting planarians from fresh water ponds and streams**

To collect flatworms from a pond or stream or river: enclose a small amount of canned dog/cat food or a small piece of fresh chicken/beef liver in a cheese cloth or old nylon sock. Wrap a string tightly around the cloth and let it soak in a pond or stream overnight. Pull out the bag in the morning and collect flatworms crawling over the bag. Keep worms in a Tupperware or other flat container and make sure to keep the water clean. Use Poland spring or pond water where you collected the planarian.
Common Species of planaria that are used in research labs:

- *Dugesia japonica* – (small brown) well-known model system for studying molecular genetics of regeneration (provided by Monday speaker)

- *Schmidtea mediterranea* – (light brown) also a good regeneration model system. Genome is being sequenced (provided by Monday speaker)

- *Dugesia tigrinia* – (brown) traditional model system for classical conditioning experiments (purchased from Carolina Biological)

- *Phagocata gracilis* (black) - an accidental addition to the lab, this species is often used in ecotoxicological studies

- *Dugesia dorotocephala* (large brown), Native species sold by Carolina Biological

- *Procotyla fuviatilis* (white) is rare and not used often.

Do not cross-contaminate the species in case they carry pathogens that could live in the other species’ colonies. Use separate pipettes etc.. for each species and wash your hands if they have been in contact with any colony’s water.