Science Unit: *Animal Growth and Changes*
Lesson 5: *Metamorphosis*

School Year:	2012/2013
Developed for:	Hastings Elementary School, Vancouver School District
Developed by:	Linda Herbert (scientist); Natacha Corrie and Chris Donegan (teachers)
Grade level:	Presented to grade 2/3; appropriate for grades 1 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Notes:	Painted Lady larvae (caterpillars) can be ordered from a variety of online suppliers. The butterfly larvae used in this lesson were ordered from Boreal Science www.boreal.com. Boreal Science sells classroom butterfly kits that include larvae, rearing cups, food and a butterfly pavilion. Displays of BC butterflies can be borrowed from the Spencer Entomological Museum (University of British Columbia) for classroom use. Contact Karen Needham (Curator) at needham@zoology.ubc.ca for details or visit http://beatymuseum.ubc.ca/collections/entomological.

Objectives

1. Learn about metamorphosis and the Painted Lady butterfly lifecycle.
2. Practice making observations of butterfly larvae.

Background Information

Painted Lady butterflies are one of the most widely distributed butterfly species on earth and can be found on every continent except South America and Antarctica. In Canada their distribution extends from BC to Newfoundland and although they are not common up north they have been observed as far north as Nunavut. Like all butterflies, the Painted Lady lifecycle involves complete metamorphosis and the developing organism passes through four stages: egg, larva, pupa and adult. The length of each stage depends on environmental temperature and conditions, and in the case of the larval stage, also depends on food availability. The average time for each stage in the painted lady reared at 18-22°C is as follows: egg 4-5 days; larva 12-18 days; pupa 8-10 days; adults 14-20 days. Colder temperatures will prolong each stage.

Complete rearing kits can be ordered from Boreal Science. The kits (item 6706200) include all necessary materials as well as detailed set up and rearing instructions. Instructions are also available online: (https://www.boreal.com/stibo/hi_res/10060686.pdf).

Painted Lady butterflies can be successfully raised in the classroom and released in BC from April-September. The lifespan of the adult is quite short. Adults are ready to lay eggs after 3-4 days and only live for 14-20 days. If you wish to begin the lifecycle observations again the eggs can be collected and reared. Additional nutrient/food for the larvae can be ordered from Boreal Science or fresh food can be provided (leaves of thistle, knapweed, burdock, sunflower, artichoke, chrysanthemum etc.).

Vocabulary

Incomplete	For aquatic insects: a type of insect development with distinct egg, naiad, and adult stages; the naiad and adult share some similar characteristics and there is no

metamorphosis:	inactive pupa stage; naiad is an aquatic nymph.
Complete metamorphosis:	A type of insect development characterized by changes in the body form of insects that include egg, larva, pupa (resting and reorganizing stage) and adult stages; the larval stages look different from the adult stage.
Insect:	A class of invertebrates with (among other characteristics) an exoskeleton, six legs, a three-part body and one pair of antennae
Larva:	The juvenile form present after the egg of an animal that undergoes metamorphosis hatches. The larval form of a butterfly is also known as a caterpillar. The larval stage may include several molts.
Molt:	In insects this refers to the process by which an insect sheds its exoskeleton to accommodate new growth.
Exoskeleton:	An external skeleton. A hard outer shell possessed by insects and some other invertebrates instead of a skeleton.
Endoskeleton:	An internal skeleton, such as that possessed by humans and other mammals.
Pupa:	The stage in a butterfly's life cycle during which it undergoes metamorphosis into an adult form.
Chrysalis:	The specialized exoskeleton that encloses the pupa during metamorphosis.
Cocoon:	A protective case generally formed of silk that some caterpillars spin to enclose the pupa during metamorphosis.
Cremaster:	A hook like structure at the tail end of the pupa used to help suspend the chrysalis.
Head:	One of three segments of an insect's body: It contains the eyes, mouth and antenna.
Thorax:	The anterior segment of an insect's body, located closest to the head.
Abdomen:	The posterior segment of an insect, located farthest from the head.
Mandible:	Term for the jaws of an insect (and other animals) used for chewing, biting and grabbing food.
Proboscis:	Specialized mouthpart used for sucking up nectar. It resembles a coiled up straw.
Antenna:	Sensory organs located on an insect's head. Used to detect a variety of senses including touch and smell.

Materials

- Worksheets
- Pencils
- Preserved butterfly specimens (optional – see note above)
- 6706200 Butterfly kit form Boreal Science (contents listed below)
- 30 live larvae
- 30 vials with lids
- 8oz. of nutrient
- Butterfly Pavilion
- Camel hair brush
- Plastic spoon
- Instruction sheet (also available at https://www.boreal.com/stibo/hi_res/10060686.pdf)

In the Classroom

Introductory Discussion

1. Today we are going to talk about metamorphosis.

    - Who can tell me what metamorphosis means? [Metamorphosis means to change or transform. When we talk about an insect metamorphosis, it refers to a change from an immature or juvenile form to a mature or adult form.]

    - Who can give me an example of an insect that undergoes metamorphosis?

2. We are talking about metamorphosis today because we have some new residents in the classroom, our Painted Lady caterpillars, which will undergo metamorphosis to become Painted Lady butterflies. Let's discuss the lifecycle of the Painted Lady: Painted Ladies undergo what is called complete metamorphosis. Complete metamorphosis has four stages. [Draw life cycle on board and ask students to name stages. If they don't know just start explaining as below.]

    - Adult butterflies lay their eggs on leaves. Painted Lady eggs are light green and shaped kind of like a football or watermelon but with tiny ridges on them (draw on board). Once the eggs hatch (after about 4-5 days) the larva emerge and they are basically little eating machines. They start out as small as ants and grow to be ~2.5 cm in only a couple weeks so they need a lot of food! They usually start off by eating their egg casing, called a chorion. It is high in protein and super nutritious. They larvae prefer to eat leaves from plants such as thistles, alfalfa, knapweed, asters and burdock but will also eat sunflower, artichoke, chrysanthemum and hollyhock leaves.

    - As we've discussed in previous lessons, insects such as caterpillars have hard outer shells called exoskeletons instead of stretchy skin like we have. How do you think caterpillars grow if their shells don't change size? Can they get bigger if their exoskeleton stays the same size? If you had a hockey helmet on could your head keep growing? How do insects get larger? [molt exoskeleton and grow a new larger one] (Solicit ideas from students on how molting could occur.)

    - The process begins with the too small exoskeleton starting to separate from the body. A special fluid accumulates in the space between the exoskeleton and the body that begins to soften and dissolve the exoskeleton [can compare this to what happens when an eggshell is left in vinegar for several days]. While this is occurring a new skin starts forming around the body, this new skin or cuticle starts out pliable and stretchy like a balloon. When the time is right the caterpillar will puff itself up and swallow a lot of air in order to split the old exoskeleton and stretch out the new cuticle. [Have students try flexing all their muscles and inhaling as much air as they can – they can wrap tape measures around their chests and/or waists first to see how much bigger they can make them. You can also use a tape measure to demonstrate how arm or leg muscles expand when flexed.]

    - Once the new skin is exposed to the air it begins to harden into the new exoskeleton. When this process is complete the caterpillar releases all the air it has swallowed and goes back to its regular size giving it lots of room to grow inside of its new exoskeleton. The caterpillar will often eat the old exoskeleton because like the chorion it contains a lot of protein and nutrients.

    - After every molt the caterpillar changes in both size and appearance. Painted Lady caterpillars will grow for an average of 12-18 days after hatching.

    - The next stage in the lifecycle is the pupa. A pupa is a caterpillar that is ready to form a chrysalis. The caterpillar attaches itself to a leaf or branch with a strand of silk attached to its cremaster and the final exoskeleton is shed to reveal a specialized skin called a chrysalis underneath. Over the next 8-10 days the pupa will undergo a dramatic transformation into an adult, aka a butterfly. Some of the caterpillar's body parts will be retained and modified while others will be "lost" and

recycled into new body parts seen only in the adult or butterfly form. If we could see inside the chrysalis during the process it would look like a soupy, gooey mess for much of the time.

- While undergoing metamorphosis the pupa is very vulnerable to predators. What are some tactics it can use to avoid or scare away predators? [camouflage, location, shaking – don't be surprised if you see your pupa shaking and rattling, they aren't ready to emerge yet, they are just scaring off predators.!]
- Once the butterfly emerges its new wings are soft and wet. It requires space to fan them out to dry and harden. Adult Painted Lady butterflies are usually ready to lay eggs in 3-4 days and will live for 14-20 days.

3. Description of science experiment/activity.
   - Students will compare the appearance of caterpillars and butterflies and then record observations of their caterpillar's current appearance.
4. Processes of science that the students will focus on: Students will focus on making and recording observations.
5. Safety guidelines.
   - Do not touch the caterpillars.
   - Be gentle with the caterpillars. Do not shake or drop the containers.
   - Wash your hands at the end of the lesson and prior to eating.

Science Activity

Activity Title: Painted Lady Observation

Purpose of Activity: To observe the changing appearance of the Painted Lady caterpillars over time. This activity will record the current appearance of the caterpillars, which can be compared with subsequent observations.

Methods and Instructions:
Set-up prior to experiment: This activity assumes that the larvae have already been set up and distributed into individual cups as indicated in the rearing instructions.

Students will each observe their caterpillars individually.

1. See detailed instructions on worksheet.
2. Additional worksheets are included for follow up observations and classroom observations.

Closure Discussion

1. Discuss worksheet responses.
2. What does your caterpillar look like?
3. How does it differ from a few days ago when we received them? How does it differ from those of the other students in your group?
4. Why do you think not all of the caterpillars are at the exact same stage of development? [Some will have molted sooner and/or grown more than others.]

References

1. Shepard, John and Crispin Guppy. 2001. Butterflies of British Columbia. UBC Press.
2. <http://www.bcbutterflyatlas.ca/> BC Butterfly Atlas. [Includes factsheets, identification guides and specimen photos]. Accessed May 31, 2013.
3. <http://butterfliesofamerica.com/index.html> Butterflies of America. Butterflies of America Foundation. [Many specimen photos]. Accessed May 31, 2013. Specific children's page with Painted Ladies photographs is: <http://butterfliesofamerica.com/L/t/Vanessa_cardui_a.htm>.
4. <http://linnet.geog.ubc.ca/efauna/Atlas/Atlas.aspx?sciname=Vanessa%20cardui> Vanessa cardui Fabricius, 1807. Website hosted by E-fauna BC: Electronic Atlas of the Wildlife of British Columbia. [Biological and ecological information and photographs]. Accessed May 31, 2013.
5. <http://www.goert.ca/documents/Butterfly_ID_sheet.pdf> Butterflies of Southern Vancouver Island and Gulf Islands. Website hosted by Gary Oak Ecosystems Recovery Team. [Butterfly photographs to aid in identification and easy comparison between species]. Accessed May 31, 2013.

Extension of Lesson Plan

1. Ongoing observations of the Painted Lady development can be taken every few days. An observation sheet as well as a classroom temperature log has been included with the worksheets that accompany this lesson.
2. Students can use the classroom temperature log to calculate the degree days required for each stage of development, particularly the development of a pupa into an adult.
3. Compare metamorphosis that occurs in butterflies (complete) with the metamorphosis that occurs in some of the aquatic organisms observed in lesson 3. Some aquatic organisms undergo complete metamorphosis (mosquito) while others undergo incomplete metamorphosis (dragonfly).

Scientist Name:_____

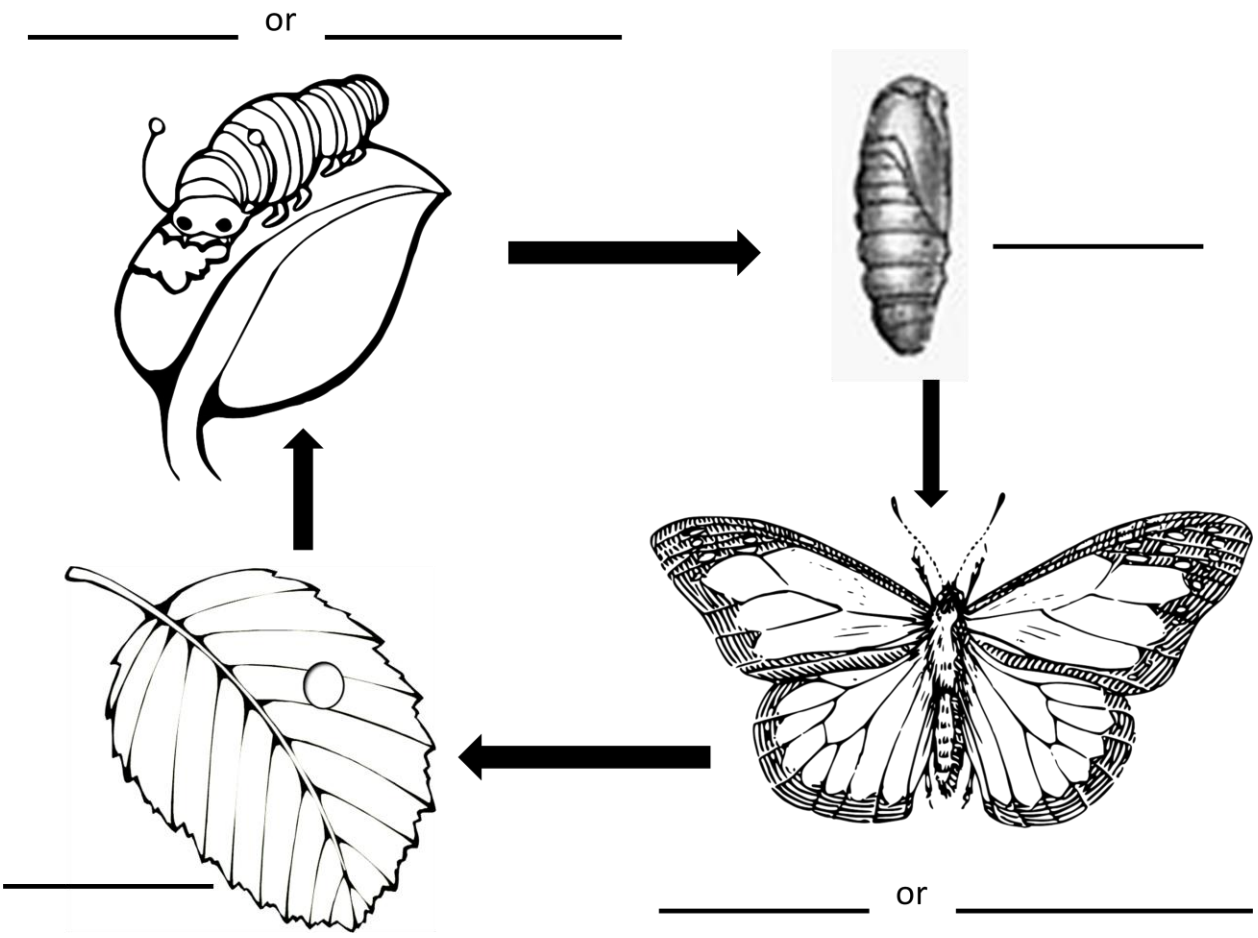
Date:_____

METAMORPHOSIS

Life Cycle of the Painted Lady Butterfly

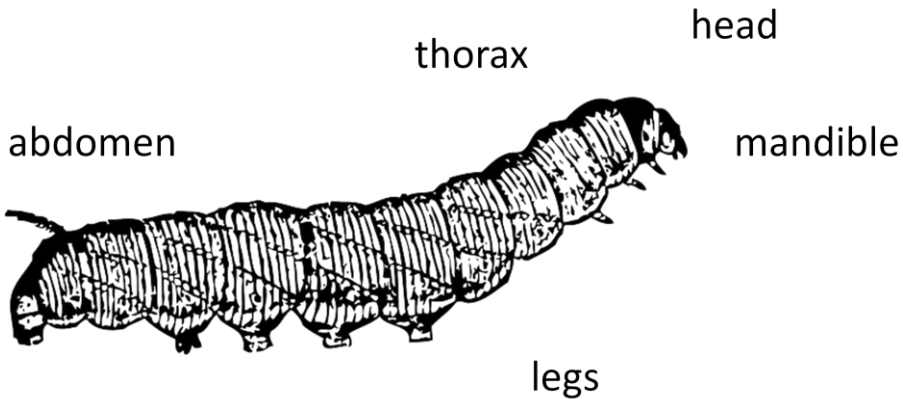
Use the labels below to complete the life cycle diagram

adult larva caterpillar egg butterfly pupa

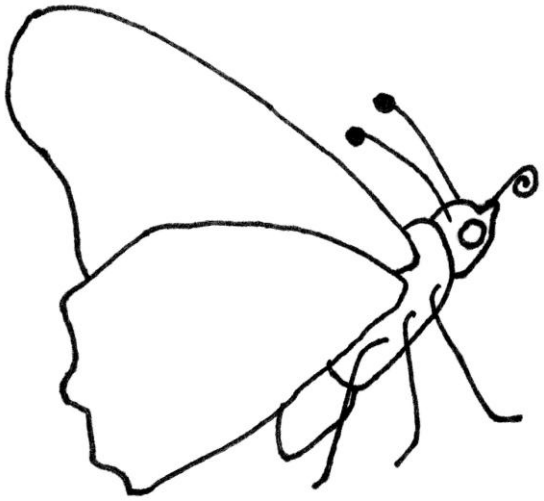


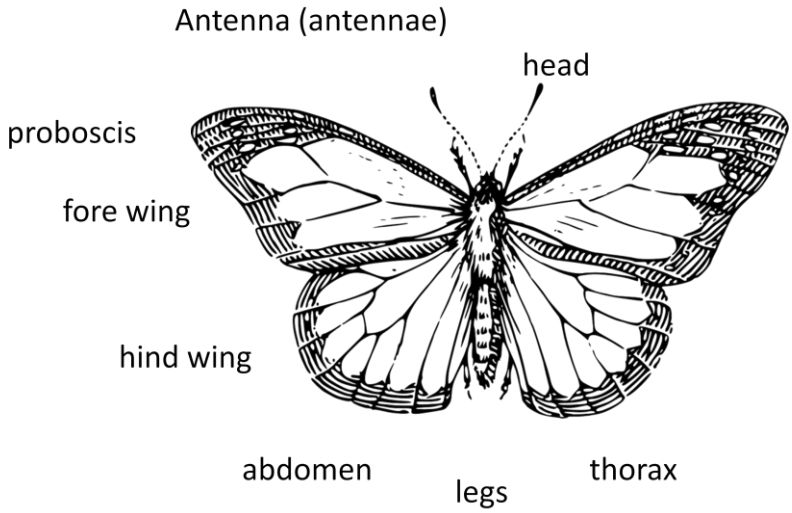
All images downloaded from pixabay.com and freely available in the public domain, CC0 1.0

Draw arrows to label the caterpillar diagram.



Draw arrows to label the butterfly diagrams.





List 3 changes that occur during metamorphosis from a caterpillar to an adult:

1. _____

2. _____

3. _____

Scientist Name:_____

Date:_____

What do painted lady caterpillars eat?

_____

How do painted lady caterpillars eat?

_____

_____

What do painted lady butterflies eat?

_____

How do painted lady butterflies eat?

_____

_____

The most interesting thing I learned about painted lady butterflies was:

_____

_____

_____

Scientist Name:_____

PAINTED LADY INITIAL OBSERVATION LOG

Date: _____ Classroom temperature: _____

Stage: _____ Estimated Size: _____

Draw and color a detailed picture of one of the painted ladies.

Describe the current appearance of the painted ladies (size, color, body features).

_____

_____

_____

Record any other observations you have such as behavior

_____

_____

_____

_____

Scientist Name:_____

PAINTED LADY OBSERVATION LOG

Date: _____ Classroom temperature: _____

Stage: _____ Estimated Size: _____

Draw and color a detailed picture of one of the painted ladies.

Describe the current appearance of the painted ladies (size, color, body features). How have they changed since your last observations?

_____

_____

_____

Record any other observations you have such as behavior

_____

_____

_____

PAINTED LADY CLASSROOM OBSERVATION LOG

DATE OF ARRIVAL: _____

DATE	TEMPERATURE	STAGE

PAINTED LADY CLASSROOM OBSERVATION LOG CONTINUED

DATE	TEMPERATURE	STAGE