



Slug and Snail Biology

The focus is primarily on non-native, terrestrial slugs and snails, however, the aquatic apple snail *Pomacea canaliculata* should also be considered as it is a pest on all the islands except Molokai and Lanai and is often found in the lo'i. Another aquatic snail, *Pila conica* is present on Molokai. Both of these species are in the Ampullariidae family.

Standards Addressed:

3-LS2 Ecosystems: Interactions, Energy, and Dynamics

- 3-LS2-1. Construct an argument that some animals form groups that help members survive.

4-PS4-1 Waves

- Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

4-LS1 From Molecules to Organisms: Structures and Processes

- 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- 4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

5-PS3 Energy

- Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

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.

5-ESS3 Earth and Human Activity

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.

MS-LS1 From Molecules to Organisms: Structures and Processes

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.

MS-LS1-4.

- Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

MS-LS1-5.

- Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-LS1-6.

- Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS1-8.

- Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Learning Objectives:

- Students learn the basic morphological features common to slugs and snails.
- Students understand basic differences and similarities between slugs and snails.
- Students understand gastropod biological behavior relating to locomotion, feeding, and reproduction.
- Students are able to identify commonly found, non-native slugs and snails found in their location.

Reading for understanding:

Slug and Snail Biology



Our focus is on non-native, **terrestrial** (land-living) slugs and snails. We should keep in mind that the apple snails, which are **aquatic** (water dwellers) can carry rat lungworm disease and are often found in lo'i.

We can learn to identify many of the commonly found, non-native slugs and snails in our gardens, however identification of some species can be difficult and may need the assistance of an experienced **malacologist** (a person who studies slugs and snails). A properly taken photograph of a slug or snail that we do not know the name of can be sent to a malacologist who can possibly help with identification of the slug/snail we are looking at. However, we must remember that some species require dissection, and the malacologist must look at the reproductive organs to identify to species. Because of this difficulty there are some species we may only be able to identify to family or simply say, slug or snail, and write comments regarding description. Eventually we will be able to identify them with some help from experts.

These are a few of the external features we use when identifying a slug or snail. You will need to know some basic slug and snail biology, and if photographing the

specimen, you will need to properly position your subject so these features can be seen.

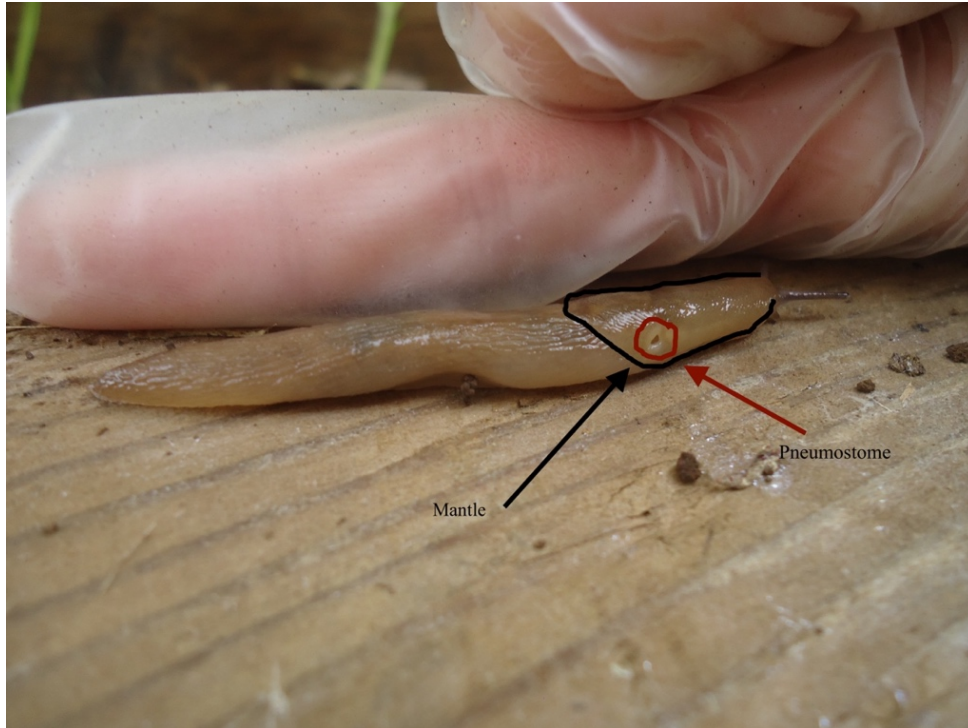
Things to remember when photographing a gastropod:

- Size: how large is the gastropod? Put an object in photo, such as a ruler, pencil, or coin, to give an indication of size. Metric measurements should be used as all scientists use the **metric system** (good opportunity for conversions!).
- Mantle: the mantle is a flap of skin that covers part or all of the gastropod body and functions as the lung. How far does the mantle cover the body? This is an important identification question as it can differ greatly between species.
- Pneumostome: (new•mō•stōm) the breathing hole. Where is the pneumostome located on the body? The pneumostome is always on right side of the gastropod body. Where is the pneumostome located in relation to mantle? Is it toward the **anterior** end (front), **posterior** end (back), or middle?
- Keel: does the tail have a ridge, or keel, or is the tail rounded?

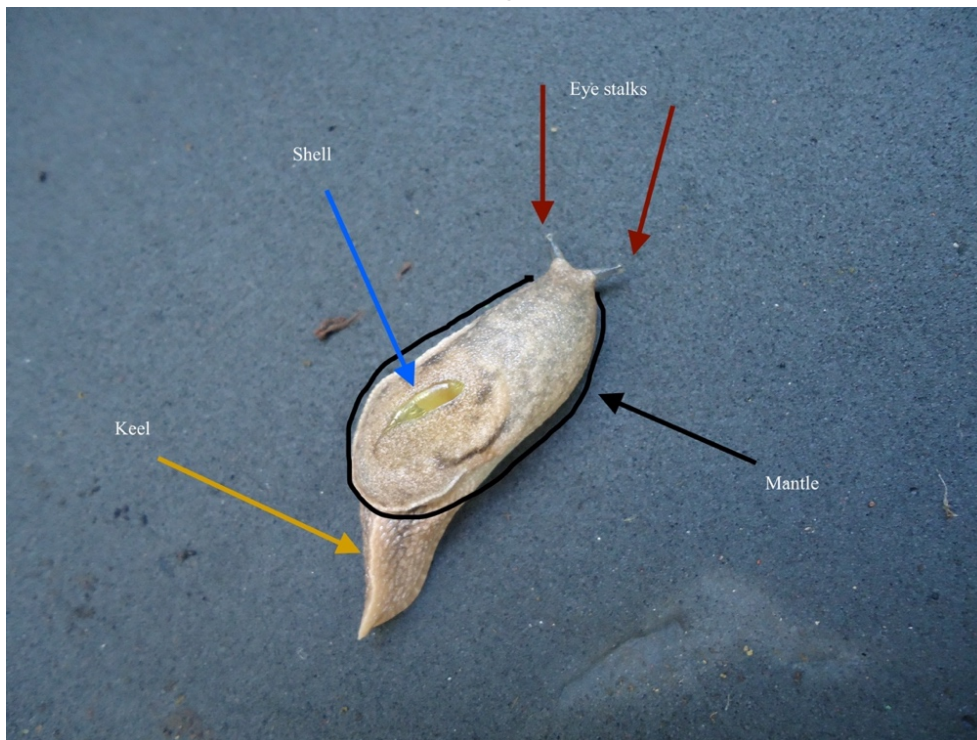
Basic Morphology

From photographs of slugs commonly found in Hawai'i you will learn to recognize these **morphological** (relating to the form or structure of things) features. Learn to recognize the slugs and snails that will regularly be found in your location and notice the differences in their morphological characteristics.

Deroceras reticulatum the field slug. The mantle is outlined in black, and the pneumostome is outlined in red.



Parmarion martensi the semi-slug. The mantle is outlined in black.



The mantle

The **mantle** is like a cloak covering the organs, and it covers the mantle cavity, which is where **respiration** takes place. The mantle is often very muscular, such as in the giant African snail *Achatina fulica* (below), and is used as a kind of foot for traveling. In snails, the mantle helps form the shell.



Veronicella cubensis the Cuban slug (below). The mantle, outlined in red, covers the entire body. The tail is rounded and therefore does not have a keel.



Locomotion: the foot and the slime.



Laevicaulus alte the leatherback slug, also in the Veronicellidae family and looks similar to the Cuban slug. The foot is light colored and covered by the mantle (red arrow).

In the photo (above) you can see the underside of the slug and view the foot. The foot is a muscular structure that contracts in a wave-link motion, providing **locomotion** for the gastropod. The slug or snail will lay down a layer of slime, which creates the surface over which the slug moves. The slime is interesting; it provides a sticky surface on the **substrate** the slug or snail is traveling over, which is why they can climb up walls, trees, and other **vertical** surfaces, and it provides a slippery surface for the foot to move smoothly over. Slugs and snails can make different kinds of slime that are used for different purposes and have different properties. There is the slime just discussed, that provides locomotion, there is a slime that is **exuded** when the slug or snail is threatened, there is a slime that the animal exudes to keep its outer surface moist, there is a slime snails produce to close off the opening of their shell in dry weather, and there is a slime snails will use to attach themselves to a surface.

Optic and anterior tentacles

Most gastropods have two sets of **tentacles**, located on the head. Because gastropods do not have the sensory organs to see or hear, they rely on smell to find their way in the world, and there are **olfactory** (smell) organs located at the tips of each of the four tentacles. There are the two **optic** (light sensing) tentacles located at the top of the head, and two **anterior** tentacles located at the bottom of the head and near the mouth. The anterior tentacles are used to smell, feel, and act as lips to help bring food into the mouth. The optic tentacles have both olfactory organs and an eye, which is located at the tip of the tentacle. The eye has a **cornea**, a **lens**, and a **retina**. However, the eye is not used for vision but to tell light from dark and to maintain **circadian** rhythms (reoccurring cycles that occur naturally on 24 hour intervals).



Parmarian martensi the semi-slug (above and below). Can you see the mantle covering the body and the keeled tail? Describe the tail. The semi-slug has a **vestigial** shell that is covered by a flap of the mantle that can open or close. You can see the

slit in the mantle that covers the shell in the picture above. The optic tentacles are extended. The anterior tentacles are not visible in this photograph but are located at the base of the head, just in front of the mouth.



The mouth

Slugs and snails have a mouth, but instead of teeth they have radula. The radula is a tongue-like organ with many rows of rasping teeth, similar to a shark. When one row gets worn down another row is ready to replace it. These animals feed on plants and fruits and can scar fruit and make holes in leaves. If you see these types of damage it will alert you that you may have a slug or snail problem in your garden. The damage to the papayas in the photograph below was caused by giant African snails rasping on the fruit. The damage can make the fruit less attractive to consumers and bring lower prices for farmers.



The shell

Slugs and snails are similar in structure and biology, but snails have a shell and slugs do not. Semi-slugs, such as *Parmarion martensi*, have a **vestigial**, or remnant shell. The shell of a snail is made of **calcium carbonate**, which is the same thing limestone is made of. Snails need a source of calcium carbonate to grow their shells larger as the snail grows in age, **mass**, and size, and for repair of the shell if it is damaged. The giant African snail, *Achatina fulica* is known to eat stucco plaster off the side of a house, with the stucco providing the source of calcium carbonate. The shells of snails vary greatly and differences in shell structure are used as identifying factors. Conchologists are scientists who study shells. The **absence** or **reduction** of a shell in slugs lessens the need for calcium carbonate and provides a greater **range** of **habitats** than that required by snails. It is a contributing reason as to why terrestrial slugs are one of the most successful of all mollusk groups. Lack of a shell and a worm-like body allows slugs to access crevices and squeeze through small openings. For more information visit:

<http://www.molluscs.at/gastropoda/index.html?/gastropoda/coiling.html>



The shell of *Cornu aspersum* the European garden snail (above).

Nervous system

Terrestrial gastropods have a **peripheral nervous system** (PNS) made of nerve cells that react to **stimuli**, and a **central nervous system** (CNS) made of **ganglia** that control functions like movement, eating and digestion, and bodily functions. The central nervous system has two types of cells, **neurons and glia cells**. The **cerebral**

ganglion is usually referred to as the **brain**, and receives signals from the peripheral nerves and sense organs, especially in the head.

Reproduction

Most terrestrial gastropods are **hermaphrodites** and cross fertilize each other during mating. Some species of gastropods have developed the ability to **self-fertilize**, a brilliant survival technique that ensures survival during times when the population declines. Mating among gastropods can be random or can include mate choice. Most terrestrial gastropods lay eggs, which can be deposited in the soil, under leaf litter, or attached to leaves or other objects (however there are species of native Hawaiian snails that give live birth!). Eggs are often calcified or partially calcified, and the hard shell can help prevent the developing **embryo** inside from drying out. One of the most important environmental conditions necessary for successful egg development is a moist site. Egg size varies among species, and egg numbers also varies between species. Egg numbers can also be affected by competition, seasons, and climate. Some species will retain their eggs during dry conditions. Some terrestrial gastropods reproduce after just one season and then die, and this may be with case with the semi-slug *P. martensi*. Others will reproduce during one season and then go on to reproduce again over the course of years, such as the giant African snail *A. fulica*. Below are two reproducing *A. fulica*.



Behavior and feeding

Gastropods will focus their daily behavior on where and when to be active, what to do when active, where to be when inactive, and how to get to sheltering or roosting sites. The different species in a population of gastropods will vary the time of their emergence as darkness falls to avoid other slugs and snails that may be **predatory** gastropods. There is also seasonal variation in gastropod activity, with the time of highest activity usually occurring during the rainy season. Some gastropods will **aestivate** during the hot, dry season. Aestivate is to hot as hibernate is to cold; a time of inactivity and a way to wait out extreme weather. To seal off the opening of the shell, snails will secrete a thin, paper-like membrane called an **epiphragm**. Factors that increase slug activity include temperature, soil moisture, and wind speed. When moving about, gastropods will travel downwind to reduce drying of their body surface. They will also follow each other's slime trails to find a good place to shelter during the day, which may vary with species preference. Gastropods will also clump together to preserve moisture. We often will see slugs and snails grouped together to prevent drying, such as these Cuban slugs in this photograph below.



For more interesting information on slug and snail biology visit this informative website:

<http://www.molluscs.at/index.html>

Student Activities:

Where and when?

1). A hunt is a good way to survey for invasive pests that may be hiding in the garden and for this we must think like a slug or snail. What time of the day is it and how has the weather been? Has it been rainy and cool, or hot and dry? Have you seen slugs or snails at your school or your homes? Can you remember where they were seen and what time of the day or night you saw them? Write a brief statement before the hunt that discusses recent weather patterns. Describe moisture (dry, rainy), temperature (cool, hot), and weather (sunny, partly cloudy, overcast). You can hunt in teams of 3-4 students each. Bring your pencils and journals, a ruler for measuring, and your sharp eyes. When you find your target, observe its surroundings. Where did you find it? Describe in detail its environment.

What and how?

2). Observation is one of the most important activities we can engage in to better understand the biology of the pests we are trying to control. Use your eyes to observe the characteristics of slug and snail you found. Without touching, observe the gastropod. Can you see the mantle? How far does it cover the body? Can you see the pneumostome? Where is it located, toward the anterior, or middle of the mantle? What is the length of your gastropod? What color is it and does it have any distinctive markings (stripes, bands)? If it is a snail, describe its shell. Does the shell have whorls? Which direction does the shell **aperture**, or opening, face? On what type of surface was your gastropod found (soil, pavement, plant, etc.) Describe using detailed words or pictures the environment in which your slug or snail was living.

Who?

3). Can you identify what type of slug or snail you have found? What is its scientific name? What is its common name, if it has one? Can you find facts about your slug or snail on a website? Draw a picture of the slugs or snails you found below. Write facts about each species or about slugs and snails in general from information found online. Start to make an identification file using photographs taken of commonly found slugs and snails at your school garden site for your classroom and school garden. Were there any other living organisms found in the same area? Describe what you found. Did you see any eggs? If so, can you guess or do you know whose they are?

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