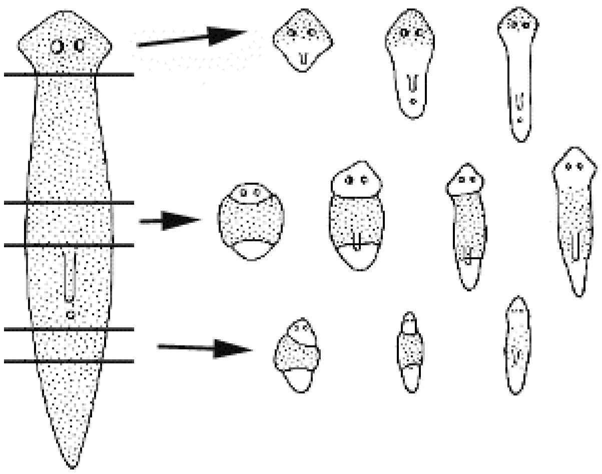
Regeneration

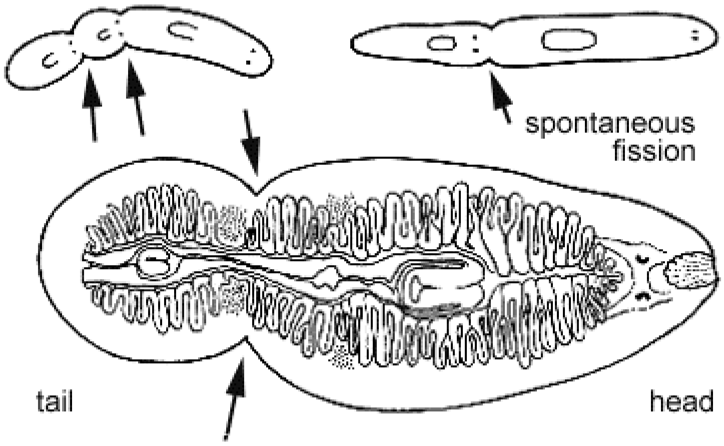
In contrast to higher vertebrates, some free living flatworms show a fascinating ability of regeneration. Cut off its head and it grows a new one. Divide its head laterally into two, three or more parts and a two, three or multiheaded worm will result. Worms can be cut into ten parts and ten complete smaller worms grow, one from each fragment (see lower figure, left panel - the freshwater triclad *Dugesia tigrina*). Since the phenomenon of regeneration is of high interest to biologists several flatworm taxa serve as model system for extensive studies on regeneration (see also section: Polyclads in Neurobiology). Currently, detailed information on regeneration exists primarily for polyclads (Order *Polycladida*) and for freshwater triclads (Order *Tricladida* - the name means *three-branched gut*), the latter also commonly known as planarians (see section: Phylogeny).

Although biologists have studied planarian regeneration for about a century, the answers to some questions, especially the molecular mechanisms governing the regeneration process still remain elusive. Scientists agree that planaria capable of regeneration maintain and utilize a reservoir of embryonic stem cells called neoblasts. Depending upon the species, neoblasts comprise up to 30% of the total number of cells in an adult worm. These totipotent cells, which are scattered throughout the worm's body and which are capable to give rise to any other cell type, perform two roles. They replace cells that die in the course of normal physiological turnover and they provide the cellular raw material for regeneration and wound healing. Regeneration is quite rapid. Within as little as 15 minutes after amputation, epithelial cells at the edge of the wound close over the lesion. Within a day, a high number of neoblasts accumulate beneath the wound epithelium. Then, a combination of cell migration and cell division leads to an exponentially growing aggregate of regenerating cells underlying the epithelium. This structure is called blastema. Within about 5 days, depending on temperature, newly differentiated structures become evident within the growing blastema and under optimal conditions regeneration of lost body parts is complete within about 10 days after amputation (Baguna et al., 1994).

Planaria have a strong sense of head and tail (anterior - posterior polarity). When cut, the anterior cut surface almost always regenerates a new head and the posterior cut surface regenerates tail structures. There has to be a mechanism of maintaining the worm's knowledge wether to regenerate a head or a tail. At present, two hypotheses exist to explain anterior-posterior polarity. One calls for an inductive interaction between the newly formed epithelium, which covers the wound during the initial healing process, and the underlying blastema cells. The other hypothesis suggests some sort of molecular gradient of anterior-posterior determining factors. Despite a large body of experimental data, no clear evidence supports either point of view.

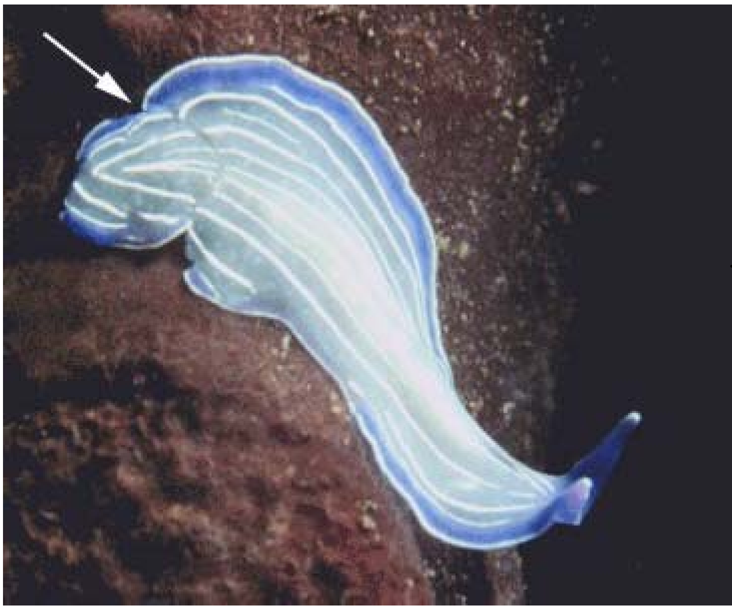


Regenerative capacity of the freshwater planaria *Dugesia tigrina* after transverse cutting.



Asexual reproduction by spontaneous fission of the freshwater planaria *Planaria fissipara* (Tricladida).

Most freshwater planaria reproduce sexually and are exclusively oviparous (they deposit their fertilizes eggs). Some species also exhibit asexual reproduction via parthenogenesis (activation of egg without sperm). However, flatworms of the taxonomic families *Dugesiidae* and *Planariidae* (Order: *Tricladida*) show an occasionally ability to reproduce by binary fission (see upper figure, right panel - the freshwater triclad *Planaria fissipara*). Adults undergo spontaneous binary fission and the resulting small tail piece differentiates a pharynx and will become a feeding worm within two weeks. Investigations on the reproductive modes of natural populations of *Dugesia tigrina* revealed that under optimal conditions (24 °C) up to 20% of the worms are fissiparous (reproduction by fission). Asexual reproduction by binary fission seems also possible among marine polyclad flatworms as demonstrated by this rare document (photo left). It shows a polyclad of the genus *Prostheceraeus* (Family: *Euryleptidae*) in the progress of spontaneous fission. The tail piece



Prostheceraeus sp.
(PHOTO © Dr. Alexandros Frantzis)

marked by the arrow will become a new worm after fission and subsequent cell reorganization. However, according to another explanation the worm is in the progress of regenerating after a predators attack and the "fissing tail portion" is caused by an aborted feeding attempt (see section: Predation and Defence).

| main | back | photo galleries! |

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