



Accompanies Episode 8 of the 13-part video series

— Down the Waterfall —

Written by Eric R Russell & Bruce J Russell

In this episode...

Carried by the current, the *Cyclops* and her crew continue their journey down a rocky stream. As they drift ever closer to a waterfall they come across a colony of **blackfly** larvae thriving in a fast skim of water barely an inch deep. When the *Cyclops* is swept over the waterfall they find themselves trapped inside a plastic bottle, which turns out to be the ideal place to observe one of the strangest aquatic insects inhabiting the white-water... a **water penny**.

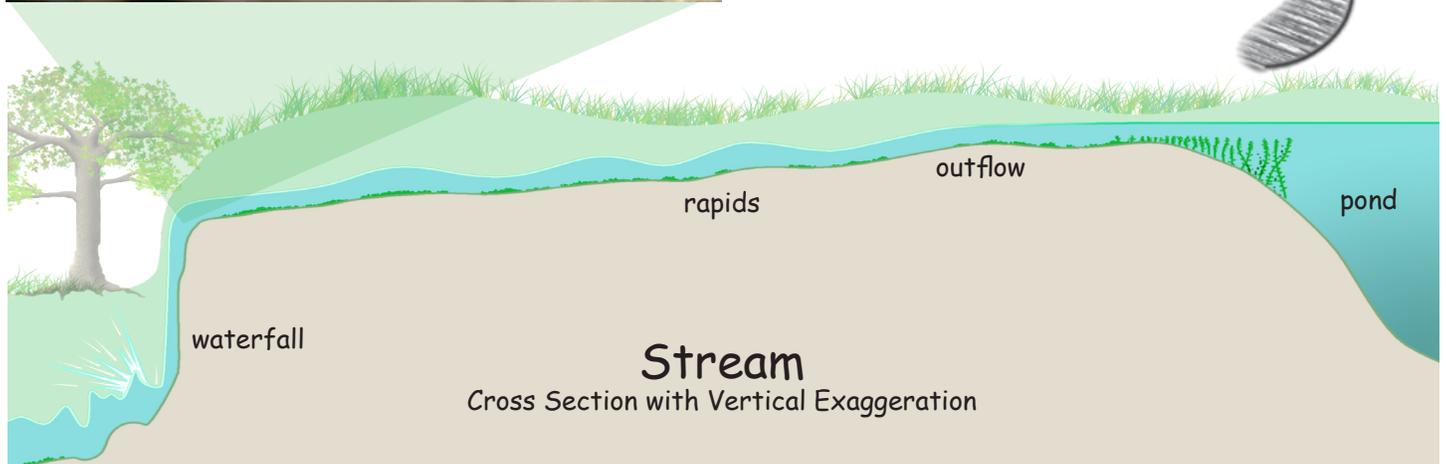


Stream Ecology: Waterfall
The Log of Captain Jonathan Adler

Day 14: 08:25 hours... It is our second day of un-planned exploration down a fast-flowing rocky stream. The view outside our windows is a rapid blur of white water bubbles and rocky stream bottom.

The speed of the current increases. I can see that we are being swept over a shallow flat surface, probably a stream-worm sheet of granite. And we are not alone!

Anchoring ourselves we get an outstanding view of the insects living here in the fast water. The smooth rock surface is crowded with hundreds of blackfly larvae. A blackfly's tube-like body sticks up into the current, gripping the rock with a claw-like foot pad. From the head end, the larva extends feather-like fans that catch tiny bits of food drifting by in the current.



MS Cyclops

Vehicle Dimensions

LENGTH	1 mm
BEAM	.65 mm

Vehicle Mission

Maximum speed	10 centimeters per minute
Maximum depth	2.5 meters
Mission duration	60 days

The microsubmersible *Cyclops* is designed for extended exploration of freshwater ponds, streams, and wetlands. The vehicle carries a standard crew of four.

- Captain
- Ship's Naturalist
- Helmsman/Navigator
- Engine Master

There are two onboard auxiliary craft for specialized exploration: a *diving bell*, and a *terrestrial crawler/rover* (disassembled).

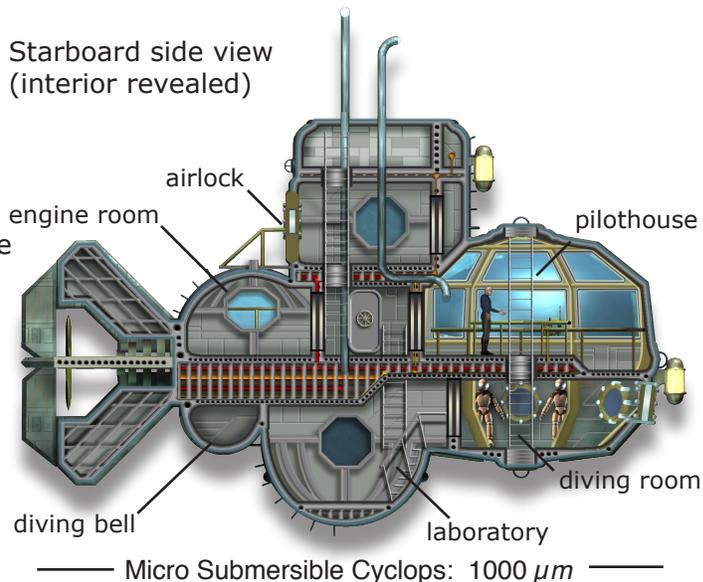
The glass enclosed pilothouse is a unique feature that allows for optimal observation of the surrounding aquatic environment.

Manipulator grabbers (claws) facilitate rapid making-fast and retrieving samples for study.

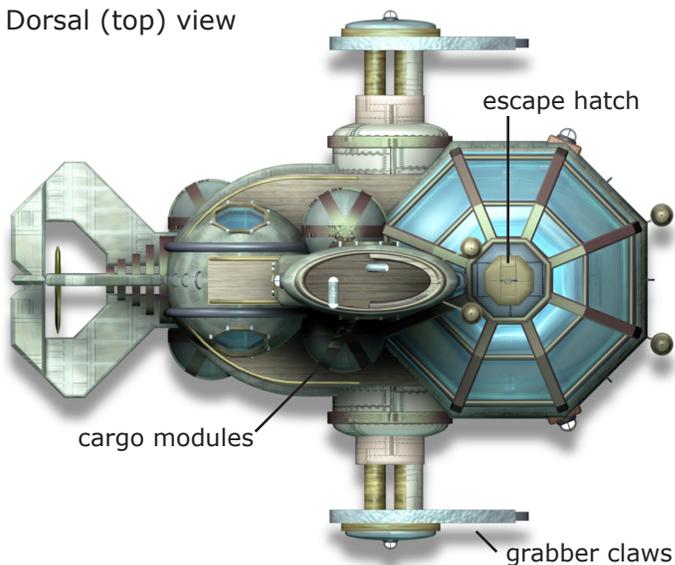
What if you were a scientist onboard the *Cyclops*? Imagine what the pond environment looks like to these micro sized explorers, only 50 microns (μm) tall. What unique problems might they encounter because of their size? How would they acquire repair materials, such as glass? Where would they find food, fuel, or oxygen?

Contents of this guide...

- The Cyclops Exploration Vehicle
- About the Organisms
- Key to Organisms



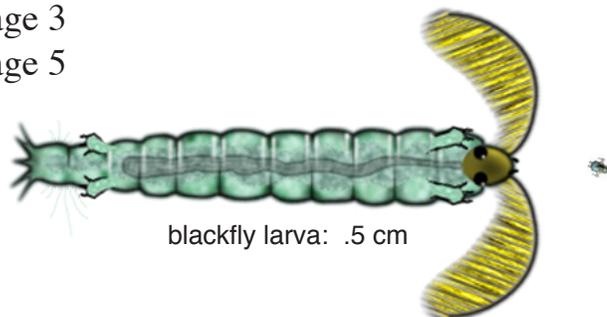
Dorsal (top) view



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About the Organisms

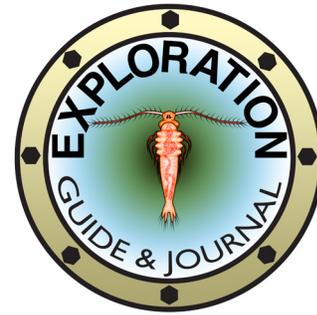
Adaptation: Observing stream life reveals that by living in extreme conditions a species can avoid competition for food resources and avoid being eaten by predators. To do this, however, the insect needs to be equipped for hanging on. This helps explain the remarkable adaptations seen in the inhabitants of rapids and waterfalls.

Blackfly larvae: Great masses of these worm-like larvae are found where sheets of shallow water race over the stream rocks. A smooth flow with little turbulence is a requirement for the blackflies' feeding style. Holding to the rock with a sucker-like basal disc, they throw out fan-like filters that trap microorganisms and tiny bits of debris carried by the current. Periodically the filters are drawn through the mouth parts and cleaned of food. If disturbed the larva releases its hold on the rock and drops down stream by playing out a safety line. After things calm down, it climbs back up the line and reattaches to its feeding station.



As the stream level drops in summer the larvae pupate – that is, develop from larval stage into adult stage, just like a caterpillar becomes a butterfly. This leaves the pupa exposed to air, which assures successful hatching of the adults.

Adult blackflies are bothersome parasites that feed on the blood of warm-blooded animals. The small adult black flies burrow into the animal's hair (or feathers), nip through the skin while bathing the wound with an anesthetic that deadens feeling.



The Log of Captain Jonathan Adler

10:20 hours... We have observed that these blackfly larvae prefer life in one of the most demanding habitats of the stream. Their adaptations for survival allow them to live in a place without any competition for food! Another insect would be whisked away by the powerful current.

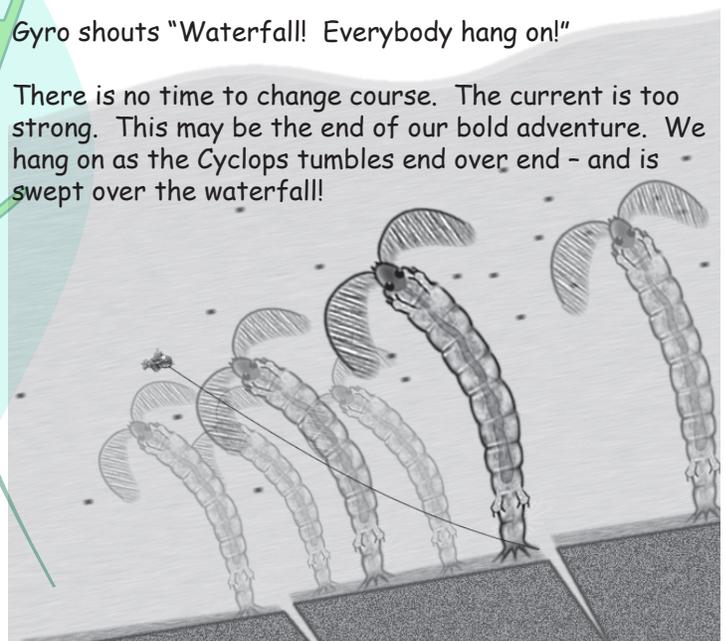
As microscopic algae and other tiny organisms drift down stream they are caught in a blackfly's food-gathering fans. Every few seconds, the larva gathers in the fans and devours the accumulated snacks. There is no hunting for this aquatic insect - it just waits for the food to drift into its trap.

If fish or large animals disturb the water around the blackflies, the larvae respond instantly by releasing their hold on the bottom. As the insects drift downstream, they let out safety lines. When the disturbance passes, the larvae crawl up the safety line and reattach themselves in the best location for gathering food.

11:50 hours... I have ordered the anchor stowed - the Cyclops is once again on an unknown course down the stream.

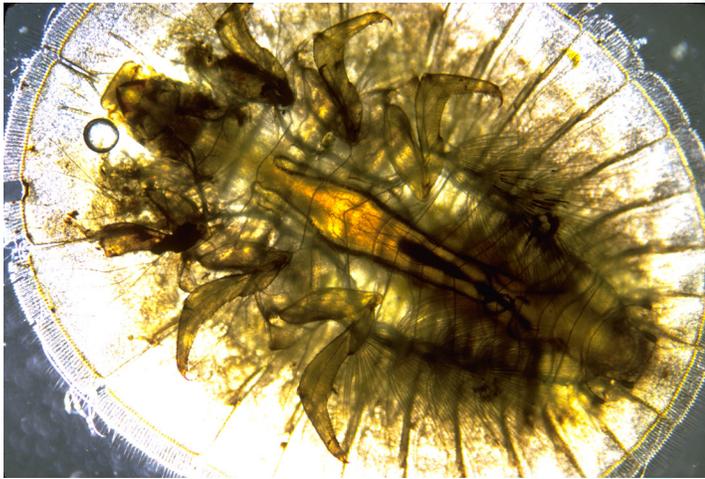
Gyro shouts "Waterfall! Everybody hang on!"

There is no time to change course. The current is too strong. This may be the end of our bold adventure. We hang on as the Cyclops tumbles end over end - and is swept over the waterfall!

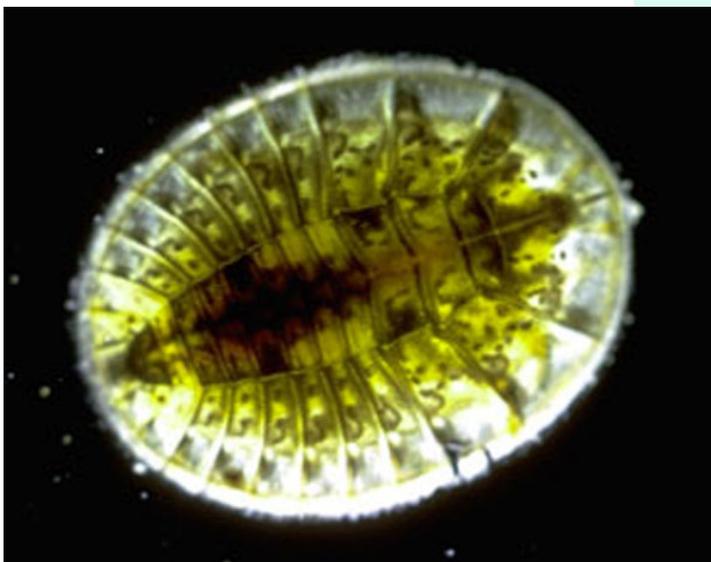


About the Organisms

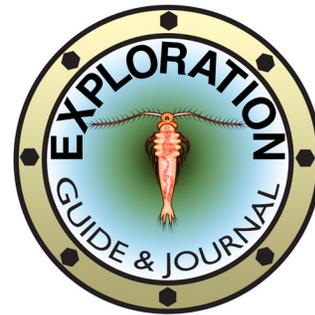
Water Penny: This extremely flattened insect is the larval stage of a small aquatic beetle. Look for water pennies clinging to the rocks in stream rapids. Pressing one between two microscope slides allows viewing the insect from its underside.



This view shows the six sharp hooked feet that permit the water penny to hang on to the current-swept rocks, and the fringe of hairs around the outer shell that deflects the current, keeping it from getting under the insect and washing it away. Fluffy tufts of gills collect dissolved oxygen and help get rid of carbon dioxide. Under the microscope, the circulatory fluid can be seen coursing through the insect's flattened body.



In this view, you can see the stubby mandibles used for scraping algae from the rock.



The Log of Captain Jonathan Adler

12:10 hours... We tumble through an explosion of thundering white water. I am certain that we will, at any moment, be smashed into the rocks. But that is not our fate!

Suddenly all is still. All is calm. But how? A look outside reveals that by pure luck the Cyclops has washed over the waterfall and into a discarded bottle! Clinging to the outside of our transparent refuge we see one of the strangest aquatic insects we have yet come across on our stream voyage - a water penny. The familiar insect body is protected by a flattened outer shell, a shape that is so perfectly streamlined that the fast current cannot wash the insect away. It appears to have found a perfect place on the bottle surface for scraping off algae for food!



14:15 hours... Just when we were beginning to worry that we might never escape from this plastic bottle sanctuary, a flicker of bright light from above the surface catches our attention. It is our companion Tara! She is focusing sunlight through a lens in our direction. Tara is trying to help us with our problem, but how can focusing sunlight free us from the bottle?

By using a mirror we redirect Tara's sunbeam through yet another lens. We focus the light into a very hot point at the bottom of the bottle. To our relief it works, and the plastic quickly melts. In no time we carve out an escape hatch. Not far from the waterfall the stream slows. We are able to navigate our way to shore where we reunite with Tara who is eager to expand our biological explorations into the nearby forest. It seems that the work of biological discovery is never done!

Key to Organisms

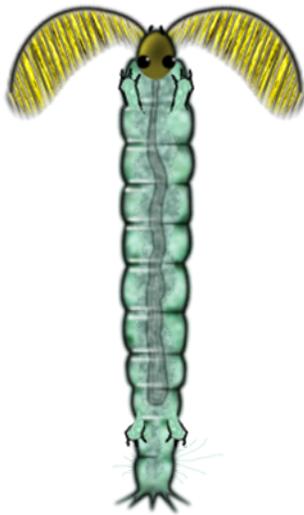
Different Adaptations

The blackfly larva and the water penny show two sets of very different adaptations for living in fast-moving water.

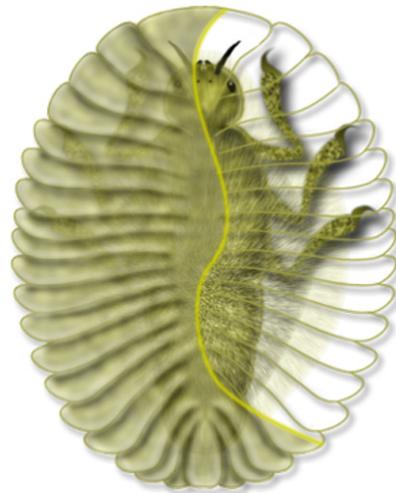
The **blackfly** sticks up into the current and uses fans to catch small food organisms as they drift by. If disturbed the insect lets go and washes downstream, letting out a safety-line filament. When the disturbance has passed, the blackfly uses the safety-line to crawl back to its ideal feeding spot in the current.

The **water penny** is almost perfectly flat, and clings so tightly to the rock that the current passes smoothly over its protective streamlined shell. Under the shell the insect scours the surface of the rock, scraping off algae with its sharp mandibles.

Blackfly



Water Penny





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