Angiostrongyliasis - Rat Lungworm Disease

Standards Addressed:

Life Science

MS-LS1-1.

- Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

MS-LS1-2.

- Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

MS-LS1-3.

- Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Health

Standard 1

Core Concepts: Understands concepts related to health promotion and disease prevention

- HE 6-8. 1.9 Person Health and Wellness – Identify choices individuals can make to promote or harm their health.

Standard 3: Self-management: Practice health enhancing behaviors and reduce health risks.

- HE 6-8 3.2 Personal Health and Wellness – Explain the importance of assuming responsibility for personal health behaviors

Standard 6

Decision making and goal setting: Decision making across topic areas

- HE 6-8 6.1 Describe decision-making processes related to health-related decisions
- HE 6-8 6.2 Access health-related decisions for consequences that affect oneself and others

Standard 7: Advocacy: Advocate for personal family, and community health

Advocacy across topic areas

- HE 6-8 7.2 Use appropriate methods to communicate accurate health information and ideas

This lesson can be simplified for grades 5-6, modified for grades 7-8, and expanded upon for grades 9-12.

Learning objectives:

- Students will learn the medical term for rat lungworm disease.
- Students will understand how the rat lungworm parasite travels through the host organism after ingestion of the parasite.
- Students will understand how infection from rat lungworm disease can affect systems of the body.
- Student will understand current diagnostic and treatments for rat lungworm disease.
- Students will identify other diseases or injuries that can cause brain injury and how these are different or similar to angiostrongyliasis.

Reading for understanding:

Angiostrongyliasis

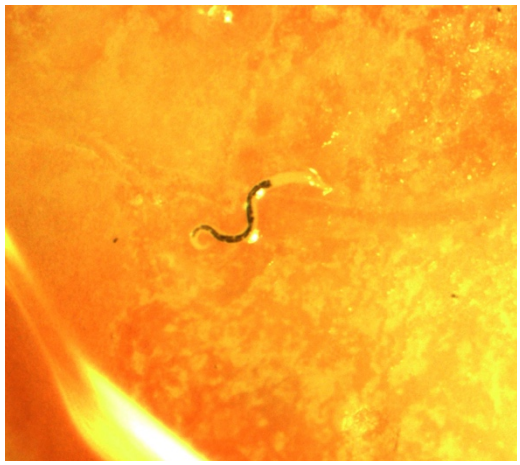
Angiostrongyliasis is the medical term for rat lungworm disease. The term is associated with the scientific name of the parasite, *Angiostrongylus cantonensis*.

Effects on the systems of the body

The infective L3 stage larvae of the parasitic nematode *Angiostrongylus cantonensis* the rat lungworm will travel through the accidental host (human, dog, horse, primate, etc.) in a manner similar to the route it would take in the definitive host, the rat. Upon ingestion, the third stage *A. cantonensis* larvae safely travels through the stomach acid and enters the small intestine, both of which are part of the **digestive system**. The stomach, large intestine, small intestine, pancreas, liver, and gallbladder are all organs that make up the digestive system. Once in the small intestine, the larvae will burrow through the intestine wall. How the larvae get through the intestine wall is not known, they may chew their way through or they may excrete chemicals that aid them. Once through the intestine wall, the larvae enter blood vessels in the **circulatory system** of the host. This system is comprised of vein, arteries, and capillaries, and the blood is pumped throughout the body by the heart. The rat lungworm larvae use the blood stream like rivers to move through the body. Some of the larvae will pass through the lungs, which are part of the **respiratory system**, and then travel through the heart on their way to the brain,

which is part of the **central nervous system.** The larvae must reach the brain if they are to continue their development and become adults. The larvae that make it to the brain may travel to different parts of the brain, including the **brain stem**, which is communicates with the brain and the rest of the body and controls breathing, heart rate, blood pressure, consciousness, and sleep cycles, and the **cerebellum**, which coordinates voluntary movements including speech, posture, balance, and coordination. Some larvae may enter the **cerebral cortex**, which is the large part of the brain and is associated with higher functions such as thought and action. The larvae might also travel to the **optic nerve**, which is the nerve that connects the eye to the brain.

As soon as larvae enter host they begin to feed on the host and grow. From microscopic examination of third stage larvae found in the lungs of rats we assume they are feeding on blood as their digestive tract is dark in color. You can see one of these larva in the photo on the left. Some of these larvae may remain in the lungs, however some are successful in their journey to their target, the **central nervous system.** Once a third stage (L3) larva arrives in the central nervous system it will grow through two molts, first becoming a fourth stage larva (L4) and then becoming a fifth stage larva (L5), or young adult rat lungworm. These larvae are now **macroscopic**, growing up to 15 millimeters in length. In the brain the larvae are feeding, burrowing, **defecating**, and damaging the **myelin** layer surrounding nerves. Myelin insulates nerves in a manner similar to the way the plastic coating on an electrical cord insulates the metal wires that transfer electricity. If the myelin coating is damaged the nerve signals cannot travel properly, which can cause bodily dis-function.



<u>Immune system response and inflammation</u>

Once the body detects these parasitic invaders, the **immune system** jumps into action. The rat lungworm is a fairly large parasite and even though it is still microscopic upon ingestion it is much bigger than bacterial or viral **pathogens**. The immune system will notice the presence of a large parasite in the body and

will produce a special, immune cell called an **eosinophil.** The eosinophil cells attack and kill *A. cantonensis* larvae, however the toxins that kill the parasites can also kill healthy brain cells and create inflammation in the brain. Because the brain is surrounded by the hard, bony skull, inflammation in the brain can be serious. Inflammation is one of the main symptoms that doctors will need to treat in cases of angiostrongyliasis, or rat lungworm disease.

Disease Symptoms

Angiostrongyliasis often presents with flu-like symptoms within days or several weeks after infection, although it is also stated that symptoms may occur months after infection. Initial symptoms can include issues associated with the digestive tract, including **nausea** and **diarrhea**. These symptoms may be caused by the passage of larvae through the intestinal wall and inflammation resulting from the damage. Victims then report feeling **lethargic**, having restlessness that may cause difficulty sleeping, a feeling of tingling or a crawling sensation under the skin, body and joint aches, and in some cases fever. These symptoms may possibly be experienced when the larvae are in the circulatory system. If the larvae reach their target of the central nervous system and brain, symptoms can become much more serious and include headache and a very stiff neck, which is a symptom of **meningitis.** Meningitis is a condition where the **meninges**, the tissues that surround the brain and spinal cord, become inflamed. Meningitis can be caused by **bacteria**, **viruses**, or in the case of rat lungworm, by a parasite. In cases caused by angiostrongyliasis, the meningitis is caused by the eosinophil cells the body produces to attack the rat lungworm parasite. While this cell it is good at killing the parasite, they can also damage nearby healthy tissue and may kill brain cells and create more inflammation. The meningitis caused by angiostrongyliasis is referred to as **eosinophilic meningitis**. This type of meningitis, unlike bacterial or viral meningitis, is not **contagious**, meaning it cannot be spread from person to person.

If the disease continues to progress, even more serious symptoms may begin to occur. Bladder and bowel paralysis has been reported, requiring hospitalization of the victim. Extreme skin sensitivity known as **paresthesia**, is often reported by survivors of the disease. The skin becomes so sensitive that even the slightest breeze or touch of hair causes extreme pain. Headaches can become more severe and sensitivity to light may occur. There can be facial paralysis or paralysis of the lower limbs, memory loss, confusion, and hallucinations. The eyes may be affected

from damage to the retina, optic nerve, or nerves controlling muscles of the eye. Victims also may experience hearing loss. This is most likely the stage at which the larvae have reached fourth or fifth stage, or may be young adult rat lungworms, trying to find their way out of the brain. The damage caused by burrowing, feeding, defecating, and dying can cause significant and often irreversible damage, resulting in coma, death, or permanent disability.

What we still don't know

It is generally assumed by the medical community that the young adult *A. cantonensis* cannot make their way out of the brain of a human. However, there are cases in young children where adult male and female *A. cantonensis* worms were found in the lungs of those who died of the disease. In Hawai'i, there are reports of lung complications from cases of rat lungworm disease. Could these problems be caused by adult worms finding their way out of the brain, or from third stage larvae that never made their way out of the lungs? There are many questions researchers have regarding this disease, as there are many victims who report on-going health problems, some of which change over time. Doctors have reported *A. cantonensis* can live for up to a year in the human host. If this is so, in what organs might they be lost and what damage might they causing? What we do know for sure is that rat lungworm disease in Hawai'i is a serious concern for public health and we all need to play a role in disease prevention.

Diagnosis

Angiostrongyliasis is a serious disease that needs more research for better diagnostic and treatment methods. People suffering from angiostrongyliasis are often misdiagnosed as having the flu, which delays important treatments. Diagnosis may be based on possible exposure the victim might have had to the parasite and symptoms the person is experiencing, however confirmation of angiostrongyliasis requires more evidence. Currently the diagnosis for angiostrongyliasis infection requires a spinal tap. This procedure must be done in a hospital and requires a needle to be inserted into the spinal column to withdraw some of the spinal fluid that surrounds the brain and spinal cord. This fluid is examined with a microscope for any visible evidence of rat lungworm larvae, however it is rare to see larvae in the spinal fluid. Next, doctors will look for elevated (high) levels of eosinophil cells, depleted (lower) glucose (sugar) levels,

and elevated protein levels, which all indicate infection by *A. cantonensis*. Finally, a molecular test called a PCR (polymerase chain reaction) will be done in a laboratory that will look for DNA that the parasite may have shed in the spinal fluid. If the DNA of *A. cantonensis* is found then a confirmation is given for angiostrongyliasis, rat lungworm disease. There are scientists in Hawai'i and in other countries who are working on a blood test diagnostic for the disease. The blood test will look for **antibodies** that are specific to those the human body will make in response to rat lungworm infection. This test will make diagnosis easier and will allow us to better determine the true number of rat lungworm disease.

Treatment

The current standard treatment is for doctors to administer a steroid, which will reduce the inflammation and is crucial to prevent brain damage. Pain medication may also be administered, and spinal taps may be given to pull fluid off of the brain and reduce the pressure on the brain. There is good evidence that the early use of anti-parasitic will lessen the damage the parasites can cause, however there is still **controversy** about the use of these drugs with the argument being that the dead worms will cause more inflammation than live worms. But some argue that by not killing the larvae, they will continue to migrate through the brain and cause damage, and because the larvae grow from microscopic to macroscopic it is better to kill the larvae when they are small rather than when they grow bigger. If anti-parasitic drugs are used they must be given with steroids to reduce any inflammation resulting from dead worms. An exception to this might be administration of the anti-parasitic drug alone immediately or within several hours following known ingestion of a slug, snail, or paratenic host.

A serious case of angiostrongyliasis can cause acquired brain injury and may require long-term treatments, such as physical therapy and nerve pain medication. Many people in Hawai'i who have been affected by angiostrongyliasis have sought alternative treatments to help with long-term symptoms. These have included acupuncture, the use of supplements, and intravenous vitamin injections to name a few. Some of the more serious long-term problems survivors have reported include skin sensitivity, vision, balance, bladder, bowel, kidney and lung problems, and short-term memory loss. It is essential that better methods be found to treat and cure angiostrongyliasis to lessen or eliminate long-term symptoms that affect the

quality of life.

Acquired brain injury

Angiostrongyliasis, or rat lungworm disease, can cause acquired brain injury. Acquired brain injuries (ABI) are injuries to the brain that happen after birth and are not related to genetic or **degenerative** issues. Causes of ABI include stroke, meningitis, and blows to the head. Moderate to severe ABI can increase the risk of degenerative brain disease. Research is now showing that some professional football players who experienced multiple blows to the head are showing signs of degenerative brain injury. Degenerative brain diseases include Parkinson, Huntington, Alzheimer disease, and multiple sclerosis. Some of the treatments used for recovery from ABI and degenerative brain diseases may be useful for treatment of angiostrongyliasis. Treatments may promote improving brain plasticity, which is the ability of the brain to find new routes to send neuron signals, bypassing routes in areas of the brain that have been damaged. There is a good amount of medical research being conducted on both ABI and degenerative brain diseases, and hopefully more research will be conducted on diagnosis and treatment of angiostrongyliasis.

Learning activities:

Students work in teams of 3-5 to conduct research and present findings to the class. Use of PowerPoint is encouraged.

1). The human body is comprised of eleven main systems. Find the names of these systems and each group can pick one. Each group describes organs associated with the system and their purpose. Describe how the different systems are interdependent on each one another.

2). Acquired brain injury is often the result of a blow to the head, such as from a fall, sports accident, or fight. As these are the types of injuries that would be most common among school age students, these activities are important for students to investigate and understand what preventative actions they can take to protect themselves. Students can work in groups to investigate how injuries result from the following actions, their effects on the brain, and measures that are in place or can be taken to prevent them.

- Accidents
- Sports injuries
- Stroke

3). Students who know a survivor of brain injury from angiostrongyliasis, stroke, accident, etc. can conduct an interview with that person and make a report that discusses the source of the ABI, symptoms experienced, treatment, and recovery.

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 credit: Jarvi lab