



The Rat Lungworm Lifecycle

It is important to understand the lifecycle of a pest in order to effectively control it. The lifecycle of *Angiostrogylus cantonensis* is complex. If students are to be educators for their families and communities they must have sufficient familiarity with the lifecycle in order to explain it to others.

Standards addressed:

Next Generation Science Standards

5-LS2 Ecosystems: Interactions, Energy, and Dynamics

5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers and the environment.

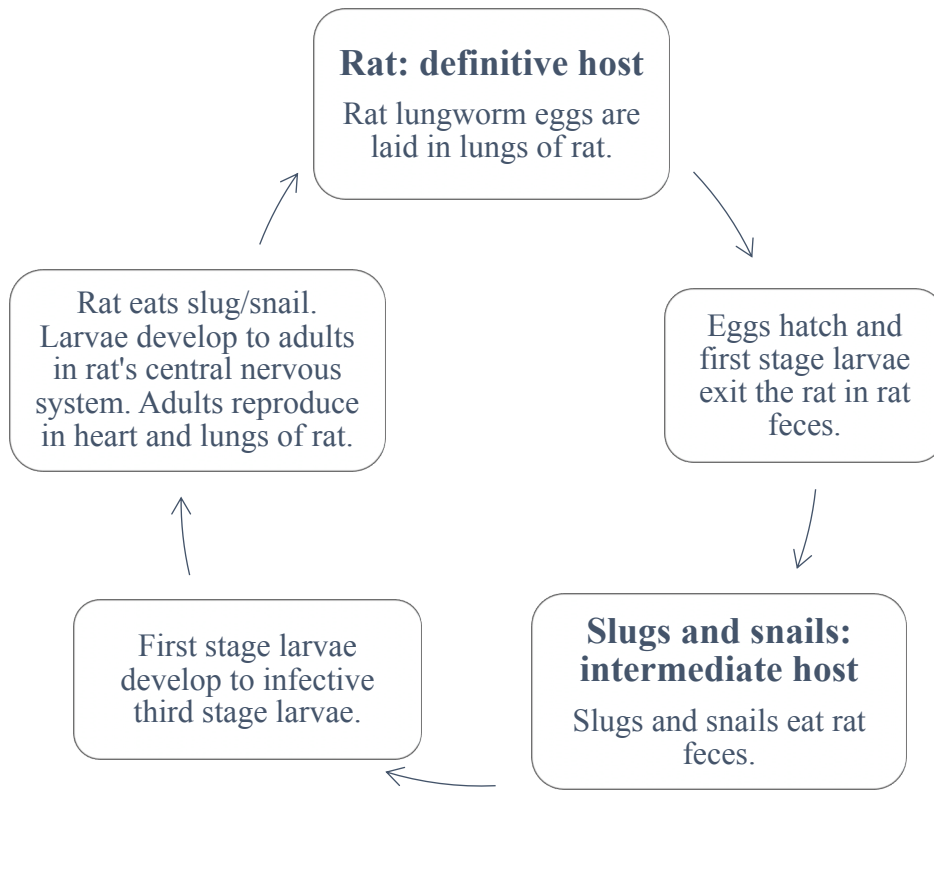
MS-LS1, MS-LS2

- MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behavior (and specialized plant structures) affect the probability of successful reproduction of animals (and plants respectively). (In this case for the rat lungworm parasite).
- MS-LS2-4: construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. (In this case Rats, slugs and snails, and the rat lungworm)

Learning objectives:

- Students will learn the biological definition of a lifecycle.
- Students will work in teams to model the hosts of the rat lungworm and model the various stages of the parasite in each of the hosts.
- Students will be able to explain the rat lungworm lifecycle to peers and adults, including family.
- Students will be able understand what conditions or actions can interrupt the rat lungworm lifecycle.

Angiostrongylus cantonensis Lifecycle



Reading for Understanding:

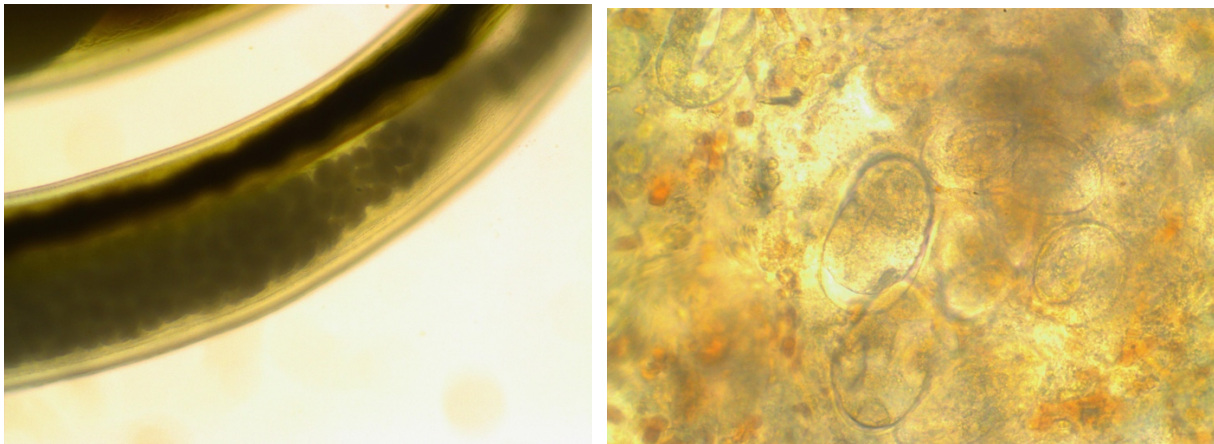
A lifecycle is defined as the changes an organism goes through from its inception, or beginning, through the stage at which it reproduces.

The rat lungworm *Angiostrongylus cantonensis* is a roundworm known as a nematode. Nematodes have adapted to almost every ecosystem. They can be found in both fresh and salt water; in soil, plants and animals; from polar regions to the tropics; and from high elevations to low elevations. They can be found almost

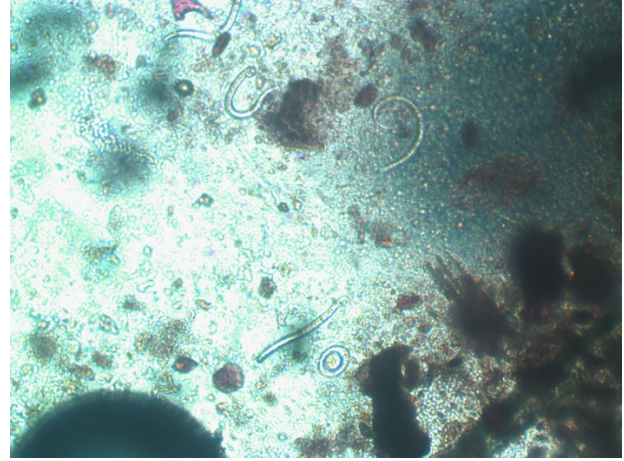
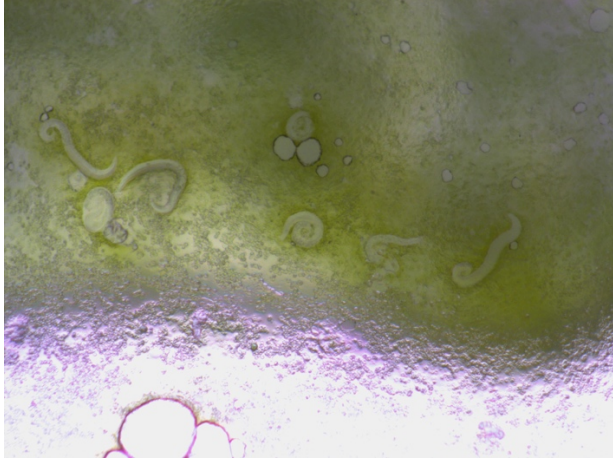
everywhere on the earth's surface, including the oceans, and there are estimated to be about one million different nematode species, many of which are parasites of plants and animals. The rat lungworm is a parasite of animals. Nematodes are similar to insects because as they grow they molt, or shed their old skin and form a new skin to fit their larger size.

The lifecycle of the rat lungworm nematode requires two very different hosts.

Rats are the **definitive host**, or the host in which the parasite reaches maturity and reproduces. The adult male and female lungworms mate in the heart and the blood vessels that carry blood from the heart to the lungs. After mating the female worm lays eggs which are flushed into the lungs where the eggs **embryonate**, or develop into embryos. In the **alveoli**, which are tiny air sacs in the lungs, the embryos develop into microscopic worms called first-stage larvae. These larvae are very active and can crawl up the rat's windpipe, also called the **bronchial tree**, where they are swallowed with the rat's saliva and are transported into the rat's stomach. The first-stage larvae are able to survive the acid in the rat's stomach and are eventually eliminated in the rat's feces.



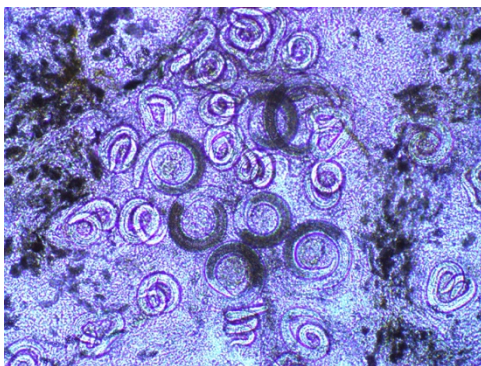
Eggs in posterior end (tail end) of an adult female rat lungworm (above left). Embryonating *A. cantonesis* eggs in the lung tissue of a rat (above right).



First stage larvae *A. cantonensis* larvae in the lung tissue of a rat (above left). First stage larvae in rat feces (above right)



Slugs and snails are **intermediate hosts**. An intermediate host is an in-between host that provides a home for the immature rat lungworm parasites. Slugs and snails ingest the rat feces infected with first stage larvae (L1). Once inside the intermediate host, the L1 rat lungworm larvae will **migrate** through the slug's digestive tract, through the slug's lungs, and finally move into the slug's muscle tissue where they will stop moving, curl up, and slowly grow. The larvae first grow into a second-stage larvae (L2). The L2 larva look like a C, or a comma. Then the C-shaped, L2 larva will grow into a third-stage larva (L3), which will look like a spiral or a coiled spring. The L1 larvae can grow into an L3 larvae in as few as 12 days, and the L3 larvae can live inside of a slug or snail for up to a year. In the slug host the larvae do not shed their molt skins and so a third-stage larva will have two molt skins from



the two stages of development it has just gone through. This L3 larvae is infective. Why? Because the L3 larvae are similar to the L1 larva after they hatch in the rat's lungs. They can survive stomach acid. Why is that important? It is important

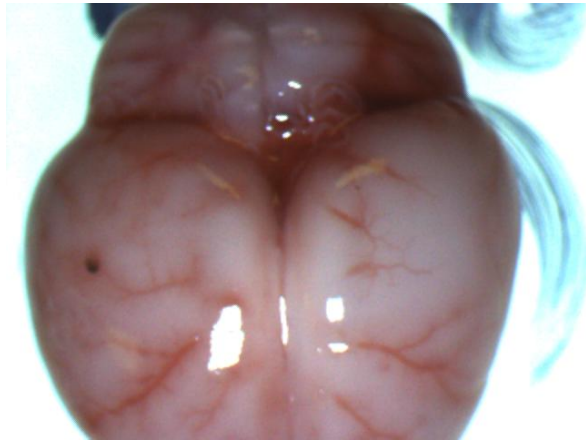
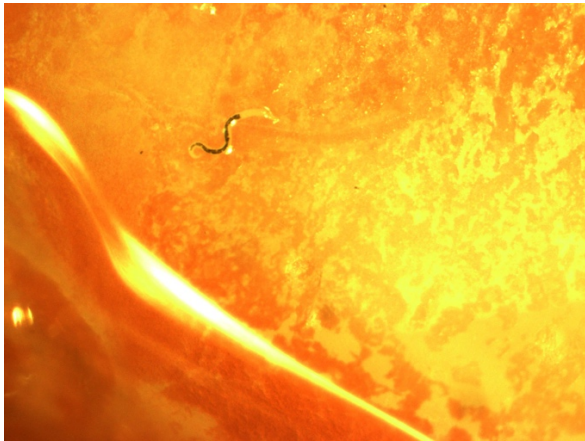
because slugs and snails are part of a rat's diet. If a rat eats a slug or snail that has the L3 larvae, the larvae can survive the rat's stomach acid and they can continue their development to become adults in the rat. Let's see what happens next.



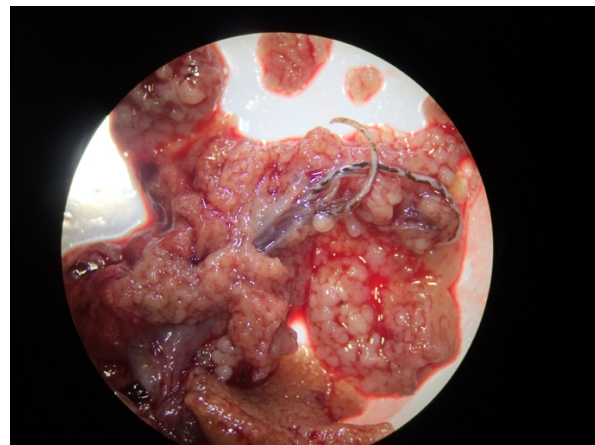
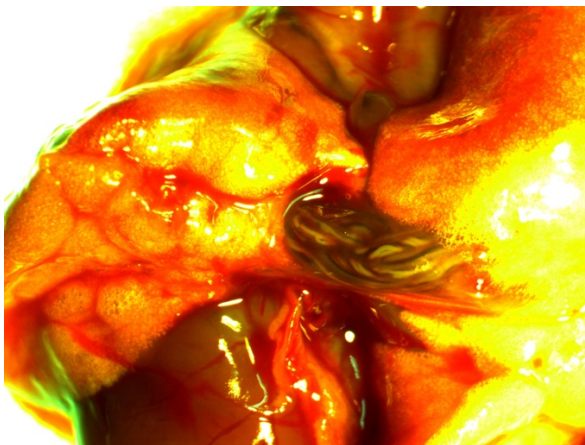
Rats again. If a rat eats a slug or snail that has infective L3 larvae, stomach acid dissolves the molt skin surrounding the rat lungworm larvae, releasing the larva from its coiled shape. The freed larvae swim in an S-shape, looking very much like small snakes, and they are quite fast. The freed larvae will swim through the rat's stomach into the intestines and within a few hours of **ingestion** the larvae will have burrowed through the intestine and will have entered the rat's the blood stream. Once in the blood stream the swimming larvae make their way through various organs, such as the liver and lungs, and head towards the rat's brain. The L1, L2, and L3 larvae are **microscopic** - you need a microscope to see them. However, once back into the rat host the larvae grow and begin to become **macroscopic**, meaning you can see them with your eyes.

As the L3 larvae make their way through the blood stream and begin to head to the rat's **central nervous system**, some will be lost along the way. The larvae that do make it to their target will begin their final stages of development. In the central nervous system, the L3 larvae will grow rapidly into fourth-stage (L4) larvae, and then molt once again and become even bigger, fifth-stage (L5) larvae or young adult rat lungworms. It has been about 35 days since the L3 larvae first entered the rat, and now these young adult worms are ready to reproduce. The young adults find their way out of the rat's central nervous system and move back into the blood vessels, finding their way to the large blood vessel called the **pulmonary artery**, which is located between the rat's heart and lungs. About ten days after having left the brain, and 35 days after having first entered the rat, the adult rat lungworms are ready to reproduce. The female adult rat lungworm is about one inch, or 2.54 centimeters long. The male rat lungworm is a little smaller, about three quarters of an inch, or 1.91 centimeters long. In the blood vessels between and in the heart and the lungs, the mature male and female worms mate and reproduce. The female

rat lungworm will release thousands of eggs that will be flushed to the lungs to begin to embryonate, and the rat lungworm life cycle begins again.



Third stage *A. cantonensis* larva in lung tissue of a rat (above left). Larvae pass through the lungs on the way to the rat brain. Larvae are visible on the surface of the brain of the rat (above right). These are 4th or early 5th stage *A. cantonensis* larvae.



Adult *A. cantonensis* are visible through the wall of the pulmonary artery of the rat (above right). Adult male and female *A. cantonensis* in the lung tissue of the rat (above right). The female rat lungworms have a twisted, red and white appearance, rather like a barber pole or helix.



Only a small percentage of the thousands of eggs the female adult rat lungworm has laid will survive, become adults, and reproduce. If the rat feces containing the first-stage larvae dry out or are not eaten

by a slug or snail, the parasite will die. If the slug or snail is not eaten by a rat, the parasite will eventually die in the intermediate host. If a rat does eat an infected slug or snail and some of the larvae get lost and don't make it to the rat's brain they cannot continue to develop into adult rat lungworms. This weeding out of larvae prevent too many from making it to the rat's brain. Out of thousands of larvae that can be found in some slugs and snails, less than 100 will make it to the rat's brain, which does not seem to affect the rat's health. If too many larvae made it to the rat's brain the infection might kill the rat, which would kill the parasite and prevent its reproduction. It is not beneficial to a parasite to kill the host. The evolution of the rat lungworm's relationship with its hosts is really quite remarkable if you think about it. However, if an accidental host, an organism other than a rat, such as a person, is infected with rat lungworms, and any of the larvae make their way to the brain and central nervous system, the infection can cause brain **inflammation**, and brain, nerve, and eye damage.

Understanding the rat lungworm lifecycle is important if we are going to come up with strategies to prevent infection. Reducing the number of slugs and snails using IPM can help control the spread of rat lungworm. Can you think of other ways we can break the rat lungworm lifecycle?

Student activities:

3D modeling of the rat lungworm lifecycle.

Grades 5-6

Materials:

- modeling clay or Play-Doh
- “The Mystery of Rat Lungworm Disease” lifecycle page 15, or
- <https://www.cdc.gov/parasites/angiostrongylus/biology.html>

Team activity with 3-5 students per team



- With dark clay make a rat and some rat feces.
- With blue clay make two flat ovals to represent lungs and put them on the sides of the rat just behind the front legs. Make a flat circle and put it on the rat's head to represent the brain. Make a flat heart shape and put it on the rat's chest to represent the heart.
- With another color(s) of clay make slugs and snails.
- With white clay roll out worms of different sizes (these are only representations; they are microscopic in three of the five larval stages).
- Students will re-enact the rat lungworm life cycle using their clay models.
- Students will explain the rat lungworm lifecycle to peers or the teacher.

Drawing the rat lungworm lifecycle

Grades 7-8:

Materials: Newsprint tables or large paper, colored markers

Team activity with 3-5 students per team

- Students can warm-up their lifecycle skills first using the clay activity if

desired.

- Student teams use draw the different larval and adult stages of the lifecycle, showing in which host or organs the stages would be found. Students will then describe the lifecycle to the rest of their team. Teammates will help with corrections until students feel proficient with the lifecycle.
- Student teams choose a team member who will describe the rat lungworm life cycle.
- The chosen team members will describe their role in the rat lungworm lifecycle to the class.
- Classmates will evaluate the class presentation and identify any incorrect information and give their approval if the information is correct.
- Student discussion will follow describing how infection might occur, and how infection can be prevented.

Learn more about lifecycles: Students learn about and then compare and contrast the lifecycles of rats, which are mammals, slugs and snails, which are invertebrates, and the rat lungworm, also an invertebrate.

Vocabulary: lifecycle nematode parasite definitive host intermediate host accidental host embryo/embryonate microscopic/macrosopic pulmonary artery bronchial tree central nervous system alveoli migrate ingestion excrete feces molt

This material is written by Kathleen Howe and produced by the Hawaii Island Rat Lungworm Working Group with funding from the Hawaii Invasive Species Council and support from the Daniel K. Inouye College of Pharmacy. Photo credits: Jarvi Lab.