Course

#### Rationale

Medical Microbiology

Unit V Microorganisms

# Essential

Question What types of parasites infect humans?

#### TEKS

130.207 (c) 3A, 4B-G, 5A-E

#### **Prior Student** Learning

Intro to Microorganisms Basic Biology

# Estimated time

3 to 5 hours

## Parasitology is the study of organisms that derive their nourishment from other living things and cause damage.

## **Objectives**

Upon completion of this lesson, the student will be able to:

- Identify the morphology and characteristics of parasites
- Explain signs and symptoms of parasitic infections and the diseases they cause
- Diagram parasite life cycles
- Classify parasites in proper family, order, phylum, genus or species
- Define key terms related to parasitology •
- Observe slides or photos of organisms in different stages of development

## Engage

Read the beginning of chapter 8 in The Woman with a Worm in Her Head or another parasitic case study. Discuss the vague symptoms that can accompany parasitic infection and why it is important that medical professionals have ways of identifying different types of infections.

Excellent alternative case study resource: http://path.upmc.edu/cases/case332.html

# **Key Points**

- I. Parasites that infect humans have various classifications, characteristics, and life cycles. The patient suffering from a parasite infection is referred to as the 'host'. Most infections occur when a person is a definitive host (aka final host) which is defined as the organism in which a parasite passes its adult and sexual existence. Many animals are intermediate **hosts**, the organisms in which a parasite passes its larval or nonsexual existence. Parasites may be an **obligate parasite**, one that is entirely dependent upon a host for its survival, or a facultative parasite, one that may be parasitic upon another organism but can exist independently.
  - A. Protozoans
  - **B.** Apicomplexa
  - **C.** Helminths
  - **D.** Arthropods
- **II. Protozoa** are microscopic one-celled organisms that are categorized according to their method of movement.

**A.** Amoeba - also known as sarcodina, are single celled organisms which

include the pathogenic amoeba *Entamoeba histolytica* and *Endolimax nana* which cause amebiasis, or dysentery, in humans. These infections can be treated with metronidazole.

- **1.** Entamoeba histolytica
  - a. The third leading cause of death in the world and infects 10% of the world's population. High prevalence in Texas and other southern border states due to frequent travelers and immigrations. The acute phase causes fever, cramping, nausea, and bloody mucus stools (avg. 10-12 per day). Chronic carriers are asymptomatic and just pass the cyst stage on to others. The organism can move outside the digestive system and invade the blood stream and liver. Some cases have even shown infections in the lungs, brain and other organs. It takes about 100 cysts to be ingested to cause infection.
  - **b.** Life cycle of *E. histolytica* starts with the ingestion of the cyst stage. The stomach acid and the small intestine alkaline Ph help the cyst's walls to dissolve. Once in the large intestine it may be in the trophozoite stage causing amebic dysentery or cyst stage with normal stools (like the chronic condition). The trophozoite stage causes tissue destruction; they also ingest hemoglobin from red blood cells. The trophs are resistant to compliment mediated lysis; they shed antibodies and are resistant to direct ingestion by macrophages.
  - **c.** Diagnosing an intestinal parasite infection is usually done with a fresh stool (less than 30 min. old) used to create a 'wet mount' slide. The trophozoites are very motile and can be viewed under a microscope. The average troph is 15-20 microns ( $\mu$ ) and has one main nucleus. Part of the stool sample is transferred into ova and parasite containers that have preservatives that help sustain the parasites while limiting bacterial and other growth. These preserved samples are often concentrated and the sediment should contain any cysts. The average cyst stage is as much as 10-20 $\mu$  and contains 4 nuclei when mature. Antigen testing is done on fresh stools to definitively diagnose infection.
- Endolimax nana is much smaller in size than *E. histolytica. E. nana* averages 5-8µ and, in the troph stage, it has one nucleus with a faint nuclear envelope while the cyst stage has up to 4 nuclei. The organism has a similar life cycle to that of *E. histolytica*, but does not cause tissue damage and is much more susceptible to our immune defenses.
- B. Ciliates Protozoa that move by means of short, hair-like projections. The only parasitic ciliate that causes disease in humans is *Balantidium coli* that cause an intestinal infection and diarrhea. It is a zoonotic infection, meaning the original host is usually a hog, which

accidentally infects humans. The life cycle has an infective cyst stage that gets passed in stool of hog or human. The trophozoite stage is 15-50 $\mu$  and has sluggish non-directional motility and contains one large eccentric karyosome. The cyst stage is 15-25 $\mu$  and will be binucleated when young and maturing to up to 8 nuclei. Farmers, vets and butchers or others with lots of animal contact are most at risk. Usually self- limiting infection after a few weeks.

- **C.** Flagellates -- Three of the most common and medically significant includes *Giardia lamblia*, *Trypanosoma sp.*, and *Trichomonas vaginalis*.
  - Giardia lamblia (commonly referred to as 'giardia') is the most common in the US and is passed by fecal-oral route or contaminated water. Resistant to chlorine and creates explosive foamy diarrhea that often self-resolves in 1-5 days or patients may be given Flagyl to treat infection. Can be prevented with simple hand washing. Very specific cyst and trophozoite forms and was even identified by Lavenhook in first microscope.
  - 2. *Trypanosoma sp.* known as hemo-flagellates as they are found in blood and tissue infections. Some examples include *Trypanosoma brucei gambiense or rhodesiense* which cause sleeping sickness and may take several years from infection to symptoms. These have extra stages in their life cycle but the two often seen are the amastigote (cyst-like and diagnostic stage) and trypomasticogte (flagellate stage). The other two stages are only seen in the insect vectors and they are needed for replication. Causes the patient to be sleepy, headache, dizzy and, as the organisms replicate in the cerebral spinal fluid (CSF) eventually causes death. *Trypanosoma cruzi* causes Chaga's Disease and is passed by the kissing bug and all parts of the life cycle can occur in man in blood or tissue. Detected by heart biopsy or blood sample; causes death by heart failure.
  - 3. Trichomonas vaginalis is a flagellate that is infective in the trophozoite stage and does not have a cyst stage. It is passed sexually, usually by males, causing trichomaniasis. Males maybe asymptomatic or have mild irritation. Females may have any combination of symptoms including vaginal odor, itching, painful urination or intercourse, frothy discharge. A sample of discharge from male or female is viewed under a microscope where the organisms are able to move about freely. Treatment is metronidazole, (or Flagyl, brand name) is the drug of choice to treat infection.
- III. Apicomplexa
  - **A.** Malaria caused by the *Plasmodium sp* including *P. vivax, P. malariae, P. ovale and P. falciparum* with *P. vivax* being the most common and *P. falciparum* being the most deadly. Mosquito vector,

the definitive host, transmits infection after feeding on an infected person and then transmitting to the next person bitten. With malaria man is the intermediate host and the mosquito is the definitive host (opposite of most parasitic infections). All *Plasmodium sp.* cause fever cycles that are often timed and help identify species. Side effects can cause kidney damage and *P. falciparum* can migrate to the brain causing blocked capillaries that can lead to stokes and coma. Chloroquine, Mefloquine or a combination with Pryrimethamine/Sulfadiazine can be given for prophylaxis while Quinine and Primaquine can be given during infection or to prevent relapse.

- **B.** *Babesia microti* transmitted by hard or 'deer' ticks causing babesiosis that clinically presents very similarly to malaria. Often found in the NE US near Martha's Vineyard and Nantucket Island. Treatable with Clindamycin and quinine after identification by antibody testing usually done by the CDC.
- **C.** *Toxoplasma gondii* -- affects up to 50% of the US population and has worldwide distribution. Commonly called 'Toxo' causes may be asymptomatic or cause mild flu-like symptoms and when no longer active resides in the tissues. Can be passed to a fetus and cause serious birth defects. Definitive host (sexual and asexual reproduction) is the household cat. Oocytes are passed in cat feces which become actively infectious after two days and can be inhaled or ingested. Identified by serologic testing for IgG or IgM specific antibodies.
- **IV. Helminths** are worm-like parasites. The clinically relevant groups are separated according to their general external shape and the host organ they inhabit. The intensity of the disease process caused by the parasite is often measured by the worm burden, or the number of worms an individual host carries which, depending on the worm, can be measured either directly, or indirectly.
  - A. Tapeworm (**cestoda**) infections begin by ingestion of the larval stage in the flesh of an animal and they reside in the small intestine. They absorb digested carbohydrates and proteins while secreting a substance that keeps them from being digested. Man is the definitive host while animals are the intermediate hosts. They may be from 3-4,000 segments long and live up to 25 years.
    - 1. Diphyllobothrium latum fresh water fish tapeworm widespread in Japan, will also infect fish eating mammals (like humans). The head, or scolex, is 3mm long and it may be up to 3m in full length with 3,000-4,000 sections or proglottids and may produce up to 100,000 eggs a day. Those infected maybe asymptomatic or have mild abdominal symptoms, nausea, vomiting, pain, discomfort. *D. latum* competes for vitamin B12 absorption and

may cause megaloblastic anemia as a result, a rare but serious side effect.

- 2. Simplified life cycle starts with the egg in feces that must reach water to develop into the first larval stage. The first larval stage infects a flea where it matures to the second larval stage that is then swallowed by fish. The third larval stage migrates into the flesh of the fish and when consumed raw or under cooked the larva is ingested and attaches to the intestine wall and matures to adult.
- 3. Taenia saginata Beef tapeworm
- **4.** *Taenia solium* Pork tapeworm
- **B.** Roundworms (**nematodes**) need time outside the body for eggs to mature and many will penetrate through the skin to infect. Several need time in the blood to before going to the intestines. The worm burden is still an issue as the more there are, the bigger the problem, and in children they can cause a lag in physical and mental development.
- C. Enterobius vermicularis aka Pinworms
  - 1. Have separate sexes and a simple digestive system but no circulatory system. Attaches to the host using a type of lip at the anterior end, and forms a thick cuticle layer that keeps it from being digested. Worldwide distribution affecting mainly small children and their families causing generalized and intestinal symptoms. The human is the only known host passing it from person to person.
  - 2. Life cycle of the pinworm is complicated; the male averages about 8-13mm and is rarely ever seen. The female migrates out of the anus at night and lays eggs on the skin of the perianal area and migrates back inside. The eggs are the infective stage and can airborne and usually cause itching that can lead to ingestion (from scratching and carrying them to mouth due to bad hand hygiene). Once eggs are ingested (from hands or inhalation) the larva is released and molts into the adult. Retroinfection can be caused by larva migrating back into the anus and adding to the worm burden.
  - 3. Diagnosis is made by collecting eggs from the perianal area first thing in the morning with sticky tape that is then placed on a glass slide. Once confirmed the whole family gets treatment and all bedding is cleaned, nails shortened and diligent hand washing are all needed to beat infection.
- D. Trichuris trichuria aka Whipworm
  - 1. Worldwide distribution, especially in the tropics, and may cause light worm burden that is asymptomatic to heavy worm burden causing chronic diarrhea, malnourishment and can lead to rectal prolapse. Treatments are expensive and have very toxic side effects. Humans are the primary host and it is prevented by

personal and community sanitation.

- 2. Life cycle takes about 3 months and involves a male and female that creates eggs that are passed through the feces and take about 3 weeks to become infective. Once infective egg is ingested the larva is released, molts into an adult, and begins making more eggs.
- E. Wuchereria bancrofti
  - 1. A filarial worm spread by a mosquito vector, the intermediate host. *W. bancrofti* causes lymphatic filariasis and can lead to a chronic condition known as elephantiasis.
  - 2. The life cycle of *W. bancrofti* is similar to other filarial worms. It begins with the adults in the lymphatic system producing live born larva. The larva, or microfilaria, migrate to the circulatory system and are ingested by the blood sucking insect (mosquito in this case). While in the insect the microfilaria develops into infective flariform larvae or juveniles. The mosquito bites another human and regurgitates the filariform into their blood stream where it migrates to the liver to develop into a fertile adult.
- F. Ascaris lumbricoides
  - 1. The giant round worm in humans that causes the disease ascariasis and is thought to be the most common parasitic worm in humans.
  - 2. The life cycle of *A. lumbricoides* begins with eggs, which become infectious after 2-3 weeks outside a host, being ingested (fecal-oral route due to poor sanitation). The lipid layer around the egg helps it survive through the stomach and harsh exterior conditions. Once in the intestines it matures to the first larval stage, burrows through the intestinal wall and into the circulation where it may get into the liver, heart then the lungs, where it will mature in the alveoli. The second larval stage is coughed up the trachea and swallowed down the esophagus again. Once in the intestines, it has reached the adult stage and will be male or female. Fertilization can now occur and the female can produce up to 200,000 eggs a day.
- G. Flukes (trematoda) are rare in the US and often seen in immigrants. They have a leaf like appearance (except schistomas) and absorb nutrients through their skin and have no real digestive system. They range from several millimeters up to 3 inches in size. Most eggs must reach water for development and they have multiple larval stages and multiple hosts. A general fluke life cycle may look like this: Egg excreted in feces – Once in fresh water matures to Miracidium (1<sup>st</sup> larval stage) – 1<sup>st</sup> intermediate host (snail) and matures to cercaria (2<sup>nd</sup> larval stage) – back into water and many different steps at this point lead to second intermediate host that is usually ingested by man (fish, crab, crayfish, water vegetation).

- 1. *Fasciolopsis buski*: giant intestinal fluke, found in the human duodenum of the small intestines, contracted from dogs or chestnuts. As worm burden increases causes diarrhea, nausea, obstruction and Vitamin B12 absorption problems
- 2. Heterophyes heterophyes and Metagonimus yokogawai cause infections in the small intestines and are found in under-cooked fish. Mostly inconsequential and a very high worm burden is needed to show symptoms.
- 3. Paragonimus westermani causes lung infections and often found in Asia and the Philippians. From fresh water they are ingested in crab or crayfish and they burrow through the intestines and diaphragm into the lungs. Symptoms arise once the fluke is in the lungs and creates chest pain, fever, bloody sputum and passes eggs in sputum and feces as sputum gets coughed up and swallowed.
- 4. *Faciola hepatica,* sheep liver fluke, and *Opisthorchis spp.,* Chinese liver fluke, are both liver flukes that get swallowed and burrow through the intestinal wall into the liver. Primary host is snails or fish and reservoir host may be sheep, cats or dogs but maturation includes the water stage.
- 5. Schistosoma spp. have split bodies, are both male and female, and may live up to 30 years. There are several species and they may live in the veins of the bladder, large intestines, or small intestines depending on the species. They infect by direct skin penetration and burrow to preferred sites.
- V. Arthropod is the name of the phylum that includes spiders, mosquitoes and human parasites like ticks, lice, and others.
  - A. Pediculus humanus humanus, or the body louse
    - 1. Is found on or near the seams of clothing. Body lice must feed on blood and usually travel to skin to feed. They cause intense itching and are a nuisance, but may pass on other infections when feeding. Most infestations are short lived if the host has access to regular bathing and laundered clothes and sheets.
    - 2. The body louse life cycle begins with the eggs, or nits, that are often laid in the seams of clothing near the waist line or under arms. Occasionally they may attach to human hair and they take 1-2 weeks to hatch. The nymph, or immature louse, hatches from the nit and feeds as it matures in 9-12days. The mature louse looks like the nymph only larger and is about the size of a sesame seed. The adult louse feeds to survive and will die if separated from its person at room temperature.
    - 3. Treatment is to wash all clothing at high temperatures or to leave all clothing unwashed and unworn for 1 week. Either technique inactivates or kills eggs and lice. Medication can be given if needed but regular laundering and bathing is often enough.

- **B.** *Pediculus humanus capitus* or head louse is an obligate ectoparasite of humans and prefers to lay its nits on human scalp hair rather than on clothing. The head louse has a similar appearance and follows a very similar life cycle to the body louse but is much harder to treat. Infestations are spread usually from head to head contact and much less often through contact with shared items like combs or pillows. Many chemical options are available and wet combing for nits and lice is suggested every 3 to 7 days for the whole household. Unlike the body louse the head louse does not pass on other diseases.
- **C.** *Phthirus pubis* is also known as the pubic or crab louse and affects 2% of the world wide population. The crab louse is commonly found in pubic hair or eyelashes. It is an obligate ectoparasite of humans and follows a similar life cycle to the body and head lice. The crab louse has a very different appearance as it is very round and the back pair of legs is very large. An infestation is known as pediculosis pubis or phthiriasis pubis. They are transferred by close sexual contact and rarely through sharing bedding, towels or other linens. The main symptom is itching and there are many chemical treatments available for topical use.
- D. Pulex irritans or the human flea is a small, wingless insect that has great jumping ability. Humans can be host for other varieties of fleas as well. Fleas feed on blood meals from the host, and as a result can serve as a vector for passing infections from one species to another. Microorganisms passed by fleas include several varieties of bacteria (including Yersinia pestis or the bubonic plague), viruses, helminthes and protozoa. The site of a feeding can become raised and itches or may trigger a rash response. Human treatments are limited to treating the symptoms while animals and homes can be treated with chemicals to destroy fleas and eggs.

#### Activity

- I. Practice key word vocabulary with Parasitology Memory Game.
- **II.** Complete the Parasitology Laboratory Investigation, or alternately have students do a web scavenger hunt for photos of organisms at different stages in their life cycles and make a presentation.
- III. View clips of Malaria Fever Wars (PBS Home video).
- IV. Complete chapter 8 in <u>The Woman with the Worm in Her Head</u>. Discuss different aspects of the case and diagnosis. (A great book to have if you are teaching Medical Microbiology).
- V. Complete the Parasitology Worksheet / Quiz.

#### Assessment

Completion of Parasitology Quiz Laboratory Investigation Rubric

#### Materials

Power Point Microscopes Prepared slides of protozoa and helminthes and their eggs Lens paper Video, Malaria Fever Wars, PBS Home video. ©2005, 120 min running time Book, <u>The Woman with the Worm in Her Head and Other True Stories of</u> <u>Infectious Disease,</u> written by Pamela Nagami, M.D. ©2001. St. Martin's Griffin, New York.

The Parasitic Diseases Branch of the CDC: <u>http://www.cdc.gov/parasites/lab\_science.html</u>

Case study resource: <u>http://path.upmc.edu/cases/case332.html</u>

#### **Accommodations for Learning Differences**

For reinforcement, the student will design a poster showing how to prevent a specific parasitic infection.

For enrichment, the student will research and report on a link between parasites and cancer.

#### National and State Education Standards National Health Science Cluster Standards

HLC01.01 Health care workers will know the academic subject matter required (in addition to state high school graduation requirements) for proficiency within their area. They will use this knowledge as needed in their role. Use knowledge of diseases and disorders.

HLC06.01Health care workers will understand the existing and potential hazards to clients, co-workers, and self. They will prevent injury or illness through safe work practices and follow health and safety policies and procedures.

HLC06.02 Health care workers will understand the fundamentals of wellness and the prevention of disease processes. They will practice preventative health behaviors among clients.

HLC10.01 Health care workers will apply technical skills required for all career specialties. They will demonstrate skills and knowledge as appropriate.

#### TEKS

130.207(c) (3) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: (A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so

as to encourage critical thinking by the student;

130.207(c) (4) The student describes the relationships between microorganisms and health and wellness in the human body. The student is expected to: (B) identify chemical processes of microorganisms;

(C) recognize the factors required for microbial reproduction and growth;

(D) explain pathogenic and non-pathogenic microbes in the human body;

(E) describe the morphology and characteristics of microorganisms using a variety of microbiological techniques;

(F) discuss the results of laboratory procedures that are used to identify microorganisms;

(G) explain how pathogens affect the human body systems; and 130.207(c)(5) The student examines the role of pathogens in infectious diseases. The student is expected to:

(A) outline the infectious process;

(B) classify microorganisms using a dichotomous key;

(C) categorize diseases caused by bacteria, fungi, viruses, protozoa, rickettsias, arthropods, and helminths;

(D) explain the body's immune response and defenses against infection;

(E) evaluate the effects of anti-microbial agents;

#### **Texas College and Career Readiness Standards**

Science Standards

III. Foundation skills: Scientific Application of Communication B. Scientific Reading 3. Recognize scientific and technical vocabulary in the field of study and use this vocabulary to enhance clarity of communication. D. Research skills/information literacy 1. Use search engines, databases, and other digital electronic tolls effectively to locate information.

V. Cross-Disciplinary Themes D. Classification 1. Understand that scientists categorize things according to similarities and differences.

# Parasitology Laboratory Investigation

#### Purpose:

In this laboratory exercise, the student will identify the morphology and characteristics of parasites and the diseases they cause.

#### **Background Information:**

#### Materials:

Microscopes Prepared slides of protozoa, helminths and their eggs Lens paper

#### **Procedure:**

- 1. Examine prepared slides of parasitic protozoa.
- 2. Examine prepared slides of the eggs of common parasitic worms.

## Data:

Draw sketches of protozoa and helminth eggs.

#### **Conclusion:**

1. Differentiate protozoa from other microorganisms.

2. List diseases caused by parasites. Include symptoms and treatment.

3. Diagram the life cycle of a disease-causing parasite. Include a sketch of the parasite.

4. Explain prevention and control measures for the chosen disease causing parasite.

# PARASITOLOGY QUIZ

Match the following parasite descriptions with the appropriate name:

1. Pinworm a. Taenia saginata \_\_\_\_2. Elephantiasis b. Plasmodium sp. \_\_\_\_3. Sexually-transmitted Entamoeba histolytica C. 4. Beef tapeworm d. Wuchereria bancrofti Taenia solium \_\_\_\_5. Pork tapeworm e. 6. Fish tapeworm f. Ascaris lumbricoides 7. Giant roundworm Enterobius vermicularis q. 8. Malaria h. Diphyllobothrium latum \_\_\_\_9. Flagellate i. Giardia lamblia \_\_\_\_10. Amoebic dysentery Trichomonas vaginalis j. 11. Protozoa that move by means of short, hair-like projections are the 12. The only ciliated protozoa that infect humans are \_\_\_\_\_. 13. The most common intestinal parasite in the U.S. is \_\_\_\_\_\_ and is transmitted by \_\_\_\_\_. 14. List symptoms of Trichomonas infection: 15. Flatworms have sections called \_\_\_\_\_\_ which contain the reproductive structures. 16. The medical term for body lice is \_\_\_\_\_\_ and for head lice is \_\_\_\_\_. 18. Fleas can infest household pets and \_\_\_\_\_ 19. The definitive host of *Toxoplasma gondii* is the \_\_\_\_\_\_ and it can cause severe fetal defects. 20. *Plasmodium sp.* are transmitted by a \_\_\_\_\_\_ vector.

# Key for Parasitology Quiz

- 1. G
- 2. D
- 3. J А
- 4.
- 5. Е 6.
- Н 7. F
- В 8.
- 9.
- L
- 10. С
- 11. Ciliates
- 12. Balantidium coli
- 13. fecal-oral (or contaminated water) Giardia lamblia
- Urethral discharge, dysuria (painful urination), local itching, painful 14. intercourse, vaginal discharge. (only 30% get symptoms)
- 15. Proglottids
- Pediculus humanus humanus 16.
- Pediculus humanus capitus
- 17. Pubic lice or crab lice
- 18. Humans
- 19. Cat (household or domesticated)
- 20. Mosquitoes

# **Memory Game**

Host	Organism harboring or infected with a parasite		
Definitive Host	Most infections occur when a person is a and the organism in which a parasite passes its adult and sexual existence.		
Intermediate Host	Many animals are the organism in which a parasite passes its larval or nonsexual existence.		
<b>Obligate Parasite</b>	A parasite is entirely dependent upon a host for its survival.		
Facultative Parasite	A parasite that may be parasitic upon another organism but can exist independently		
Protozoa	Microscopic one-celled organisms that are categorized according to their method of movement		
Nematodes	Roundworms		
Helminthes	Worm-like parasites. The clinically relevant groups are separated according to their general external shape and the host organ they inhabit.		
Cestodes	Tapeworms		
Trematoda	Flukes		
Arthropods	A phylum name referring to certain insects (including mosquitoes and ticks) and spiders		
Infestation	A parasitic attack or subsistence on the skin and/or its appendages, as by insects, mites, or ticks.		
Worm Burden	The number of worms an individual host carries which, depending on the worm, can be measured either directly, or indirectly.		

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# Parasitology Vocabulary

1. Host	
2. Definitive Host	
3. Intermediate Host	
4. Obligate Parasite	
5. Facultative Parasite	
6. Protozoa	
7. Nematodes	
8. Helminthes	
9. Cestodes	
10. Trematoda	
11. Arthropods	
12. Infestation	
13. Worm Burden	

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# Laboratory Investigation Rubric

Student:\_\_\_\_\_ Date:\_\_\_\_\_

Scoring Criteria	4	3	2	1	N/A
	Excellent	Good	Needs Some Improvement	Needs Much Improvement	
Problem is appropriately identified.					
Problem is precise, clear, and relevant.					
Association between the problem and the predicted results is direct and relevant.					
All variables are clearly operationalized.					
Demonstrates comprehension of the use of scientific concepts and vocabulary.					
All significant data is measured.					
Data is recorded effectively and efficiently.					
Data table is well designed to the task requirements.					
All graphs are appropriate.					
All data accurately plotted.					
highlights conclusions of the study.					
Conclusion relates directly to hypothesis.					
Conclusion has relevancy in resolution of the original problem.					
Conclusion relates the study to general interest.					

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