Watch XSAA Video: Exploring Our Minds

Lesson One: The Nervous System and Mindfulness
Description: *Investigate the relationships between the nervous system and other body systems and the connection between mindfulness and mood.*
Pages: 1-3

Lesson Two: Neuroscience and Mental Illness
Description: *Students explore brain signals, AI emotion decoding, mental illness, and neuroethics*.
Pages: 4-9

The Nervous System and Mindfulness

Companion Lesson to X-STEM All Access Episode "Exploring Our Minds"

Grade/ Grade Band: 6-12	**Topic:** Neuroscience	
Brief Lesson Description: Dr. Kaye Tye is a neuroscientist who researches social isolation in order to treat and prevent the negative consequences associated with it. In this lesson, students will examine the part of the brain that regulates emotions and memories before designing their own investigations on the limbic system and investigate the relationships between the nervous system and other body systems and the connection between mindfulness and mood.		
Performance Expectation(s): NGSS MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells		
Specific Learning Outcomes: 1. Describe the relationship between the nervous system and other body systems 2. Design and carry out an investigation		
Narrative / Background Information		
Prior Student Knowledge: Students should know and understand how the human body systems are structured and their functions .		
Science & Engineering Practices: **Planning and Carrying Out Investigations** Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. (MS-LS1-1)	**Disciplinary Core Ideas:** Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8)	**Crosscutting Concepts:** **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8)
Possible Preconceptions/Misconceptions: Students believe that the human body systems operate in isolation from each other, however the systems work together to keep you alive.		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions: In a think-pair-share: ask students if they have ever faked a smile, why they did it, and did they think the other person knew the smile was a fake one? Show this video and ask students to spot the fake smiles **(1 minute video)** . While completing the test, have students record their responses on a sheet of paper to assess their performance. Debrief the results by asking how many students correctly identified 10 or more smiles- use the method of hands up if you correctly identified 10 smiles, keep them up if you identified 11 correctly and repeat until the number drops to less than ¼ of students. Then have students discuss how they determined if a smile was genuine or fake?		
EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions: Students will watch **Exploring Our Minds- Neuroscientist Dr. Kay Tye** video focusing on what Dr. Tye does, how it benefits the world and the questions asked by students, particularly Andres' and Jennifer's questions**.** Students can record notes in their notebooks, on post-its, or use the back channeling tool in Google Classroom, the Stream feature that allows students to chat in real-time. After the video, students brainstorm a list of questions based on Dr. Tye's work and/or problems that could be solved using her research.		
EXPLAIN: Concepts Explained and Vocabulary Defined: Discuss the structures and functions of the limbic system and the structures within the brain that deal with emotions and memory. Begin with a quick review of the nervous system by asking students, in teams of 4, to create **chain notes**, beginning with one student responding to the question: "what is the purpose of the nervous system", and pass the note to the next student to add their response. This will help the teacher gauge students' prior knowledge and understanding of the nervous system. Have students do a value-added share before discussing the key points below; students may know more than anticipated.		

Key Points:

1. Nervous system is responsible for receiving and processing information from the external environment of an organism. Through the nervous system, the organism is enabled to respond to these external factors accordingly.
   The nervous system is composed of the following parts:
   a. Central Nervous System (CNS)- serves as the main processing center for the entire nervous system. It consists of two main components, namely the:
      i. Brain- This is an organ located within the skull that functions as organizer and distributor of information for the body. It has three main parts:
         1. Cerebrum- large, upper part of the brain that controls activity and thought.
         2. Cerebellum- the part under the cerebrum that controls posture, balance, and coordination.
         3. Brain Stem- the part that connects the brain to the spinal cord and controls automatic functions such as breathing, digestion, heart rate, and blood pressure.
      ii. Spinal Cord- This serves as a channel for signals between the brain and the rest of the body, and controls simple musculoskeletal reflexes without input from the brain.
   b. Peripheral Nervous System (PNS)- connects the central nervous system to the organs and limbs. It has two main divisions:
      i. Somatic Nervous System- This system is associated with the voluntary control of body movements
      ii. Autonomic Nervous System- This system is associated with the involuntary control of body movements

Dr. Kay's research on feeling and emotions looks at specific structures in the limbic system. Let's take a closer look at this system within the nervous system:

2. **The Limbic System- a collection of structures involved in processing emotion and memory located within the cerebrum. It consists of the following structures:**
   a. **Hippocampus-** This complex structure plays a major role in learning and memory and contributes to regulation of motivation and emotion
   b. **Amygdala-** This structure is responsible for formation and storage of memories associated with emotional events
   c. **Hypothalamus-** This structure has multiple functions including being responsible for certain metabolic processes in the autonomic nervous system (i.e. body temperature, heart rate, hunger, sleep) and it can regulate many bodily functions by synthesizing hormones
   d. **Thalamus-**This structure is a major hub for information traveling between the spinal cord and cerebrum It relays sensory signals to the cerebral cortex and motor signals to the spinal cord. It is also involved in the regulation of consciousness, sleep, and alertness

Lead a discussion asking students why they think the body uses the same structures to regulate both memory and emotions, how and why other systems (i.e. endocrine, cardiorespiratory, musculoskeletal) are connected to the system that processes emotions and memory, and why and how mental illnesses affects other parts of the body and not just the brain (i.e. anxiety causing stomach pains or heart palpitations).

Vocabulary: limbic system, hippocampus, amygdala, hypothalamus, thalamus

ELABORATE: Applications and Extensions: In 2020, a study from the University of South Australia confirmed that the act of smiling can trick your mind into happiness, simply by how you move your facial muscles. Neuroscientists have also shown that practicing mindfulness affects brain areas related to perception, body awareness, pain tolerance, emotion regulation, introspection, complex thinking, and sense of self. While you are not recreating the study, students are going to create mindfulness activities/brain breaks and test them to see if they can improve how their mood and their body feels.

Resources:
Mindfulness Can Literally Change Your Brain
10 Mindfulness Practices
25 Fun Mindfulness Activities for Children and Teens
Top Mindfulness Activities for Teens in 2022
Brain Breaks to Energize and Recharge

EVALUATE:
Formative Monitoring (Questioning / Discussion): As students are creating the chain notes about the nervous system, gather evidence of understanding by looking at their connections between the structures and their functions.

Summative Assessment (Quiz / Project / Report): Students write a Mindfulness Activity Guide which includes instructions for completing the activity and what they found as the benefits.

Elaborate Further / Reflect: Enrichment: Students read and write a book report about a book discussing anxiety. Possible book titles:

- Something to Say by Lisa Moore Ramee
- Ghost by Jason Reynolds
- the lonely heart of Maybelle Lane by Kate O'Shaughnessy
- Sara and the search for Normal by Wesley King

SOCIAL EMOTIONAL LEARNING ACTIVITY

SELF AWARENESS and RELATIONSHIP SKILLS

In the Exploring Our Minds episode with Dr. Tye (min 49:51), the student Jennifer asks, what does her research tell us about the impact of the social isolation during the recent pandemic on children's brains. While there aren't any long-term, longitudinal studies on the impact of pandemic isolation, Dr. Kay suggested there are ways to stay connected even virtually. We feel connected to others when they know or can relate to something about us. There are a ton of "Getting to Know You" activities that seem related to the beginning of the school year. Try this one, that you can use any time throughout the school year:

Would You Rather…

Choose an option from the emoji list below.

Make your choice and defend it!

Would you rather...

find a 🦄 unicorn or find a 🧞‍♂️ genie?

be a 💃 🕺 dancer or a 🎤🎶 singer?

be a famous 🎨 artist or a famous 📚 author?

eat 🍩 donuts or 🍉 watermelon?

ride a 🛴 scooter or ride a 🚲 bike?

Be sure students have the opportunity to defend their choices. Ask students to complete a Flip Grid for an added twist.

INTERDISCIPLINARY CONNECTIONS/IDEAS

As a part of Language Arts, students written report:

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1)

As a part of Mathematics, student designed investigations:

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables and relate these to the equation. (MS-LS1-1), (MS-LS1-2), (MS-LS1-3)

Materials Required for This Lesson/Activity	
Quantity	**Description**
per students	laptops

Lesson Created by Stacy Douglas
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Neuroscience and Mental Illness

Companion Lesson X-STEM All Access Episode "Exploring Our Minds" by Dr. Kaf Dzirasa

Grade Band: Middle School - High School	**Topic:** Neuroscience

Brief Lesson Description: Students explore brain signals, AI emotion decoding, mental illness, and neuroethics.

Performance Expectation(s):

MS LS1-3: Use arguments 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 long-term changes.

HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Specific Learning Outcomes:

Students will be able to:

- explore how the brain processes and interprets sensory signals.
- explore how neuroscience technology, artificial intelligence (AI), and machine learning help decode brain activity to better understand emotions and mental illness.
- investigate how treatments like transcranial magnetic stimulation (TMS), deep brain stimulation (DBS), and brain-machine interfaces (BMIs) are used to change electrical states in the brain to address mental health conditions.

Narrative / Background Information

For centuries, scientists have tried to understand the human brain—how we think, feel, and experience the world. But the brain is not like a computer—it doesn't just store and retrieve data. Instead, it interprets information, sometimes filling in gaps or making mistakes (as seen in optical illusions).

This lesson bridges neuroscience, mental health, and cutting-edge AI technology to explore how we read, interpret, and influence the brain's electrical signals. Students will:

- Experience how the brain interprets sensory information (and how it can be tricked).
- Explore how scientists use technology and AI to understand emotions and mental illness.
- Debate the ethical implications of AI-driven brain research.

This lesson assumes middle school students have the following understandings:

1. Human Body Systems & Nervous System Basics
    - The body is made up of interacting subsystems, including the nervous system.
    - Neurons are the cells that make up the brain and nervous system.
    - The brain processes sensory information from the eyes, ears, and skin.
    - The brain sends and receives electrical and chemical signals to control movement, thoughts, and emotions.
2. Energy & Waves (Basic Physics Connection)
    - Electrical signals move through wires (basic circuits) and can also move through the body (nerve signals).
    - Light and sound waves carry information to the brain, which interprets what we see and hear.
3. Introduction to Artificial Intelligence & Technology
    - AI is used to recognize patterns (e.g., facial recognition, voice assistants).
    - Scientists can record brain waves (EEG) and use computers to understand brain activity.

Scaffolding Strategy for MS:

Before the lesson, a short activity on body systems and nerves (e.g., using reaction time tests or simple neuron models) will help solidify concepts.

This lesson assumes high school students have the following understandings:

1. Neurobiology & Brain Function
    - The brain is divided into regions (frontal lobe, occipital lobe, temporal lobe, etc.), each responsible for different tasks (e.g., vision, movement, emotions).
    - Neurotransmitters (dopamine, serotonin) and their role in mental health.
    - Electrical signals travel via action potentials along neurons and synapses.
2. Electrical and Magnetic Fields (Physics Connection)
    - The brain's electrical activity can be measured with EEG (electroencephalography).
    - Magnetic fields can influence electrical signals in the brain (TMS - transcranial magnetic stimulation).
    - AI and machine learning use patterns in data to interpret brain activity.

3. Ethics & AI in Medicine
    - AI can be used to predict emotions, diagnose disorders, and even influence decision-making.
    - Brain-machine interfaces (BMIs) may help people with paralysis but also raise ethical concerns.
    - Privacy concerns: Should companies be allowed to "read" emotions from brain scans?

Scaffolding Strategy for HS:
A pre-lesson discussion on AI in everyday life (Siri, Google Assistant, recommendation algorithms) will help students see AI's relevance before applying it to neuroscience.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Engaging in Argument from Evidence Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3) **Obtaining, Evaluating and Communicating Information** Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias for each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS1-8) **Planning and Carrying Out Investigations** Plan and conduct an investigation individually or collaboratively to produce data to serve as the basis for evidence and in the design: decide on types, how much and accuracy of data needed to produce reliable measurements and consider limitations on the precision of data (e.g., number of trails, cost, risk, time) and refine the design accordingly. (HS-LS1-3)	**LS1.A: Structure and Function** In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3) **LS1.D: Information Processing** Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical) transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8)	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8) **Systems and System Models** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3) **Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system (HS-LS1-3) **Connections to Nature of Science** **Science Is a Human Endeavor** Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (MS-LS1-3)

Possible Preconceptions/Misconceptions:

1. **If something is in your brain, you can control it.** Reality: Much of brain activity happens *subconsciously*, meaning people don't have full control over thoughts, emotions, and even actions. This is why mental illness and neurological disorders exist.
2. **If AI can read emotions and thoughts from brain activity, it means we can reliably and accurately diagnose or treat mental illness.** Reality: AI can analyze patterns, but emotions and mental health conditions are complex. Brain scans alone do not diagnose mental illness—doctors need to consider many factors.
3. **Mental illness is just a weakness or personal failing**. This connotation occurs because the term refers to the intangible mind. The assumption is that if there's no visible, physical problem, then the issue must be contained within the person's personality or willpower. Reality: Mental illnesses are biological, psychological, and environmental in nature. They involve changes in brain chemistry and structure and are not simply about lacking strength of character.
4. **Mental illness can be cured if you just try hard enough.** Reality: While treatments (medication, therapy, brain stimulation) can help, there is no simple "cure." Deep Brain Stimulation (DBS) or Transcranial Magnetic Stimulation (TMS) may also help some people but these treatments come with risks and ethical concerns (e.g., personality changes, autonomy, and consent). Managing mental health is often a long-term and complex process.
5. **If AI predicts someone's emotions or mental health risk, we should trust it completely.** Reality: AI predictions are not perfect—they depend on incomplete data, and false positives/negatives can be harmful (e.g., mislabeling someone as "depressed" when they aren't).
6. **AI is neutral and always fair.** Reality: AI is trained on human-created data, which means it can inherit biases (e.g., racial, gender, or socioeconomic bias in mental health diagnosis).

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Purpose: Capture students' curiosity by showing how the brain interprets information—and how sometimes it gets things wrong.

Objective:

- Demonstrate that the brain does not always interpret sensory information correctly.
- Show that AI and technology can "read" and even influence how we think.

Optical Illusion Activity

1. Show students the *Edward Adelson Checkerboard* optical illusion, either digitally or on paper, and ask:
    - What do you notice about the two labeled squares? (A & B)
    - Would you believe that they are the same color? (show the 2nd page, the illusion revealed, only after they have had time to explore the illusion)
    - ***Why do you think our brains sometimes "fill in" missing information?***
    - ***If our brain can be tricked by illusions, how do we really know what's real?***
2. Explain how the brain interprets visual signals, sometimes filling in missing information or making incorrect assumptions based on patterns.
    - Video to explain: Brain Tricks - This Is How Your Brain Works
3. **Key takeaways**: The brain doesn't just record what we see—it interprets information. The brain works with electrical signals, but it's not perfect—it can be tricked or influenced.

Connection to Mental Health & AI

1. Transition the conversation to how the brain interprets emotions and mental states—and how scientists use AI and machine learning to decode those interpretations.
2. Discussion Questions:
   What if we could use computers to 'read' what someone is feeling just by looking at their brain activity?
   What if a computer could predict your thoughts before you say them?
   What if technology [like AI, transcranial magnetic stimulation (TMS), deep brain stimulation (DBS), and brain-machine interfaces (BMIs) etc.] could help people with depression, PTSD, or paralysis by analyzing and altering their brain's electrical activity?

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Purpose: Investigate how the brain functions and how AI and machine learning can be used to decode emotions and illuminate mental illness from brain activity, and how treatments like TMS and DBS alter electrical states in the brain.

How the Brain Interprets Signals

1. Mini-Lecture with Brain Model or Diagram:
    - Explain how the brain receives signals from sensory organs (vision, hearing, touch) and processes them in different regions (e.g., the occipital lobe for vision, temporal lobe for sound).
    - Introduce neural pathways and how electrical and chemical signals are transmitted between neurons.
2. Hands-On Neural Signal Simulation:
    a. Have students act as neurons, passing a "signal" (e.g., a handful of cotton balls or other small soft objects) to show how the brain communicates. Neurons communicate using two types of signals: electrical and chemical signals.
        - Place several small balls (representing neurotransmitters) in the axon terminals of each "neuron."
        - Tap the first "neuron" to activate the signal, explaining that this represents sensory input, like seeing a falling vase.
        - The first neuron "fires" an action potential (students can act this out with a movement, like wiggling their arms like they are doing the wave).
        - The axon terminals (left hand) release neurotransmitter balls into the synapse, and the next neuron's dendrites collect them.
        - Receiving a Signal: Dendrites (right hand) receive a chemical signal from another neuron.
        - Triggering an Action Potential: If the chemical signal is strong enough, it changes the neuron's electrical state. If it reaches a certain threshold (enough neurotransmitter balls accumulate in the right hand of the neuron), an electrical signal (action potential) is triggered.
        - Sending the Signal: The action potential travels down the axon to the axon terminal.
        - Passing the Message: The axon terminal releases neurotransmitters (chemical messengers) across the synapse (the gap between neurons).
        - Continuing the Chain: If enough neurotransmitters are received by the next neuron, the process repeats, allowing signals to travel through the nervous system.
        - Action potentials follow an "all or nothing" rule. If the signal is strong enough to reach the threshold, a full action potential occurs and travels down the axon. There are no weak or strong action potentials—it's always a complete response or nothing at all. This helps prevent information loss during neuron communication.

b. Demonstrate how signals can slow down or misfire in conditions like depression, PTSD, or schizophrenia. (Many psychiatric disorders have been related to disturbances in synaptogenesis and subsequent plasticity.)

Teacher notes: *Neurotransmitters do not travel in the neuron. When enough neurotransmitters are attached to receptors and the necessary activation threshold is reached in the neuron, an electrical signal called an action potential is sent down the axon until it reaches the axon terminal, causing the release of neurotransmitters. Dendrites do not absorb neurotransmitters. These attach to receptors and then drop off, with some of them later on being recycled back into the neuron's action terminals.*

AI & Emotional Decoding

1. Students explore how scientists use EEG and fMRI data to train AI to recognize emotions based on brain activity. Example: AI can detect fear, happiness, or stress by analyzing brain wave patterns.
    - Possible videos to illustrate the points: EEG, The computer is learning to read your mind (note: this video is at least 6 years old and therefore advances have been made, however, it is a good representation of the challenges when using technology)
    - Interactive Simulation (if available): Students try an EEG-based brainwave game or use an online tool that demonstrates AI-driven emotional recognition.

Brain-Machine Interfaces & Mental Health Treatments

1. Introduce brain-computer interfaces (BCI) and discuss their potential applications for people with paralysis, depression, or anxiety.
    a. Video *Mind-reading computers turn brain activity into speech*
2. Introduce Transcranial Magnetic Stimulation (TMS) and Deep Brain Stimulation (DBS) as ways to treat mental illnesses by altering electrical activity in the brain.
3. Show a video explaining how TMS helps people with depression by stimulating specific brain regions.
4. Have students discuss how these treatments differ from traditional medication-based treatments.

Discussion Questions:

How does AI help scientists analyze brain activity?
How do brain-machine interfaces work, and what are their potential uses?
How can changing the brain's electrical state impact mental health?

EXPLAIN:

Purpose: Help students make connections between brain activity, mental health, and the role of AI and technology in neuroscience.

1. Introduction to the Video: Begin by informing students that they'll watch a video titled "Exploring Our Minds," which explores how artificial intelligence can interpret human thoughts and emotions by analyzing brain signals.
2. Guided Viewing: Provide students with a set of focus questions to consider while watching the video. These questions could include:
    a. What technologies are used to capture brain activity?
    b. How does AI process the data from these technologies to interpret emotions?
    c. What are the potential applications and ethical considerations of this technology?
3. Post-Viewing Discussion: After the video, engage the students in a discussion based on the focus questions. Encourage them to share their thoughts and insights, fostering a deeper understanding of the content.
4. Clarification of Concepts: Address any misconceptions or questions that arise during the discussion. Emphasize key points such as:
    a. The role of EEG and fMRI in detecting electrical and blood flow changes in the brain.
    b. How AI algorithms analyze patterns in brain activity to correlate with specific emotions.
    c. The importance of ethical considerations, including privacy and consent, in the use of such technologies.
5. Connecting to Prior Knowledge: Relate the video's content to previous lessons or activities, such as the Hands-On Neural Signal Simulation, to reinforce learning and demonstrate real-world applications.

ELABORATE: Applications and Extensions:

Purpose: Apply knowledge by designing AI-based mental health tools and debating ethical concerns.

Design a Mental Health AI Assistant

1. In groups, students design an AI system that can help people track their mental health based on brain activity.
2. They must include:
    - How it detects emotional changes
    - How it provides recommendations or interventions
    - How they would protect user privacy
3. Groups present their designs to the class.

Debate: Should We Use AI to Read and Change the Brain?

1. Divide students into groups arguing for and against the use of AI, BMIs, and electrical treatments in psychiatry.
    a. Key points to consider:
        - Potential benefits (better treatment, improved quality of life)
        - Risks (privacy invasion, ethical concerns)
2. Students present their arguments, and the class votes on whether AI in mental health should have limits.

EVALUATE:

Formative Monitoring (Questioning / Discussion):
Questions in bold, italics can be used to check student understanding throughout the lesson. Additionally, student presentations in the explore section and case study handouts in the elaborate section can be used to monitor student progress.

Summative Assessment (Quiz / Project / Report):
Score the Mental Health AI Assistant project using this rubric

Reflect using these two questions:
What is one technology you learned about today that could change mental health treatment?
Would you use a brain-machine interface if it could improve your quality of life? Why or why not?

Elaborate Further / Reflect: Enrichment:
Activity adapted from the Center for Sensorimotor Neural Engineering's Introduction to Neural Engineering & Ethical Implications-A Curriculum Unit for Grades 6-12 STEM Classes
Purpose: What happened in the past that will help students understand how the current innovations in neural engineering came to be.
Activity: Exploring the History of Neural Engineering: Students will create a timeline of events related to neural engineering from the topics of research/ethics, anatomy and physiology, prosthetics, and technology.

1. Create a timeline on the board/wall
2. Make copies of the Timeline Cards. The cards should be printed double-sided on cardstock using a different color for each topic. A full set of cards is enough for about 16 students in groups of 4.
3. Each group receives cards from one category: Ethics of Research, Anatomy & Physiology, Prosthetics, or Technology. Each card describes a historical event with a date on one side and no date on the other. Do not look at the date side!
4. Shuffle the cards and deal them evenly. Players do not look at or flip their cards.
5. If there is an uneven number of cards, place extra card(s) date side up in the middle. Otherwise, each player adds one card date side up to start the timeline.
6. How to Play:
    a. Arrange the cards in the middle from oldest (left) to newest (right).
    b. The first player places their top card where they think it fits in the timeline.
    c. Flip the card to check:
    d. If correct, leave it date side up.
    e. If incorrect, move it to the right spot and earn one point.
    f. Play continues clockwise until all cards are placed.

Discussion questions:
Based on the timeline activity, how have advancements in neural engineering improved our ability to restore or enhance movement and sensation?
What challenges do scientists still need to overcome in developing future neuroprosthetic technologies?
As neuroprosthetics become more advanced, what ethical concerns should we consider? For example, who should have access to these technologies, and how might they impact personal identity or human enhancement beyond medical necessity?

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency Addressed: Self-Awareness, Social Awareness, and Responsible Decision Making
Purpose:

1. **Ethical Dilemmas in Neuroprosthetics**
    a. Scenario Discussion: Present a real or hypothetical case where a neuroprosthetic device enhances human capabilities beyond normal function (e.g., brain implants for faster learning, robotic limbs stronger than human arms).
    b. Think-Pair-Share- Ask students:
        - Should these technologies be available to everyone or only those with medical needs?
        - How might these advancements create social or economic inequalities?
2. **Empathy Walk Activity**
    a. Assign students different roles (e.g., a person with a disability, a scientist, a policymaker, an athlete considering enhancement).
    b. Each student reflects on how they might feel about neuroprosthetics from their assigned perspective.
    c. Facilitate a class discussion on how different viewpoints shape ethical decisions.
3. **Personal Reflection Journal**
    a. Students write a short reflection on:
        - If I had access to a neuroprosthetic device, how would I use it?
        - How do I define "fairness" when it comes to who gets access to advanced technology?

Materials Required for This Lesson/Activity	
Quantity	**Description**
1 per class	Computer with Projector and Internet Access
1 per group	Computer with Internet Access for Research
1 per student	Copies of rubrics as found in the Evaluate section
1 per pair	Color copies of the Edward Adelson Checkerboard Illusion and illusion revealed (on cardstock if available)
20 pieces	Small soft objects for use in the Hands-On Neural Signal Simulation
***optional** for elaborate further section: 1 set of 20 timeline cards per group (2-4 players)	1 set of 20 timeline cards color coded to the categories: Ethics of Research, Anatomy & Physiology, Prosthetics, or Technology.

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