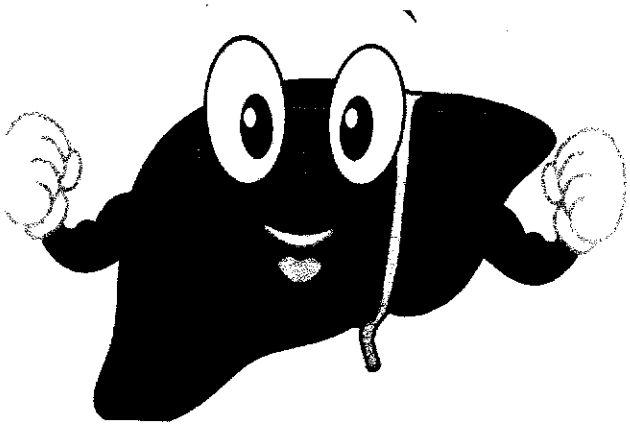
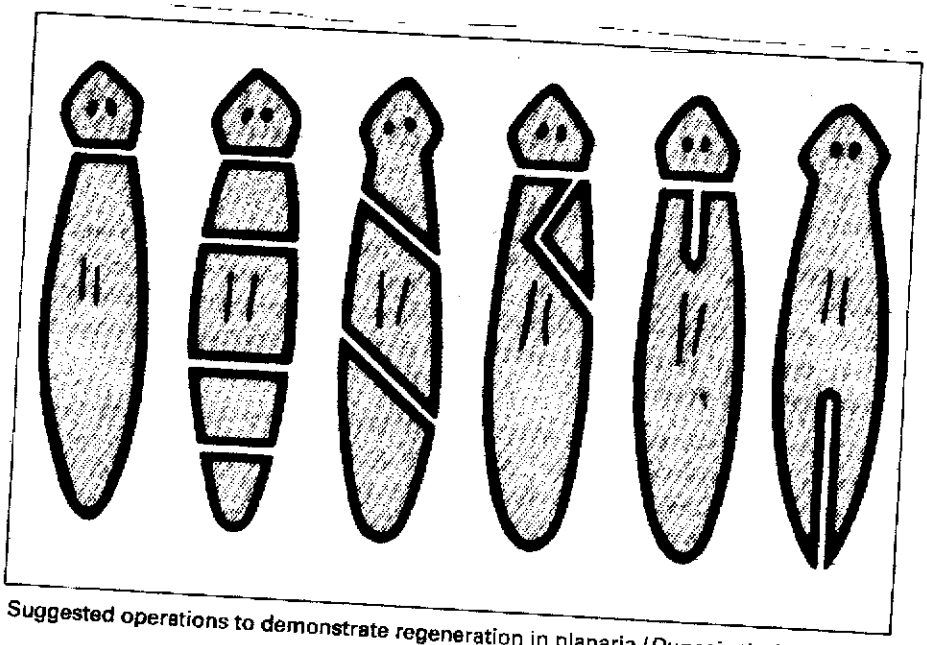
Planaria: A window on regeneration

We humans prefer to avoid getting our limbs cut off. Once your arm is gone, that's it. But life's different for a salamander. Lose a leg? Grow a new one. The same thing happens for starfish, lobsters, and a surprising number of other animals. Snails can even regrow their heads—imagine what the world would be like if humans could do that.

But we can't. Nor can we grow new limbs or even fingers. That's why some scientists are studying animals that can regrow body parts, that is, regenerate. Regeneration is fueled stem cells, cells with the ability to become other types of cells. Scientists hope that learning more about stem cells in other organisms will help us make regeneration possible in humans.



Humans' ability to regrow their livers has been known since ancient times. This statue shows the Greek god Prometheus who, as myth tells it, regenerated a new liver after an eagle ate part of it each day. (Photo: Jastrow, Wikimedia Commons)



Suggested operations to demonstrate regeneration in planaria (*Dugesia tigrina*).

Humans aren't completely without regenerative talents. We heal from wounds and surgeries and we're always creating new skin, new blood, and new linings for our stomachs, intestines and lungs. To a certain extent, our livers can even regenerate after they've been damaged. Amazingly, liver donors can offer up half of their organ and regrow the removed portion. (People have known about these qualities since ancient times. The myth of the Greek god Prometheus says that his liver regenerated every day after eagles ate it as part of a punishment by Zeus.)Many different kinds of animals show some form of regeneration, though most of them are limited to the sort a lizard is capable of, like regrowing a lost tail. A cockroach can regrow a new limb, for example, but the limb itself (thankfully) can't generate a new cockroach. Scientists call this unidirectional regeneration. A few animals with relatively simple body plans, however—hydras, sea stars, and anemones among them—demonstrate bidirectional regeneration; in other words, they can go both ways. Cut a hydra in half, and you'll get two hydra. Cut it into four pieces, and you'll get four. But few animals can equal the regenerative magic of the common, pond-dwelling planarian.

Meet the almost-immortal planarian

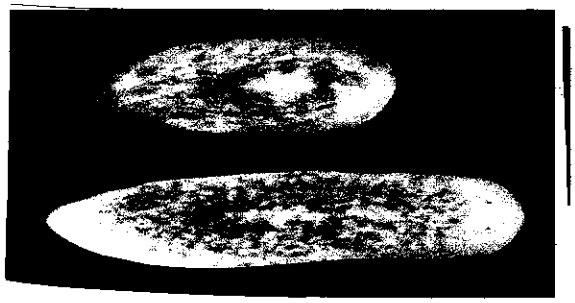
Many people make their ac- quaintance with a planaria and its regenerative capaci- ties when they cut one up in biology class. Planaria are tiny flatworms that live in freshwater and marine environments, and on plants throughout the globe.A single one can be cut into hundreds of pieces and each will grow back into a whole planarian—a remark- able feat.

Planaria species S. mediterranea and D. dorotocephla swimming together.

Planarians (and other bi-directionally regenerating animals) can use this capability to reproduce asexually, and, in effect, clone themselves. Because of this remarkable abil- ity, one planarian and its genome can be created over and over, giving it a sort of im- mortality. Just how old is the oldest planaria? No one really knows.

Scientists have recently learned that planaria are full of cells similar to stem cells. These cells are ready at any time to transform into whichever specific type of cell a planaria needs in order to regenerate lost tissue. The ability of these cells to become whatever tissue the body needs is very similar to the capacity of embryonic stem cells in humans and other vertebrates. This similarity makes planaria very interesting to scientists, and their simple bodies and few tissue types make them relatively easy to study. Interest- ingly, the planarian's stem-cell like cells are distributed throughout their bodies in great numbers, which helps lend them their amazing regenerative qualities. Any way you slice it Planarian regeneration stands out for its dramatic scope, its rapid pace, and the mecha-nisms that make it possible. And not only can the pieces of a sliced-up planarian each grow into a new flatworm, but re- generation happens quickly: It only takesa week or two for each piece to turn into a miniature version of the original flatworm.

Planaria can also work a sort of magic trick while regenerating: Imagine you're nothing but a tail trying to regrow a head. How will you eat? Or what if you're a head with no gut to digest things? The answer is that planaria feed off themselves. As a head grows back, for example, cells in the tail end will self-destruct and provide the regenerating animal with the energy needed to survive. Over time, the tail portion will shrink—to a



Both the head and tail have been removed from this planaria, S. meditarranea. This spe- cies is often used for research. Both ends of the animal will grow back in just eight days.

proportion that exactly matches that of the head it's regenerating. Once it's whole again, it will begin to feed and grow back to a normal size. How it manages to do this proportion-readjustment trick is one of the questions researchers are trying to answer.

How do they do it?

Exactly how planarians work their regenerative magic is the million-dollar question that scientists would love to answer. Researchers have an inkling of some of the genes involved, but the picture is far from clear. What they do know is that the progress of regeneration can be followed by looking at certain features as they develop.

When a planarian loses its head, or its tail, or other chunk of itself , a regeneration blastema will begin to form at the site of the wound. The blastema is an area of whitish cells that are in an embryonic-like state, filled with stem cells that are able to become any of a number of kinds of cells. Over time, these cells will divide, more and more of them will differentiate, and the form of the missing body part will take shape. If scien- tists could understand how such cells get activated to make more of themselves, or to become the appropriate new cell types, they might learn how to trigger such respons- es in humans, allowing us to regrow our own tissues under certain conditions. There are many theories as to how planarians regenerate, but for the moment, we are far from understanding it—and even farther from knowing how to harness the potential in ourselves.

Directions given to students in class:

- only use spring water for planaria. If you put them in tap water it will kill them. Pond/creek water will work unless there are chemicals in the water that would kill the planaria. Keep water at or below room temperature.
- planaria are photosensitive--put foil around the jar or put them in a dark place
- feed them cut up mealworms (from pet store) or earthworm pieces or beef liver(can be kept frozen) or a small piece of the yolk of an egg that is hard-boiled.
- the planaria were fed yesterday before students cut them, so will be fine for several days before needing fed again--feed them every three days
- when you feed them, after a few hours, clean out the remaining food
- add some fresh water every few days--it is not necessary to remove all of the old water--adding new water will introduce enough oxygen that they will do fine
- use a magnifying glass to observe changes in the planaria to record on the data sheet--if you have a stereoscope, it would be fun to look at them using the scope. It is amazing to watch the planaria eat.
- bring your data sheet to class next week
- do not let the planaria loose in the wild because it will upset the ecosystem. When students are done with the experiment, they should put clorox bleach in with the planaria to kill them.

Planaria Data Chart

Turn in during class next week

Moving?	Regenerating?	Eating?	Photosensitive?	Other observations?