

## Background information on *Daphnia*

### Part 1 - Physical description

*Daphnia*, commonly called water fleas, are a freshwater zooplankton found in ponds and lakes all over the world. *Daphnia* received the name water flea due to their jerky swimming motions. Some types of *Daphnia* can be seen with the human eye, while others must be identified with a microscope. Depending on the species they can range in size from 0.5mm to 1cm. Their outer covering, or carapace, is transparent, so many internal organs can be seen, especially the beating heart. On the head there is a compound eye and a pair of antennae, which are used for swimming. Females are usually larger than males and have a brood chamber under their outer carapace where eggs are carried.



### Food chain relationships

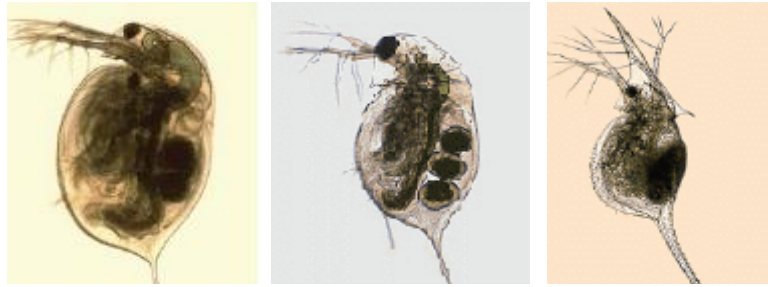
*Daphnia* are an extremely important part of aquatic food chains. They eat primary producers such as algae, yeast, and bacteria. *Daphnia* are the prey of tadpoles, salamanders, newts, aquatic insects, and many types of small fish. Fluctuations in *Daphnia* populations can cause algae overgrowth or even a drastic drop in fish populations. Through the food chain, larger animals caught or eaten by humans can be affected by large changes in *Daphnia* populations.

### Reproduction

The *Daphnia* lifespan is approximately eight weeks. *Daphnia* reach maturity quickly, within five to ten days, and produce multiple offspring each cycle. *Daphnia* can reproduce both asexually and sexually. During times of plentiful food, females reproduce asexually to produce clones. When food is scarce, *Daphnia* reproduce sexually in order to produce genetic variation and increase the chance of species survival. During harsh weather conditions, resting eggs are produced. These eggs have a tough outer coating, which can withstand time, heat, drying, and cold temperatures.

### Reactions to environmental stress

*Daphnia* have a number of natural responses to environmental stress, and due to these qualities are often used as an indicator of watershed health. The term "watershed" refers to all the land and water within a drainage area. *Daphnia* can detect the presence of kairomones, chemicals released by predators. In response to these chemicals *Daphnia* can grow larger head and tail spines or develop through a shorter gestation period. They are extremely sensitive to changes in water toxicity. This can be monitored through changes in heartbeat or *Daphnia* death. When *Daphnia* are exposed to hypoxic (low oxygen) conditions, they can increase hemoglobin production. Due to their clear outer carapace, they will appear red when hemoglobin production has increased.



**Figuur 1. Van links naar rechts: *Daphnia Magna*, *Daphnia pulex*, *Daphnia lumholtzi*.**

### Species

Three species of *Daphnia* will be used in this unit. *Daphnia magna* is very rarely found in the wild and is often sold in pet stores as a food source. They can become as large as 1/5 inch and are often less tolerant of environmental changes. *Daphnia pulex* is very similar to *D. magna*, but is usually smaller. They are the most common species found across temperate North America. *Daphnia lumholtzi* is an invasive species originally from Africa and Asia, which have extremely large head and tail spines. *D. lumholtzi* is currently invading watersheds in the United States.

### Part 2 - Seeing red: *Daphnia* and hemoglobin

Hemoglobin is an important protein found in all vertebrates and some invertebrates. Hemoglobin transports oxygen throughout the organism's respiratory system.

In complex animals such as humans, hemoglobin carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues to the lungs. Hemoglobin can be found in the red blood cells of vertebrates and the iron contained in hemoglobin is responsible for the red color of blood.

Simple invertebrates, such as *Daphnia*, do not have lungs or red blood cells.

Because *Daphnia* do not have a complex respiratory system, they generally obtain oxygen for respiration through diffusion. Oxygen molecules along with water are carried in and out through the outer carapace of the *Daphnia*. Hemoglobin in these organisms is extracellular and helps to carry oxygen to body tissues. *Daphnia*, unlike vertebrates, do not need to maintain a high level of hemoglobin to survive. However, synthesis of hemoglobin does provide a survival advantage when water conditions are low in oxygen.

Interestingly, under stressful environmental conditions *Daphnia* can increase hemoglobin production. This allows the *Daphnia* to survive in hypoxic (low oxygen) water conditions. *Daphnia* can develop high amounts of hemoglobin in a few days and can maintain this status for a couple of weeks. Hemoglobin can be produced in brood pouches, and offspring in hypoxic conditions may also produce more hemoglobin. If water conditions return to normal, *Daphnia* can lower hemoglobin production within a few days, as well. The development of hemoglobin will allow the *Daphnia* to carry more oxygen to body systems, but the synthesis of hemoglobin does use energy that would normally be used for other life processes. This energy trade-off causes the amount of energy invested in growth and development to decrease.

Due to *Daphnia*'s transparent carapace, hemoglobin can be seen as it develops. *Daphnia* with high hemoglobin content will appear red in color. *Daphnia* with more hemoglobin have access to food sources found in low oxygen areas, but their red color may be more obvious to predators.

The study of *Daphnia* hemoglobin can be traced all the way back to the 1700's. In 1758, Dutch naturalist J. Swammerdam noticed that the species of *Daphnia* that live in ponds are often pink or even red. He described the color as "like that of beef, which has been time steeped in water" (Fox 1948). In the 1940's and 1950's scientists studied pond and laboratory conditions that caused *Daphnia* to increase hemoglobin production. In the years that followed, *Daphnia* was used as an ecological bioindicator and for toxicology bioassays. Currently, the physiological impact of hemoglobin development on *Daphnia* is being studied. The genetic sequence for *Daphnia* hemoglobin has been constructed and has many genetic and ecological applications.

### Interesting Facts about *Daphnia* - summary

- *Daphnia* are often called water fleas because they swim in a jerky motion.
- *Daphnia* are extremely small and range in size from 0.5mm to 1cm.
- *Daphnia* can be found in freshwater lakes, ponds, and rivers all over the world.
- The outer carapace of a *Daphnia* is transparent so all the internal organs, even the beating heart, can be seen.
- *Daphnia* mature in approximately a week and can have thousands of offspring.
- *Daphnia* are very important to the food chain. They eat algae and are eaten by insects, water mites, and small fish.
- In the presence of a predator *Daphnia* can develop large head and tail spines.
- *Daphnia* are very sensitive to changes in their environment.
- In low oxygen water conditions *Daphnia* can increase hemoglobin production, which causes them to turn red.
- During unfavorable weather conditions *Daphnia* can produce resting eggs, which can withstand time, heat, cold, and drought.



(naar <http://www.nslc.wustl.edu/elgin/genomics/srf/Daphnia6-8.pdf>)