Teacher Guide

***Manduca sexta* Wax Model**

Lesson Summary: Students construct a wax model of the nervous system of the caterpillar, *Manduca sexta*. Changes in the nervous system during metamorphosis from a caterpillar to a moth are illustrated by changing the wax model.

Grade Level 5-8

Lesson Length
1 class period

Standards Alignment

Next Generation Science Standards

- 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.
- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- **Framework for K-12 Science Education**: Science & Engineering Practices 2,3,5,8

National Science Standards – Project 2061: Atlas of Science Literacy reference

a) Modeling: uses of models and limitations of models (p.93, Atlas Vol. 2)

Research on student learning: "Prior to instruction, or after traditional instruction, many middle- and high-school students continue to focus on perceptual rather than functional similarities between models and their referents, and think of models predominantly as small copies of real objects. Consequently, students often interpret models they encounter in school science too literally and unshared attributes between models and their referents are a cause of misunderstanding. Some middle- and high-school students view visual representations such as maps or diagrams as models, but only a few students view representations of ideas or abstract entities as models." (p.92, Atlas Vol. 2)

Objectives—Students will be able to

- construct and change a wax model to illustrate metamorphosis of the *Manduca sexta*'s nervous system from the juvenile to the adult stage.
- identify the differences in behavior, shape, and neural structure between the juvenile and adult stage of a moth using drawing, writing, and/or diagramming.

Assessment Options

- Students participated in the development of the caterpillar and moth nervous system.
- Students correctly answered Questions A and B in the instruction sheet/student guide.
- For the model of the moth nervous system, students correctly labeled the brain, SEG, each ganglia, and location where cell bodies, dendrites, and axons are found.
- Students correctly drew, wrote, and/or diagrammed the differences in behavior, shape, and neural structure between the juvenile and adult stage of a moth.

Teacher Notes — Display a copy of the ***Manduca sexta* Life Cycle Picture** available on the lesson webpage. The image is from the Richard B. Dominick Moth and Butterfly Collection, University of South Carolina, Columbia site available at https://digital.tcl.sc.edu/digital/collection/hsn/id/20257/rec/1

Terms important vocabulary that can strengthen the lesson. Select terms according to the needs and abilities of your students.

abdomen - the hindmost of an insect's three major body sections. The abdomen is the center for digestion and reproduction.
abdominal – relating to or involving the abdomen.
ganglia – groups of neuron cell bodies in which nerve signals are processed.
metamorphosis - development or transformation of an organism and involves significant changes in physical form (e.g. growth and differentiation).
nervous system – a vast network of cells that carry information to and from all parts of the body.
thoracic - relating to or involving the thorax.
thorax - the middle section of an insect's body. The legs and wings attach to the thorax, making it the center for locomotion.

Materials (for each student or pair of students)

- *Manduca* Neural Systems Puzzle
- 2 “Wax Works” wax pieces of one color (each piece about 10” long)
- 1 “Wax Works” wax piece of a second color
- 1/2 “Wax Works” wax piece of a third color
- 1 instruction sheet/student guide

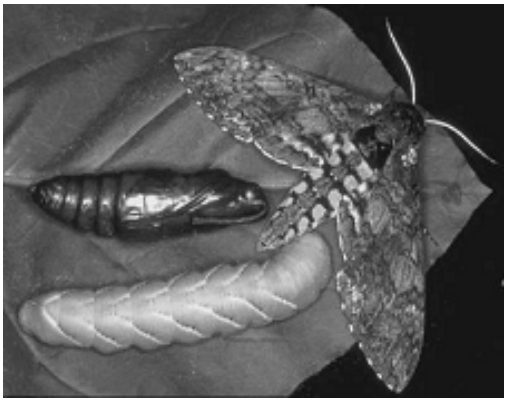

image from Richard B. Dominick Moth and Butterfly Collection, formerly at zebra.sc.edu/moth/manduca-l.html

Procedures

Engage – Show students the *Manduca sexta* Life Cycle Picture. Briefly discuss:

- different needs of caterpillars vs. moths in terms of senses, food, shelter, etc.
- the most important senses, abilities, and behaviors each life cycle stage.
- whether or not the nervous system changes during metamorphosis from the caterpillar to the moth.

Explore 1

1. Discuss terms students will need to know to complete the wax model – ganglia, thoracic, and abdominal.
2. Pass out wax pieces and instructions to each student/pair.
3. Direct students to follow instructional steps 1-5 to make a caterpillar nervous system.

   Younger students may benefit from whole group, step-by-step instruction.
4. After students have constructed the caterpillar's nervous system, briefly discuss the metamorphic process from a caterpillar to a moth.
5. Tell students to follow instructional steps 6-8 to change the caterpillar nervous system into a moth nervous system.

   Younger students may benefit from whole group, step-by-step instruction.

   Students may need help with making and pinching off the loops formed during metamorphosis.
6. Ask students to complete questions A-D on the student guide.

Develop Questions

See if students have questions regarding the life cycle stages of the *Manduca sexta* or its process of metamorphosis.

Explore 2

1. Hand out the *Manduca* Neural Systems Puzzle.
2. Direct students to figure out the correct order of the nervous system stages.
3. Encourage students to observe and then discuss the differences between each stage.

Explain – Question students about changes to the *Manduca* nervous system during metamorphosis.

1. How long is the nervous system?
2. What does pinching off of loops represent?
3. What are the advantages of losing old axon pathways?

   The old, long axon pathways (loops) get by-passed and disintegrate over time so that by the time the moth reaches the adult stage, the loops are gone in favor of short, more efficient axons.

Expand – Extension to Lesson

- Ask students how caterpillar and moth nervous systems are similar to and different from the human nervous system.

  Display similarities and differences using a Venn diagram.
- Ask students if they think changes happen in other organisms' nervous systems as they mature.

  This would be a good point to begin discussing changes to the human brain during the teen years.