Hand on a Hot Stove

Core Concept:
Neurons are connected to form pathways that result in reflex responses, conscious sensation, voluntary movement, and memory.

Class time required:
Approximately 2 forty minute class periods

Teacher Provides:
For each student
- Copy of student handout entitled Hand on a Hot Stove

For each team of 2-3 students:
- Color copy of Body Diagram (page vi). Laminate or put in sheet protector for reuse.
- Color copy of Neuron Pathway Damage (page vii). Laminate or put in sheet protector for reuse.
- Bag containing:
  - 1 red starflake bead—18 or 25 mm (purchase at local or online craft store)
  - Wikki Stix cut to specific lengths indicated below and then attached to the plastic transparency. Purchase single color packs from www.WikkiStix.com. One unit of a single color contains 36 Wikki Stix and costs $3.75. Total cost for six colors of Wikki Stix is approximately $24.00 and includes enough materials for 25 sets. Wikki Stix may be reused. You will need to prepare Wikki Stix to the following lengths:
    - 1 red Wikki Stix—add a 2 inch piece of Wikki Stix to a 6 inch piece of Wikki Stix and press together to make an 8 inch long Wikki Stix.
    - 1 dark blue Wikki Stix—2 inches long
    - 1 lime green Wikki Stix—1 inch long
    - 4 pink Wikki Stix—1 inch long
    - 5 light blue Wikki Stix—1 inch long
    - 2 yellow Wikki Stix—1 inch long
  - Optional: A piece of plastic transparency film to attach Wikki Stix for distribution and collection (page v)
Note: Some pilot teachers liked the Wikki Stix. Others found that the Wikki Stix were distracting for students. They preferred to use colored markers to draw the neuron pathways. Instead of Wikki Stix, you may have students draw the neurons using different colors of water soluble markers or dry erase markers.

Note: Some pilot teachers liked having the places in the student instructions where teacher initials were required so that the teacher could check student work. Others found this initialing unnecessary. You may tell students that they do not need to call you over to check their work.

Optional Consider using:

- A Hand on Hot Stove Animation is available for downloading from the Life Sciences Learning Center website at http://lifesciences.envmed.rochester.edu. This animation may be shown before and/or after students complete work on each part of the activity.

Suggested Class Procedure:

1. Distribute a copy of the student handout entitled Hand on a Hot Stove.

2. Ask students to work individually to complete the Introduction. They should read the Introduction and write numbers to indicate the order of events that occur when a person accidentally puts a hand on a hot stove. The Introduction may be done for homework.

3. Ask students to work individually or in teams to complete Part 1 using the information in Biology Brief: What is a Reflex? Part 1 may be done for homework.

4. Ask several students to share their answers to the Introduction and Part 1. You may need to clarify the difference between “your hand moves automatically” (happens automatically without even thinking about it) and “you move your hand voluntarily” (you think and move your hand voluntarily)

5. Distribute the Body Diagram and Biology Brief: A Reflex Arc

6. Explain that students (teams of 2-3) will use the Body Diagram make a model to help them understand and remember what happens during a “hand on a hot stove” reflex.

7. Distribute bag containing Wikki Stix and bead to each team. Explain that these sticks, if pressed firmly to the body diagram, will stick to the paper or sheet protector. Also explain that these Wikki Stix will be reused for additional classes so they should not be balled up or played with!

8. Students work in teams to complete Part 2: A Reflex Arc. As students work, encourage them to use the information in the Biology Brief: A Reflex Arc. Check student work and initial.

10. Review using the Hand on a Hot Stove animation available from the Life Sciences Learning Center website.

11. Distribute Neuron Pathway Damage diagram sheet.

12. Students complete Part 4: What’s Wrong with the Patient? This part may be done in class or as homework. Check student work and initial.
Biology Brief:  A Reflex Arc

A reflex occurs when nerve impulses travel over a simple neuron pathway called a reflex arc. Reflex arcs have five basic parts: receptors, sensory neurons, interneurons, motor neurons, and effectors.

1. **Receptors** located in the skin or sense organs detect a stimulus and create an impulse.

2. **Sensory neurons** conduct nerve impulses towards the central nervous system (brain and spinal cord). A single sensory neuron carries messages from a receptor to the spinal cord.

3. **Interneurons** in the central nervous system (brain and spinal cord) connect sensory neurons to motor neurons. One or more interneurons in the spinal cord carry messages from a sensory neuron to a motor neuron.

4. **Motor neurons** conduct nerve impulses from the central nervous system (brain and spinal cord) to an effector. A single motor neuron carries messages from the spinal cord to an effector.

5. **Effectors** respond to the impulses by contracting (if the effector is a muscle fiber) or secreting enzymes or hormones (if the effector is a gland).
### Wikki Stix

<table>
<thead>
<tr>
<th></th>
<th>Red</th>
<th>Green</th>
<th>Yellow</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark Blue</td>
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<td>Light Blue</td>
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<tr>
<td>Pink</td>
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</tbody>
</table>
Motor Cortex of Cerebrum (voluntary movement)

Prefrontal Cortex of Cerebrum (memories and decision making)

Sensory Cortex of Cerebrum (conscious sensation)

Cerebellum (coordination)

Spinal Cord

Body Diagram
Neuron Pathway Damage

Black Boxes = Neuron Damage
Hand on a Hot Stove
Teacher Answer Key

Introduction: When You Put Your Hand on a Hot Stove

Think about what happens if you accidentally place your hand on a hot stove. Use numbers 1-5 to place these statements in the order in which they happen.

___4___ You wave or shake your hand voluntarily to cool it.
___2___ Your arm moves to automatically move your hand away from the stove.
___3___ You feel pain in your hand.
___5___ You remember that you should not touch a hot stove.
___1___ You touch a hot stove.
Part 1: What is a reflex?

Reflexes

If you touch something that is very hot, your hand moves away quickly before you even feel the pain. You don't have to think about it because the response is a reflex that does not involve the brain. A reflex is a rapid, unlearned, involuntary (automatic) response to a stimulus (change in the environment).

Reflexes are responses that protect the body from potentially harmful events that require immediate action. They involve relatively few neurons (nerve cells) so that they can occur rapidly. There are a wide variety of reflexes that we experience every day such as sneezing, coughing, and blinking. We also automatically duck when an object is thrown at us, and our pupils automatically change size in response to light. These reflexes have evolved because they protect the body from potentially harmful events. Most reflexes protect people from injury or deal with things that require immediate action.

Reflex actions do not involve the higher brain regions involved in conscious sensation, decision-making, and voluntary movement. Involving higher brain regions would take too long, potentially exposing the body to risks. Using the reflex pathway as a shortcut allows reflexes to occur very rapidly.

1. What is a reflex?

   A reflex is a rapid, unlearned, involuntary (automatic) response to a stimulus (change in the environment).

2. What is the purpose for most reflexes?

   Reflexes protect people from potentially harmful events or injury or deal with things that require immediate action.

3. Why are higher brain centers not involved in making reflex responses?

   Using the reflex pathway is a shortcut that allows reflexes to occur very rapidly.
4. State two ways that reflex actions are different from other actions such as walking, talking, or driving a car.

   Reflex actions are automatic, unlearned, involuntary, happen rapidly, and involve relatively few neurons.

5. Put an X in front of the actions that are likely to be reflex responses to stimuli.

   _X_ Sneezing       ____Running       _X_ Blinking       ____ Talking

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### Part 2: A Reflex Arc

A reflex arc is a part of the nervous system involved in making a reflex response. You will use the information in the Biology Brief: A Reflex Arc, the Wikki Stix, and the Body Diagram to make a model of the neurons in a reflex arc.

1. What is the stimulus that triggers the "hand on a hot stove" reflex?

   The heat from the stove

2. Place the red bead in the appropriate location on the Body Diagram to represent a receptor that detects the stimulus.

3. Which type of neuron conducts the impulse from the receptor to the spinal cord?

   A sensory neuron
4. Arrange the RED Wikki Stix on the Body Diagram to show a sensory neuron that connects the receptor to the spinal cord. Note: Press the Wikki Stix down on the Body Diagram so that it sticks to the diagram.

5. What is the function of a sensory neuron?
   
   A sensory neuron conducts impulses from a receptor to the spinal cord.

6. Which type of neuron conducts the impulse from a sensory neuron to a motor neuron?
   
   An interneuron

7. Arrange the GREEN Wikki Stix to show an interneuron in the spinal cord on the Body Diagram.

8. What is the function of an interneuron?
   
   An interneuron conducts impulses from a sensory neuron to a motor neuron.

9. Which type of neuron conducts the impulse from the spinal cord to an effector?
   
   A motor neuron

10. Arrange the DARK BLUE Wikki Stix on the Body Diagram to show a motor neuron.

11. What is the function of a motor neuron?
   
   A motor neuron conducts impulses from the spinal cord to an effector.

12. What is the effector in the reflex that allows you to automatically move your hand away from a hot stove?
   
   A muscle in the arm

13. What is the function of the effector?
   
   The effector contracts to move the hand away from the hot stove.
14. Sneezing is a reflex that involves the brainstem (medulla)—the part of the brain responsible for automatically controlling some body functions essential for survival. Label the **interneuron**, **motor neuron**, and **sensory neuron** on the sneeze reflex diagram below.

15. Impulses travel very rapidly over neurons. It takes more time for neurotransmitters to diffuse across synapses.

**What is the advantage to having relatively few neurons in a reflex arc pathway?**

_With fewer neurons, the reflex happens more rapidly because there are fewer synapses._

16. Do you think that a person with severe brain damage could make a reflex response to a stimulus applied to the hand or foot? Explain why or why not?

_Yes, because the brain is not involved in the reflex arc pathway._
17. Put an X in front of the responses to the “hand on a hot stove” that result from a reflex arc?

_____ You move your hand voluntarily to cool it.

___ Your hand automatically moves away from the stove.

_____ You feel pain in your hand.

_____ You remember that you should not touch a hot stove.

_____ You touch a hot stove

Important! Leave the *Wikki Stix* attached to the Body Diagram.
Part 3: Using Your Brain

You are capable of behaviors that are more complex than simple reflexes. Complex behaviors require the involvement of parts of the brain. For example, when you put your hand on a hot stove, you use your brain for things that are not reflexes, such as conscious sensations, voluntary movements, and memories.

In Part 3 you will use the Body Diagram and Wikki Stix to show neuron pathways involved in complex behaviors.

### Conscious Sensations

Conscious sensations include the sensations such as touch, temperature, pressure, and pain. To feel pain, impulses travel from the receptors in your hand to the spinal cord through sensory neurons. In the spinal cord, the sensory neurons synapse with interneurons that carry impulses to the sensory cortex area of the cerebrum in your brain. When the impulses arrive at the sensory cortex of the cerebrum, you experience the sensation of PAIN!

1. You feel pain when impulses reach the ___sensory cortex____ of the cerebrum.

2. Add several PINK Wikki Stix to the Body Diagram to show the route that impulses take to get from the sensory neuron in the spinal cord to the part of the brain that enables you to feel the conscious sensation of pain.

3. Explain the following observation: When you touch a hot stove, it takes longer to feel the pain than it does for your hand to automatically move away from a hot stove.

   *There are more neurons involved in the pathway to the brain than in the reflex pathway to the muscle.*
**Voluntary Movements**

Once you feel pain, voluntary movements occur. For example, you cool your hand by shaking it or placing it in cold water. Impulses for voluntary movement begin in the motor cortex of the cerebrum. The motor cortex sends impulses via interneurons to the cerebellum where motor activity is coordinated. Then, the impulses are sent via interneurons in the spinal cord to the motor neurons that control the muscles involved in arm and hand movement.

4. Impulses that control voluntary muscle movement begin in the _____**motor cortex**______ of the cerebrum.

5. What part of the brain helps make voluntary movement coordinated? **cerebellum**

6. Add several **LIGHT BLUE** Wikki Stix to the Body Diagram to show the pathway that impulses take to result in **voluntary** and **coordinated** movement of the arm and hand.

7. Explain at least two differences between a reflex response and a voluntary movement.

   *A reflex response happens automatically. You do not need to think about it. A voluntary response requires thought and decision-making. OR fast/slow OR brain/no brain OR few/many neurons OR short/long pathway OR one long/many short.*

**Memories**

Impulses from the sensory cortex are conducted over interneurons to the **prefrontal cortex of the cerebrum** to be “recorded” as **memories** that associate the sight of a hot stove with pain. These memories cause you to be more careful when you are near a hot stove.

8. Memories are formed in the ___**prefrontal cortex**_________________ of the cerebrum.

9. Add one or two **YELLOW** Wikki Stix to your Body Diagram to show the pathway that impulses take to form the memory that stoves are hot and should **not** be touched.
10. Put an X on the processes that require parts of the brain.

- X You move your hand voluntarily to cool it.
- Your hand automatically moves away from the stove.
- X You feel pain in your hand.
- X You remember that you should not touch a hot stove.

11. Name the part of the brain which is responsible for:

- Conscious sensation of painful stimuli **Sensory area of cortex**
- Coordination of voluntary muscle activity **Cerebellum**
- Initiation (starting) of voluntary muscle activity such as hand movement **Motor area of cortex**
- Memory that touching a hot stove is painful **Prefrontal cortex**
- Decision to be careful when working around a hot stove **Prefrontal cortex**

12. Explain why actions that require involvement of the brain happen more slowly than reflexes.

*The nerve pathway has more synapses that slow down information transfer.*

13. Interneurons are neurons that function entirely within the central nervous system (spinal cord and brain). Circle the colors of Wikki Stix that represent interneurons in your model:

Green  Red  Dark Blue  Light Blue  Pink  Yellow
Part 4: What’s Wrong with the Patients?

A person’s ability to respond to stimuli may be disrupted when a neuron pathway is damaged by severing (cutting), compression (squeezing), or death of neurons. Neuron damage prevents impulses from traveling through the neuron pathways. Doctors do a neurological examination by exposing a patient to stimuli and then observing the patient’s responses. If the patient responds abnormally, additional testing can be used to develop a diagnosis to determine how the neuron pathways are disrupted.

1. Use the Neuron Pathway Damage diagram. The numbered black boxes on this diagram indicate where neuron pathways might be damaged. For each of the patients described in the chart below, write the number from the Neuron Pathway Damage diagram that best explains each of the patient’s symptoms.

<table>
<thead>
<tr>
<th>Patient’s response when their hand is poked with a needle</th>
<th>Number on Neuron Pathway Damage diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anna can feel pain and her arm automatically moves away. She can voluntarily move her arm.</td>
<td>No Damage</td>
</tr>
<tr>
<td>Bart can feel pain and his arm automatically moves away. He cannot voluntarily move his arm.</td>
<td>1</td>
</tr>
<tr>
<td>Connie’s arm automatically moves away but she does not feel pain. She can voluntarily move her arm.</td>
<td>2</td>
</tr>
<tr>
<td>David does not feel any pain and his arm does not move automatically. He can voluntarily move his arm.</td>
<td>4</td>
</tr>
<tr>
<td>Erin’s arm automatically moves. She does not feel pain and she cannot move her arm.</td>
<td>3</td>
</tr>
<tr>
<td>Fred can feel pain. His arm does not move automatically and he cannot voluntarily move his arm.</td>
<td>5</td>
</tr>
</tbody>
</table>

2. Another patient had a stroke (a blood clot in the brain). He can feel pain and make a reflex response to touching a hot object. He can also move his hand voluntarily. However, he has trouble remembering to be careful when working around a hot stove. Which part of his nervous system may be damaged by the stroke?

*The parts of the brain such as the prefrontal cortex that store memories or the pathways that connect the sensory cortex with the prefrontal cortex. Students with additional prior knowledge may also say the hippocampus.*
3. A baby is born with normal reflex responses and sensations. He can voluntarily move his arms and legs but these movements are jerky and uncoordinated. What part of his nervous system may be damaged?

   *Cerebellum*

4. Christopher Reeve (the actor who played the role of Superman in the 1978 movie) was injured when he was thrown from a horse. Even with surgery and rehabilitation, his arms, breathing muscles, and legs were paralyzed. Reeve could operate a wheelchair by sipping or puffing on a straw. His condition, called *quadruplegia*, put him at constant risk for related illnesses such as pneumonia, infections, blood clots, and wounds that do not heal.

   On the diagram on the right, draw an X to indicate approximately where Christopher Reeve’s nervous system was damaged.

5. Alex was texting while he was driving. He crashed into a tree and was seriously injured. Following surgery and rehabilitation, Alex has normal reflexes and he can move his arms, but his legs are paralyzed. His condition is called *paraplegia*. Mechanical, electrical, and computer engineers at a local university are working to develop moving braces that will enable Alex to stand and possibly walk.

   On the diagram on the right, draw an X to indicate approximately where Alex’s nervous system was damaged.

Return the following items to the kit bag:

- All Wikki Stix
- Red bead
- Body Diagram
- Neuron Pathway Damage Diagram
- Biology Brief: A Reflex Arc