Lesson Summary: The ability to identify with and understand another person's situation, feelings, or motives is called empathy. Recent developments in neuroscience have focused on a system within the brain called “mirror neurons” as a likely explanation for emotional empathy. In this lesson students explore emotions and the behavioral aspects of empathy through mirroring the emotions of other students while watching emotionally evocative videos.

Grade Level 9-12

Lesson Length
1 class period

Standards Alignment

Next Generation Science Standards

- 1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.
- 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-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms, e.g. organism movement in response to neural stimuli.
- HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- 3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.
- 3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.
- HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce.
- **Framework for K-12 Science Education**: Science & Engineering Practices 1,2,3,8

Objectives—Students will be able to

- Describe importance of emotions and mirror neurons on social survival and homeostasis.
- Carry out an inquiry-based experiment on the evoked emotional responses and the perception of those responses.
- Build observational skills for recognizing accurate emotional states in social situations.

Assessment Options

- Explain how the neural information regarding emotion flows to and from the brain.
- Explain how the emotions influence muscle movement of the face.
- Explain why accurate reading of another person’s emotions builds social cohesion and promotes evolutionary fitness.
- Explain the scientific understanding of brain function behind the TV show “Lie to Me.” How is Dr. Cal Lightman (the main character) able to crack each case? How might you use some of these techniques in your life?

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

- amygdala – part of the brain involved in processing the memory of emotional reactions, notably fear and anger
- autonomic nervous system – part of the peripheral nervous system; regulates heart rate, breathing, perspiration; also called the involuntary nervous system
- brain stem – the part of the central nervous system connecting the brain to the spinal cord. It contains pathways sending information to and receiving information from the spinal cord and peripheral nerves.
- fronto-parietal cortex – region of the brain involving the frontal and parietal lobes, controls spatial attention
- homeostasis – self-regulating process by which a system remains stable by adjusting to changing conditions
- hypothalamus – part of the brain that processes appetite, thirst, hormone regulation, control of internal body functions, sexual functions, and diurnal rhythms; located below the thalamus
- limbic system – part of the brain that processes the sense of smell, long-term memory, and emotion; made up of several structures including the amygdala and hippocampus; also known as the "emotional system"
- mirror neurons – neurons that fire when an individual does an action or sees the same action done by another individual, thereby, "mirroring" the behavior
- prefrontal cortex (PFC) – the very most anterior (rostral) part of the cortex which controls planning and thought

Teacher Notes

- Some of these videos could be considered shocking. Please view them beforehand to ensure they are appropriate for your class.
- Does the room have technology (computers or hand-held devices) appropriate for multiple small groups to view the videos? If technology is limited, the videos can be projected to the front of the room as long as you position observers such that they cannot see or hear the video.

Materials

- Nova ScienceNOW video excerpt (4:35 in length) - "Mirror Neurons Engagement Video"
- Seven evoking videos:
  Video 1: happy ukulele boy - www.youtube.com/watch?v=ErMWX--UJZ4
  Video 2: happy baby laughing at mom - www.youtube.com/watch?v=-wIEihDAcpU
  Video 3: surprising basketball blooper - www.youtube.com/watch?v=kHz8-1UFaKQ
  Video 4: scary snake - http://www.youtube.com/watch?v=IogEiKhEJFo
  Video 5: disgusting beetle eating - www.youtube.com/watch?v=Uj9CysSSsps&NR=1
  Video 6: sad commercial - www.youtube.com/watch?v=dpf2hsZGsJM&feature=related
  Video 7: scary video - https://www.youtube.com/watch?v=l4SFiMrYpIM
- Technology to show "Mirror Neurons Engagement Video" and then evoking videos 1 thru 7.

One student-accessible computer or mobile device (mp3, iTouch, etc.) per 3-5 member student group with the appropriate media files on them.

A media projector and accessible computer loaded with these videos for viewing videos simultaneously as a whole class.

- Ear-phone attachments, so viewer hears video feed but others in the group cannot.

Engage

To begin the activity, show students pictures of faces (Facial Expression Pictures in the Attachment section on the lesson webpage) displaying the basic emotions. Ask students to identify the emotion and explain what clues led them to that conclusion. Restate student thoughts to begin to build a vocabulary for talking about emotions.

Discuss with students how they are able to recognize emotional responses and why these are important. Ask students to list all of the emotional states they can.

Narrow down the list to 4-8 primary emotions, each corresponding to a facial expression like the ones used by the scientist in the engagement video. Describe the facial expressions associated with each emotion. Be as detailed as possible in the descriptions, e.g. corners of mouth pulled down, eyes wide open, eyebrows raised, etc.

Explore

1. Assemble the class into groups of three. A two-student group will consist of only a viewer and a primary observer as explained below.
2. One student from each group will sit down so s/he can fully see the video. These students are the *viewers*. The other students will split into two groups: *primary observers* and *secondary observers*.
3. Primary observers watch the viewer from their group in such a way that they can fully see the viewer's face but not see the projection screen. These observers will document the changes in the viewer's facial expression and label what they see with one of the emotions listed during the **Engage** section above.
4. Secondary observers watch the primary observers in such a way that they can fully see the primary observers' faces but not the computer screen or the primary viewer's face. These observers will document the changes in the primary observer's facial expression and label what they see with one of the emotions listed during the **Engage** section.

Explore Results

After all the data are collected, direct the small groups to discuss their individual results. Then bring the class back together to discuss results as a group.

Discuss what the data shows.

1. Are there any patterns in the data of the emotions being expressed? Why would these occur? Why did emotions expressed by the primary observer mimic those expressed by the viewer even though the primary observer did not look at the screen? Why would such a behavior be beneficial?
2. Are there similarities in the emotions expressed in response to any one video? Can some of the listed emotions be combined into a single category?

Extension

1. Try this experiment with the primary viewers holding a pencil in their teeth. What happens to their ability to express emotions? Why do you think this happens?
2. Brainstorm with your group and briefly describe an experiment that could test this phenomenon more accurately. Make a list of things you need to consider before testing. Try to be as complete as possible. *Hint: How could you use a camera or a fun house mirror? How does your experiment test brain function?*

Explain

Show the "Mirror Neurons Engagement Video" (length 4:35) – an excerpt of the 14-minute long Nova ScienceNOW segment "Mirror Neurons."

The video could be shown to the group by using a media projector or, if conducting the lesson in a media lab, your students could watch the video at their workstations. Ask "How does this information change your interpretations of the data?"

Background Materials

Question 1. What are mirror neurons?

Mirror neurons form a circuit of neurons in the *fronto-parietal cortex* that become active both when one observes behaviors in others and when one performs that behavior oneself. In human brains, mirror neurons are thought to help explain many behaviors including learning language, imitating movement, and experiencing empathy. The ability to respond to others' intentions and emotional states may also be a function of the *mirror neuron system*.

The current understanding of mirror neurons is that when an individual perceives an emotion of another person, a small number of mirror neurons begin to fire that would be activated if that individual was actually experiencing the emotion. Thus one can perceive the experiences of others by watching them.

A great resource for understanding mirror neurons and how they relate to this experiment is the PBS **ScienceNOW** video which is designed for classroom viewing; the web site contains an explanatory essay. www.pbslearningmedia.org/resource/hew06.sci.life.reg.mirrorneurons/mirror-neurons/

Question 2. How does your brain recognize and interpret emotions?

All sensory information from one's sensory and internal organs enters the brain at different locations but is transmitted and processed for emotional content by two interlinked systems: the *limbic system* and the *prefrontal cortex*.

The key structure in the limbic system, the *amygdala*, first receives information from the body and the senses and then quickly processes it for emotional content. The outputs of the amygdala can trigger quick motor reactions in facial muscles to form the facial expressions we interpret as emotional responses. It can also trigger full body motor responses such as flight, fight, tend, or defend.

The outputs of the amygdala control the automatic bodily responses that are involved in emotions by affecting the homeostatic control center of the *hypothalamus*, which in turn controls the hormonal secretions and the sympathetic nerves of the body. The quick activation of the sympathetic nerves that innervate the internal organs gives a person the raw feelings like catching his/her breath when being surprised or his/her heart racing when fearful. All this happens without taking the additional time to engage the rational decision-making parts of the cortex first.

Information is also processed and interpreted in a longer route that ends in the prefrontal cortex. The prefrontal cortex is involved in the final phase of emotional processing. After the initial

automatic, emotional reaction, humans engage the rational observation- and decision-making area of the cortex to choose how best to react. Additional synapses and time are required for a person to cognitively recognize an emotion. Hence, saying "I feel sad" happens only after the introspection and examination of one's thoughts and feelings, such as tightness in the chest or "that sinking feeling."

Question 3. How do emotions control facial expressions?

The muscles of facial expression are controlled by a pair of nerves that originate in the *brain stem*. The neurons that control the facial muscles receive input from both the motor area of the cortex and the areas of the brain involved in emotional processing.

The emotional input from the limbic areas and *autonomic nervous system* are the cause of fast and involuntary facial movements in response to emotional stimuli. Cortical input produces voluntary facial movements generating the facial expression that we show to the world. Cortical input can also suppress involuntary expressions.

For an in-depth review of this system, please see emedicine.medscape.com/article/835286-overview

Question 4. How does what we learn in this experiment apply to real life? What is the relationship between social interactions and homeostasis?

Facial expressions are an important channel of nonverbal communication. While many animal species display facial expressions, they are particularly evident in primates and, especially, in humans. Facial expressions convey subtle emotional messages in person-to-person communication. Accurate interpretation of the message being communicated prevents unnecessary conflict, establishes social hierarchies, and facilitates bonding within a group.

Recognition of and appropriate response to these non-verbal expressions of emotion aid survival within the society. Emotionally directed communication and cooperation provide the feedback signals for homeostatic control of social organization. *Homeostasis* ensures continuation of the organism's life and perpetuation of the social group.

Correct recognition and response to non-verbal cues rely on mirror neurons. Mirror neurons may help us to understand a person's actions and to learn new skills by imitation. Some researchers speculate that disruptions in the mirror neuron system may underlie some cognitive disorders, particularly autism.