My Love Affair with the Brain:
The Life and Science of Dr. Marian Diamond

Possibilities for the Classroom and Beyond

A Discussion and Study Guide
developed by Susan Johnson for Luna Productions

Overview

My Love Affair with the Brain: The Life and Science of Dr. Marian Diamond can provide educators and leaders with engaging, thought-provoking, brain enriching ways to learn about the processes of science, brain function and plasticity, a passion for teaching, and what it is like to have a life in science, especially a woman in science confronting gender bias. This collection of discussion questions, tasks, and extend lessons is designed to provide educators and leaders with paths for extending the knowledge and passion of My Love Affair with the Brain into their personal lives and the lives of their students and colleagues.

Organization of the Modules

With time being a major constraint for the classroom, the collection is organized into modules to give teachers several viewing options.

- Module 1 contains discussion questions and tasks that can be competed in traditional class period. The film is divided into chapters, allowing the educator to select a portion of the film for viewing. An educator may choose to focus on one theme/one film chapter or several themes as time allows.
- Module 2 provides more extended lessons that require several class periods, designed for teaching of several literacy and/or science standards.

All discussion questions and tasks are built around four major themes:

1. **Science**: Science as a process, as a mechanism for change, as a method of understanding the world around us
2. **Brain function: Plasticity**: Brain plasticity and its effect on science, healthcare, and our own self-care
3. **Education – how we learn**: Dr. Diamonds passion for teaching reveals much about learning, both pedagogical techniques and scientific understandings (enriched environments)
4. **Women in science and Gender Bias**: Dr Diamond as a role model for anyone for a life in science, but especially for women and girls, what it takes to succeed in the face of gender and/or racial bias.

The discussion section is organized into:

- **Engaging questions**: allow you to assess the prior knowledge of the students and prepare them for watching the film.

- **Reflection questions** are guides for leading discussions after the watching the film. They may be used for whole or small group discussions, as writing prompts, for student journal reflections, or to extended into student research projects.
- **Tasks** are designed to extend student thinking on the given theme.

The tasks are written as writing prompts, but you may choose other ways to assign them, such as any of these possibilities of other task-assignments for students:
(see also Appendix A as an example of a more detailed lesson plan using one of these: Gallery Walk of discussion questions)

- Poster
- PowerPoint presentation
- Brochure
- One-act play
- YouTube video
- Podcast
- Artwork
- Infographic
- Handbook
- Board game
- Children's book
- Rap/song/poem
- Newspaper article
- Comic series
- Multigenre writing project
- Blog
- Debate
- Oral report
- Photo essay
- Satirical project
- Metaphor maps and student anthologies
- Write a letter
- Diary entry
- Make a model
- Gallery walk of discussion questions
- Socratic circles
- "Silent" discussions- students respond to question on chart paper, then respond to each other before returning to vocal whole group discussion

Module 1: Grade 5-12, Single lesson Discussion Questions and Tasks

Module 1 is designed for short lessons to fit within a larger curricular unit or for the educator who wants to focus on specific themes in the film.

Engaging questions are designed, not to illicit full, complete responses, but to assess the students' prior knowledge of the topic and allow you to identify any misconceptions the students may have.

The reflection questions are to help guide your class discussions after viewing the film. Another option would be to provide the students with certain questions before the film so they can record the answers as they watch the film. This may require you to pause the film from time-to-time to allow students to write responses.

Below is a sample of a lesson that might be developed from this section. It uses the BSCS 5E instructional model: Engage, Explore, Explain, Extend, and Evaluate. (This is

a model based on constructivist theory of how people learn. More information regarding the 5E instructional model is in Appendix F)

Learning Sequence Concept:	Environmental factors influence the growth of organisms (MS.LS1-5)		
5E Phase	**Teacher Does**	**Student Does**	**Concept**
Engage	Ask whole group: can your brain be healthy? Unhealthy? Listen and discuss with students. Ask whole group: What be done if you damage your brain? Listen and discuss with students. Tell the students they are going to watch a documentary and you want them to think about the discussion as they watch.	Discuss Discuss	Prior knowledge
Explore	Show chapter one: "How She Changed Science." Ask the students to record information they think is important and relates to discussion. (Pause film as needed.)	Watch film and record important details.	Building content
Explain	After film: engage students in whole class discussion, allowing students to share thoughts and ask questions. Use reflection questions from "How She Changed Science" theme 2: Brain Plasticity to guide the discussion	Discuss film Respond to questions with information from the film	Building content

Extend	Assign task: How She Changed the Brain, Theme 2. Select a submission format that allows the students to best demonstrate understanding of standard and/or practice selected skills/.	3 Options • Write an explanatory paper describing the 5 factors needed for brain health and what each factor means. • Working in 5 groups, each creates a poster/chart for one of the 5 factors for brain health. Include words and art to explain how they help the brain. • Working in cooperative groups, create a plan to improve your brain health (include enrichment, brain plasticity and the 5 factors). Share plan with class when complete.	Applying knowledge
Evaluate	Evaluation occurs throughout the lesson - listen for prior knowledge and misconceptions during all discussions -evaluate task assignment- in terms of clear understanding of brain plasticity and the 5 factors of brain health	Completes and submits task	Assessment
Performance Expectations	Students can explain brain plasticity and understand environmental factors can have positive and negative effects on the brain		

Safety considerations	none

Standards

By combining themes and assignment types, the lessons can address numerous standards in core subjects (science, English language arts, and history), but also psychology, gender studies, fine arts, health, and career education classes. Examples of core subject standards are below.

Science standards:

- Content standards related to cell and organ function, interacting subsystems, the effect of the environment on growth of organisms.
- Science Practices: creating explanations, arguing from evidence, gathering and analyzing data, communicating results, etc.
- Science literacy standards: determining key words and central ideas, describing procedures, defining the question, comparing findings from other sources, etc.

English language arts:

- Informational texts: determining meanings of words, summarizing, drawing inferences, figurative language, etc.
- Writing: explanatory and argumentative writing
- Speaking, listening, and language standards through group assignments, presentations, and writing assignments.

Math:

- Math practices: the integration of math and science
- Statistics and applied math in science

History/social studies:

- Common Core literacy standards for history
- The role of science and technology in cultures
- The struggle for racial and gender equality
- The role of science in shaping governmental policy

CHAPTER BY CHAPTER
Discussion Questions and Tasks

Chapter 1: How She Changed Science (First 19.5 minutes of film)

Content summary: We meet Dr. Diamond and her trademark brain-in-a-hat box. She summarizes 5 essential things for a better brain. The first of her paradigm shattering scientific advances is carefully described: her ground-breaking 1964 research revealing plasticity in the brains of rats, the first hard evidence of plasticity/anatomical changes in the brain because of non-genetic factors, such as enriched and non-enriched

environments. At first controversial, plasticity is now widely accepted, and its meaning for each of our brains (such as, “use it or lose it’’) is explored.

How She Changed Science

Theme 1: Science

Engaging Questions	Reflection Questions Grades 5-8
How does science “work”?	Describe the experiment. What did it show?
Why does science work?	Define control group.
How does science improve our lives?	How did Dr. Diamond’ research change science?
Does science improve society? How?	
	Reflection Questions Grades 9-12
	As Dr. Diamond presented her work, another scientist shouted, “Young Lady, the brain does not change!” Dr. Diamond responded, “But we had an initial experiment and a duplication experiment that showed that it could.” This is an example of reproducibility, one of the main tools of scientific research. ✓ What is reproducibility ✓ How does it increase our confidence in our data? ✓ Why do science “facts” change? Is science research ever wrong?
	 The pictures above illustrate the steps Dr. Diamond used to take measurements of the brain. First the mouse brains were frozen. A surgical instrument precisely cut the brain into layers thin enough to see through. The brain slices were put on microscope slides. With the slides

	under the microscope, a camera was used to take pictures of the brain slices. The pictures were enlarged for Dr. Diamond to identify the cells, write on them (second picture), and take measurements. (bottom picture). This is a slow, tedious process for collecting data, which explains why the research took 2 years. How has brain research changed?

Tasks

- Dr. Diamond's brain enrichment research was simple, but profound. It resulted in a new foundational understanding of the brain at the very moment neuroscience began as recognized field of study: Using information from the film, support the claim that Dr. Diamond changed our scientific understanding of the brain by using proven scientific research methods.
- Methods for examining the brain have greatly improved since the 1960's when Dr. Diamond her work. Research how technology has improved brain imaging, including EEG, PET, MRI, and fMRI. How have these methods expanded what science knows about brain plasticity?
- Eyewire is a game that uses crowdsourcing to help map the brain. Anyone can play and no science background is needed. It's as simple as an online coloring book. https://eyewire.org/

How She Changed Science
Theme 2: Brain Plasticity

Engaging Questions	Reflection Questions Grades 5-8
Can our brains be healthy or unhealthy? What would unhealthy mean?	What is meant by brain plasticity?
What can you do if you damage your brain?	What is enrichment?
What do you think your brain is?	What are the 5 things my brain needs, based on Dr. Diamond's research?
How do we grow our brains?	What is meant by diet? Exercise? Challenge? Newness? Love?
How do we change them?	How can I use Dr. Diamond's research to make my brain better?
	Are these the only ways to improve your brain? (No)
Have you ever thought, "I'm sorry teacher, my brain is full." What did that feel like? What might be happening to you?	What are some environmental factors that harm the brain?

	Dr. Diamond discusses “Your own personal masterpiece, your mature brain.” What does the mean? What does it mean to you personally?
	Why use a word like “masterpiece” to describe your brain”?
	Reflection Questions 9-12
	Dr Diamond had a new idea that shattered the old one. “It was a controversial scientific battle ground, and it was bitterly fought.” What was the new idea? What was the old one?
	There’s an old saying that “you can’t teach an old dog new tricks.” What does this mean? Would Dr. Diamond agree or disagree?
	Dr. Arnie Schiebel once defined the brain as “the organ of experience.” What did he mean by that? Make a list of other words that also work to define the brain, “the organ of ____”

Task

- Dr. Diamond conducted science research that changed how science thought of the brain. Before, the brain was thought to be genetically set and it couldn’t be changed. She proved this was not true. There are environmental factors that the brain requires to be healthy. Based on information from the film, construct an explanation stating that each person can maintain and improve one’s brain health.

How She Changed Science

Theme 3: Learning

Engaging Questions	Reflection Questions Grades 5-8
How does the brain learn?	How can we change our own brains?
Can I improve how I learn?	What environmental factors hurt my brain? How do I protect my brain from those factors?
Can I learn more than I think I can?	Can I make enriching my brain an active part of my daily live?
	Reflection Questions 9-12
	Can I continue to enrich my brain as I get older?

Tasks

- Building on Dr. Diamond's ground-breaking research, more recent research has found additional environmental factors can help the brain (positive effects) and harm the brain (negative effects) Using the film and additional research (as needed) develop a plan or model for maintaining/improving your brain health. (Include positive and negative factors) Develop a way to share your plan for brain health with others.
- In 2011, Flint, Michigan changed water sources in what is now called the Flint Water Crisis. The new water source corroded the water pipes and large amounts of lead were released into the city's drinking water. Ingesting lead, especially for children, causes damage to the brain, including learning difficulties, seizures, and delays in development. All of Flint's 6,000 children were affected to varying degrees. Based on what you have learned about enriched environments, what are some steps the teachers in Flint can take to help the students' brains? Using evidence from the film and our class discussions, develop an explanation for the need of an enriched environment and how the concept of brain plasticity to help the students.

How She Changed Science

Theme 4: Women in Science and Gender Bias

Engaging Questions Grades 9-12	Reflection Questions Grades 9-12
Where does science stand on racism?	What is meant be genetic determinism?
Is there any science that supports the supremacy of any race?	How could her research speak to racism?
	As Dr. Diamond presented her research at a crowded meeting another scientist shouted at Dr Diamond, "Young Lady, the brain does not change!" Yelling at a presenter during a presentation isn't proper etiquette, meaning it's very rude. ✓ Why do you think the scientist did this? ✓ Do you think he would have yelled at a male presenter? Why or why not?
	What does "use it or lose it:" mean to Dr. Diamond? What does it mean regarding your brain?

Task

- At the turn of the 20th century, science was used to promote genetic determinism, the concept that races were genetically different and certain races were superior to other races. Jim Crow laws were enforced until 1965. Dr. Diamond's research

on brain plasticity challenged the belief that brains were genetically set and couldn't be changed. Using evidence from the film and information from class to construct an explanation for how science does not support genetic determinism.

CHAPTER 2: Teacher to the World **(19:30 – 26:45)**

Content summary: We see why Dr. Diamond is a "science rock star." Her inspirational anatomy lectures both challenge and engage students using verbal, auditory, kinesthetic, and social teaching methods, bringing a difficult and dry subject matter to life.

Teacher to the World
Theme 3: Learning

Engaging Questions	Reflection Questions Grades 5-8
How can I develop a passion for learning?	Dr. Diamond said, "When you see a lady with a hatbox, you don't know what she is carrying do you?" She carried a human brain in a hat box. What do you think about this? Is this too gross? Is this a good way to teach? Why or why not?
What makes someone a "good" teacher?	Dr. Diamond had her students open and close their hand 72 times in a minute to simulate the beating of a human heart. Since people can live to be over 100 years old, that means your heart beats none stop for a long time! What do you think about this? What are some other amazing things your body does? Is this a good way to teach? Why or why not?
	Reflection Questions Grades 9-12
	She uses the anatomical term "cardiac muscle." What is that? What are other muscles? Is there a difference between saying "heart" or saying "cardiac muscle?
	What did you learn about your own body from this film? Cite specific examples from the film.
	Have you ever had a teacher that just made every seem easy or fun? What did that teacher do to make you feel that way? How were they different from other teachers? If you haven't had a teacher like that, what do you wish teachers would do? What would need to happen

	for you to enjoy a class?
	Dr. Diamond loved the brain and studying anatomy for, almost, her entire life. What are some topics that interest you? Is there any topic/subject that you feel could hold your attention for a lifetime?
	During the filming, Dr. Diamond's lectures had 1.7 million hits on YouTube. A year later, in 2018, that grew was 4.5 million views, around the world. Does that popularity make sense to you? Why would a human anatomy class be popular around the world?
	Dr. Diamond tells a story about 2nd graders being willing to answer aloud in class, but college students in class not willing to do the same. Why do you think 2nd graders answer questions? Why are college students reluctant? When do you feel comfortable responding in class?
	PowerPoint lectures vs. a teacher writing on chalkboard the old-fashioned way. What does Dr Diamond prefer and why? What are the advantages or disadvantages to each?

Tasks

- Repeat Dr. Diamond exercise with her students and have your students stand up, open and close their hand 72 times while counting it out loud as a simulation of the beating of a human heart in a single minute. Since people can live to be over 100 years old, that means your heart beats none stop for a long time! What do you think about this? What are some other amazing things your body does? Select an organ, organ system, or human process to research and present the information to the class. What makes your selection amazing?
- Dr. Wendy Suzuki said, "I saw, I saw a science rock star!" What is a "science rock star?" Using evidence from the film, develop a definition and explanation of what a science rock star is and how one might earn that title.
- Dr. Diamond spent years teaching anatomy to packed, theater-sized classrooms. Even though her method appears to be "standard lecture," her students are focused and engaged in the learning. Using evidence from the film, support the claim that "lecture" can be engaging if done correctly.
- Dr. Diamond said, "..I've been teaching here for many decades because I love to awaken students to anatomy." Using evidence from the film and your own

experiences (if applicable), support the claim that a teacher's passion for her subject can positively effect learning.

CHAPTER 3: The Woman with Einstein's Brain **(25:45 – 33:10)**

Content summary: Dr. Diamond has the clever idea of studying the greatest brain of all time. Her research measuring the glial cells in the brain of Albert Einstein reveals evidence in support of yet another controversial new understanding of how the brain functions.

The Woman with Einstein's Brain

Theme 1: Science

Engaging Questions	Reflection Questions Grades 5-8
What makes an experiment reliable, something that can be trusted?	What was the hypothesis for her investigation?
	What were her findings?
	Why was Dr. Diamond criticized for her study of Einstein's brain?
	Reflection Questions Grades 9-12
	Dr. Diamond said, "In science if you want to get answers that matter, you have to find your way to the right question. It's not easy… to find a question so powerful that the answer makes a difference." ✓ What was the "right question?" ✓ What was the hypothesis for her investigation? ✓ What were her findings? ✓ In statistics, N is used to represent sample size. In this research, N=1. What does this mean? What is wrong with N=1? ✓ Dr. Diamond said the finding were "significant." What does that mean? ✓ How did the findings influence science? ✓ If you could do research on someone's brain, who would you choose? Why? What do you think you would learn?

	✓ What is the power of a question in science?

Task

- Dr. Diamond's research on Albert Einstein's brain drew criticism from other neuroscientists. According to the film,

> *Some criticized the quality of the 11 younger average human brains used for the comparative study. Others objected because apparently Einstein never gave permission to have his own brain preserved and studied. But mainly the criticism was for making any suggestion about the function of the glial cell based on Einstein's brain alone.*

  Based on what we have learned about proper investigative research procedures and protocols, develop an argument that supports the claim that the critics were correct in their criticism.
- Students investigate the role of ethics in science, science research or, more specifically, the role of ethics when working with animals and/or humans. What are the rules and who writes them? Write a set of ethical rules for your class to follow.

The Woman with Einstein's Brain
Theme 2: Brain Plasticity

Engaging Questions	Reflection Questions Grades 5-8
Who is Albert Einstein? Do you think his brain might be different from yours?	Was Einstein's brain different? How was it different?
Is everyone's brain the same? Different? If different, how would they be different?	What are glial cells? What did science think their function was in the past?
	What do scientists think glia cells do now?
	If you could do research on someone's brain, who would you choose? Why? What do you think you would learn?
	Reflection Questions grades 9-12
	What is the difference between neurons and glial cells?
	How does the research on Einstein brains support Dr. Diamond's research on brain plasticity?

Task

- Dr. Diamond's early research showed that rats in enriched environments experienced an increase in the number of connections between neurons and glial cells, and an increase in the number of glial cells. Her examination of Einstein's

brain showed a similar increase in the number of glial cells Select one of the options below to research. Research may be submitted as a written report, poster, PowerPoint presentation, brochure, one-act play, YouTube video, podcast, series of art work, infographic, handbook, board game, children's book, rap/song/poem, newspaper article, comic series, or other teacher suggestion.

- ✓ Research the life of Einstein focusing on how he provided his brain with an enriched environment.
- ✓ Research current science findings on brain plasticity and enriched environments.
- ✓ Develop a plan or model for ways to enrich your own brain.

The Woman with Einstein's Brain

Theme 4: Women in Science and Gender Bias

Engaging Questions	Reflection Questions Grades 5-8
What is gender bias? Why do some people not listen to woman?	Dr. Diamond states that her research on Einstein's brain "caused a stir all over the world in the first place that it was a woman that it." What does it mean to cause a stir? Why would a woman researching Einstein's brain cause a stir?
Who are some women that have changed science?	
	Reflection Questions Grades 9-12
	What are some examples of gender bias presented in the film?
	Dr. Diamond doesn't talk about gender bias on film, even though she experienced it. Why do you think she didn't speak of it? Was she right not to or do you think she should have spoken out about it?
	A colleague of Dr. Diamond referred to her research on Einstein's brain as "tawdry." A quick google search of "tawdry" provides the definition as "(of finery, trappings, etc.) gaudy; showy and cheap. low or **mean**; base: **tawdry** motives." A google search for use of tawdry in a sentence provided, "We get a wonderfully balanced birdseye view of the **tawdry**, neon world of Vegas." ✓ Why do you think other scientists chose the word "tawdry" to describe Dr. Diamond's work on

	Einstein's brain? ✓ Do you feel that word have been used to describe the work of men? What unfavorable words might have been used to describe men's work? ✓ What was Dr. Diamond's response to gender bias?

Task

- Dr. Diamond doesn't speak about gender bias in the film, but she certainly experienced it. Investigate the accomplishments of other women scientists and how they prevailed or didn't prevail over gender bias.

CHAPTER 4: This is Your Brain on Love **(33:11 – 43:50)**

Content summary: Using love (in this case, stroking, cleaning, and caring for her lab animals) Dr. Diamond prolonged the lives of her experimental animal populations, allowing her research to demonstrate that plasticity in the brain is a life-long. This is yet another paradigm shattering insight, changing how we understand the brain with profound implications for each of us and our own brains. She teaches brain anatomy to a 4-year-old little girl and after; reflects on the gender discrimination she faced in science.

This is Your Brain on Love

Theme 1: Science

Engaging Questions	Reflection Questions Grades 5-12
Do scientists study love? Why or Why not?	Why was it unusual for Dr. Diamond to conduct research on love?
	The film states, "*Marian began her research on love -as a methodological solution to a very real scientific challenge."* What is methodology? What is a methodological solution? What was the real scientific problem she faced?"

Task

- Dr. Diamond said she provided her rats with love. What did she actual do to demonstrate love to the rats? Is it fair to call this love? Research current research on love and longevity and/or love and the brain. Does the current research continue to support Dr. Diamond's findings?

This is Your Brain on Love

Theme 2: Brain Plasticity

Engaging Questions	Reflection Questions g Grades 5-12
Does love affect the brain in any measurable way?	What was the effect of “loving” mice in Dr. Drummond’s experiment?
What is the effect of love on an aging brain?	How did they show “love” to the rats?
	Dr Diamond’s research confirms that the brain remains plastic for our entire lives. What are some of the real differences between old and young brains?
	“Use it or lose it” says Dr. Diamond. What does this mean in light of the research confirming life-long plasticity?

Task

- The film informs us that Dr. Diamond passionately believes that “love” is needed for brain health, and she has the data to support her belief! Use evidence from the film to support the claim that love has a positive effect on brain health.

This is Your Brain on Love

Theme 3: Learning

Engaging Questions	Reflection Questions Grades 5-8
What is a biography? What do we learn from biographies?	Dr. Schiebel says that his students are more interested in his relationship with Dr. Diamond than in her science. He says “Never underestimate the personal, the emotional, the limbic.” What is the limbic system? What does he mean?
	Reflection Questions Grades 9-12
	In this chapter, we meet Dr. Diamond’s husband, Dr. Arnie Schiebel. Earlier in the film he spoke as an expert in neuroscience and the importance of Dr. Diamond’s work. Do you think he gave an honest and fair opinion of her work? Can we trust what he says about his wife? Can we trust the film that surprises us with this information?
	This film is biographical, science documentary about Dr. Marian Diamond, her research, and how her research

	changed science. What do you think about a science documentary that takes time to tell a love story about the main character? Is this appropriate or in appropriate for a science film? Why or why not? Does it help us better understand Dr. Diamond or does it waste our time?
	Dr. Prasad is the father of the 4-year-old girl getting a personal lesson in brain anatomy from Dr. Diamond. Dr. Diamond was Dr. Prasad's favorite teacher and he wanted his daughter to learn from her. Have you ever had a favorite teacher? What made him/her your favorite?

Task

- Dr. Che Prasad is the father of the 4-year-old who we see getting a personal lesson in brain anatomy from Dr. Diamond. He says, "I wanted her to come and to talk to the professor who inspired me." Off camera he explained more. He was afraid Dr. Diamond would die before his daughter was old enough to be taught by the "most important teacher in his life." Do you have teachers in your life that you consider that important? How did that teacher change you? What do you think are the most important characteristics of a great teacher? Write a paragraph listing at least three characteristics of a great teacher and explain why each characteristic is important to teaching.

This is Your Brain on Love
Theme 4: Women in Science and Gender Bias

Engaging Questions	Reflection Questions Grades 9-12
Have you ever been in a large group and notice no one in the room is like you? You were the only female/male/minority. How did you feel after this revelation?	When Dr. Diamond attended UC Berkley in the early 1950's, she was one of only 5 women in a class of 105 students. How do you think she might have felt? How would you have felt?
Magellan was the first to circumnavigate the world in a boat in 1519. Lindbergh made the first nonstop transatlantic flight from New York to Paris in 1927. Armstrong became the first human to walk on the moon in 1969. These are common names most people would recognize. Why do we remember "firsts"? Does it matter? Why?	Why were there so few women at UC Berkley in the 1950's and 60's?

Do you know any female doctors? Do you know more female doctors or more male doctors? Who was the first female medical Dr. in the US? (Elizabeth Blackwell)	When preparing to write up their research on brain plasticity, Dr. Krech put Dr. Diamond's name last and in parenthesis. Why? What was Dr. Diamond's response?
	Dr. Diamond said, "Never learn bitterness, because you are the only one who suffers." What did she mean by this? Do you agree or disagree? Explain.
	Women who attended college in the early 20th century were often directed to take classes in "home economics"? Why?
	In the 1930's and 40's, women were directed to degrees in teaching and nursing. Why were these careers favored for women?

Task

- In 1871, the Board of Regents (of UC Berkley) stated that women should be admitted on an equal basis with men. Yet, in this chapter we learn that Dr. Diamond was one of only 5 women in a class of 105 students in UC Berkley's medical school. Research women's history after WWII. Why weren't there more woman enrolled in medical school? How long did it take for female students to outnumber male students in medical schools?

CHAPTER 5: Enrichment in Action **(43:50 – end)**

Content summary: Dr. Diamond applies her research on plasticity to a school of orphans in Cambodia, benefiting their lives and confirming her ideas. She reflects on her life and career, from falling in love at age 15 with studying the brain through her retirement after 60 years as a professor, having taught more than 60,000 students. They are her true legacy

Enrichment in Action
Theme 1: Science

Engaging Questions	Reflection Questions Grades 5-12
Can science improve society? How?	Why did Dr. Diamond go to Cambodia?
Is science used to determine government policies? Can you give examples?	Dr. Diamond described this trip as applied research. What is the difference between applied research and experimental research?
	Dr. Diamond said, "Applied science is leaving the lab for the messiness of the real world. What does she mean by

	"messy?"
	Why is this type of research important? Why not just stay in the nice, clean lab?
	At the end of the film, Dr. Suzuki is crying. Why?
	How did you feel at the end of the movie? Why?
	What do you think is her legacy? Do you think her research has effected your own life in any way?

Tasks

- Dr. Diamond was not satisfied to conduct brain research and teach. She was compelled to act on her research. She went to Cambodia to provide impoverished children with a human "enriched environment," including healthy food and education. Use evidence from the film to support the claim that science research can improve society.
- Dr. Diamond says she "fell in love" with the brain at the age of 15. Using evidence from the film, support the claim that Dr. Diamond's life demonstrates a "love affair" with the brain.

Enrichment in Action

Theme 3: Learning

Engaging Questions	Reflection Questions Grades 5-8
How can learning improve your brain?	Why did Dr. Diamond go to Cambodia?
What does your brain need to be healthy?	What was she able to accomplish?
How is brain research used to improve learning in the classroom?	How can her ideas be replicated in the classroom? In your life?
	Dr. Diamond says she loves to teach. Why does Dr. Diamond retire?
	Reflection Questions Grades 9-12
	How can we or our organization use Dr. Diamond's research to make a difference in our community, state, nation?
	The film shows us a filled football stadium. Why? Discuss visual metaphors and visual analogies?

Task

- “When you know better, do better” is currently a popular expression. Explain what this expression is asking people to do. Support the claim that Dr. Diamond’s life modeled this expression.
- 60,000 students are a lot of students! Compare this number to other large numbers, such as the number of elementary schools in the US, the number of new medical doctors that graduate each year. How does her number of students compare? Dr. Diamond taught for approximately 60 years. How many students did she teach on average each year? Many of her students became doctors or have some roll in healthcare or became science professors themselves. Knowing this, explain how Dr. Diamond’s influence as a science teacher extends far beyond her 60,000 students.

Module 2: Grades 5-12: Extended Learning Opportunities

The lessons in this section are organized in grade bands- grades 5-8 and grades 9-12. The length of the lessons depends on the performance task you assign to your students and the number of standards being addressed. All lessons include literacy skills, such as reading and writing informational texts, close-reading strategies, arguing from evidence/supporting a claim, and making inferences.

This module is designed for the viewing of the entire film. Because MyLAB includes brain vocabulary, it is suggested that students learn the major parts of the brain and nerve cells before viewing the film, as well as concepts about cells in general, i.e., cells are the structural and functional units of organs, cells work together to form tissues, etc. (A simple brain/nerve cell lesson is included in Appendix A, along with brain-related vocabulary.)

The entire film is 57 minutes long and might take two regular class periods to watch. Therefore, the shortest time frame for conducting a Module 2 lesson, with film time included, is 3 to 4 days. Slightly more extensive lessons may take 7 to 10 day, with the most extensive taking several weeks. (See Module 1, page 2, for ideas for varying the assignment submission.)

Pre-Assignment Preparation

Procedure:

1. Make sure students have background knowledge necessary to understand the film without becoming frustrated.
2. Before showing the film, engage your students in a discussion about the film by asking questions on the topics/concepts you want to address after the film. Question samples are below.
3. Show the film and watch it (again) with them.
4. After the film, ask questions and engage your students in discussion. Additional discussion questions may be found in Module 1.
5. Lead the students into the follow-up lesson/activity.

Pre-film discussion questions.

- ✓ Can I improve my brain? If I can, how?
- ✓ What do scientists actually do all day?
- ✓ Some scientists spend their lives researching one topic. How do they do that?
- ✓ Can you give examples of how science "break-throughs" changed the world?
- ✓ Does the environment effect how our brains work?

Comprehension, Collaboration, and Communication:

English, science, and history teachers (in most school districts) are required to teach content literacy skills, such as comprehension, collaboration, key ideas and details, craft and structure, integration of knowledge and ideas, and informational and argumentative writing. These skills are not limited to the written word, but include plays/movies, documentaries, poems, historical documents, speeches, and other sources of information. The film could be used to teach and practice all these skills. (See ELA-Literacy standards)

Tasks

1. Analyze the film like a text:
   - What did the film say?
   - How does the film work (vocabulary, structure of the film, directors' craft)?
   - What does the film mean (make inferences)?
   - What does the film inspire you to do (create something new)?

   Creations might include writing assignments (narrative, explanatory, and argumentative) on the following topics,
   - research regarding the brain or other amazing organs,
   - research on "good" teaching
   - community/national activism
   - gender bias/female scientists

   Or non-writing assignments, such as,
   - build a model of the brain
   - dissect a sheep's brain
   - build a model of an enriched environment
   - start a "brain-enriching" club that focuses on enriching activity
   - raise money for an education, brain-enriching organization.

2. The film maker wrote a blog for *Scientific American* called, "What is the Best Way to Talk About Science?", which makes the argument that biography is needed in science education. On the other hand, much of the science education in the US is focused on memorizing facts, vocabulary, and, hopefully, doing science itself. (https://blogs.scientificamerican.com/guest-blog/whats-the-best-way-to-talk-about-science/)
   - Read the blog and annotate it following teacher instructions.

- Identify the author's claim.
- How does the author support his claim?
- Was the author successful in supporting his claim? Do you agree or disagree with the claim?
- Give examples of possible counterclaims.
- Are there advantages to including more of a scientist's story in science education? Disadvantages?
- Write a paper to supporting or disagreeing with the author's claim. Use evidence from the film and your reaction to it to support your argument.

3. Describe Dr. Diamond's experiment on enriched environments. What did she mean by "an enriched environment?" What would that look like for a human?
    - Students may write about, draw, and/or construct an "enriched environment" for humans.
    - Conduct research to extend the list of environments that promote or hinder brain health.
    - Investigate solutions to help students/children that have experienced impoverished environments.

4. According to Dr. Diamond, a healthy brain requires 5 things: a healthy diet, exercise, challenges, newness, and love.
    - Students write a "public service announcement," explaining the 5 factors and describing how to incorporate them into your daily routines.
    - Students research more about enriched environments and develop a plan for incorporating one or more of the 5 factors into their lives.
    - Students research environments that impoverish the brain and the actual effects on the brain.
    - Students analyze a primary research paper for experimental design and new findings.

5. Dr. Diamond was not satisfied to conduct brain research and teach. She was compelled to act on her research with her Enrichment in Action initiative.
    - Research organizations that work to provide enriched environments.
    - Raise money and donate it to an organization that supports "brain enrichment" projects for impoverished children.

The Nature of Science

To be a scientifically literate, a person needs to understand the nature of scientific knowledge- "that scientific knowledge itself is open to revision in light of new evidence." (NGSS. Appendix H. p. 2) My Love Affair with the Brain models this concept several times. The tasks in this section focus on analyzing Dr. Diamonds tactics and strategies that lead to revising science knowledge. (See Next Generation Science Standards)

Tasks

1. Use Dr. Diamond's enrichment experiment as a model for how science changes in light of new evidence.
    - Research science information about the brain's ability to change pre- and post-Dr. Diamond's research.
    - Research other examples of how new discoveries changed science. Possible topics include: the Copernicum System, evolution, investigations of Louis Pasteur, Theory of Relativity, discovery of penicillin, DNA structure, x-rays, Niels Bohr, etc.

2. Use Dr. Diamond's experiments as models for experimental design.
    - From the film the research document, have students identify from Dr. Diamonds brain enrichment study the elements of experimental design: observations, questions, hypothesis, experimental methods, data collection and analysis, results, conclusion, repeat.
    - Allow students to read and analyze Dr. Diamond's paper, "The Effects of an Enriched Environment on the Histology of the Rat Cerebral Cortex." Develop an outline of paper and compare to other primary source papers or the students' own investigations. Students may also compare this type of research to theoretical research or applied research.

3. Scientific knowledge is based on empirical evidence.
    - Dr. Diamond's research has many data tables that students can analyze. Younger students can investigate her use of averages (mean) and percent changes in the brain. Older students can explore her use of standard deviation and standard error.
    - Science is a way of knowing that is based on empirical evidence. Students can research the importance of empirical data and how anecdotal evidence (such as "evidence" used in commercials for diet plans and over-the-counter memory enhancing products) does not meet scientific standards for data.

4. Science is a human endeavor. Therefore, it can be as flawed as humans.
    - Students can research gender and race bias throughout science history, such as they eugenics movement in the early 20th Century, women's and civil rights movement.
    - Dr. Diamond did not know that Einstein had never given permission to have his brain studied. The man who had Einstein's brain was an autopsy doctor who, in effect, stole the brain and then 25 years later, provided Dr. Diamond with the 4 sections of the brain to study. Scientists follow a strong set of ethical rules, including a responsibility to weigh the rights of human and animal subjects. What are these rules? Did Dr. Diamond violate these rules by studying Einstein's brain without his permission? Does it matter that Dr. Diamond didn't know that Einstein had not given permission? Support your claim with evidence.

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Appendix A: Gallery Walk for Nervous System Basics

We recommend that students understand basic brain and brain cell anatomy before watching the film and are providing such a lesson. The lesson is designed to use an active-learning strategy called a “carousel” or “gallery walk”.

To best facilitate a carousel, use the following steps:

1. Assign areas of the room that will serve as “stations” for the activity, at each station place a several copies of the nervous system information pages, i.e., cerebrum will be a station, cerebellum with be a different station, etc., with 6 stations in total.
2. Divide the students into 6 cooperative groups of 3-4 students each.
3. Explain the following concept to the students:
    - They will have a specific amount of time to read the information page and record key ideas on their data sheet.
    - While at the station, they must work as a group and remain there until the signal to rotate is given. Make sure students know which station to move to before giving the signal.
    - They are not to move ahead or try and work ahead during the activity
    - If they do not finish their task within the time allotted, the groups must still rotate to the next station when told to do so.
    - When you give the signal to rotate, all groups will stay together and move to the next station.
    - Remind students to be focused and work together at each station!

At the end of the rotation series, each group will have completed the entire assignment given for the carousel activity.

Before starting, walk through the rotation if necessary, to ensure that the students are aware of the direction they are to rotate. Ask the students if they have any questions concerning the procedure or activity. Announce how much time they will have at each station. Then have each of the groups go to a different station, staggering the groups if possible. Begin the activity and monitor the groups as time is kept. When the rotations are complete, have the groups return to the designated area for follow-up and discussion.

Helpful Hint: Print the information pages on colored card stock paper and instruct the students not to write on or make marks of any kind on them. The information pages can be stored and used for multiple class and multiple years.

Vocabulary:

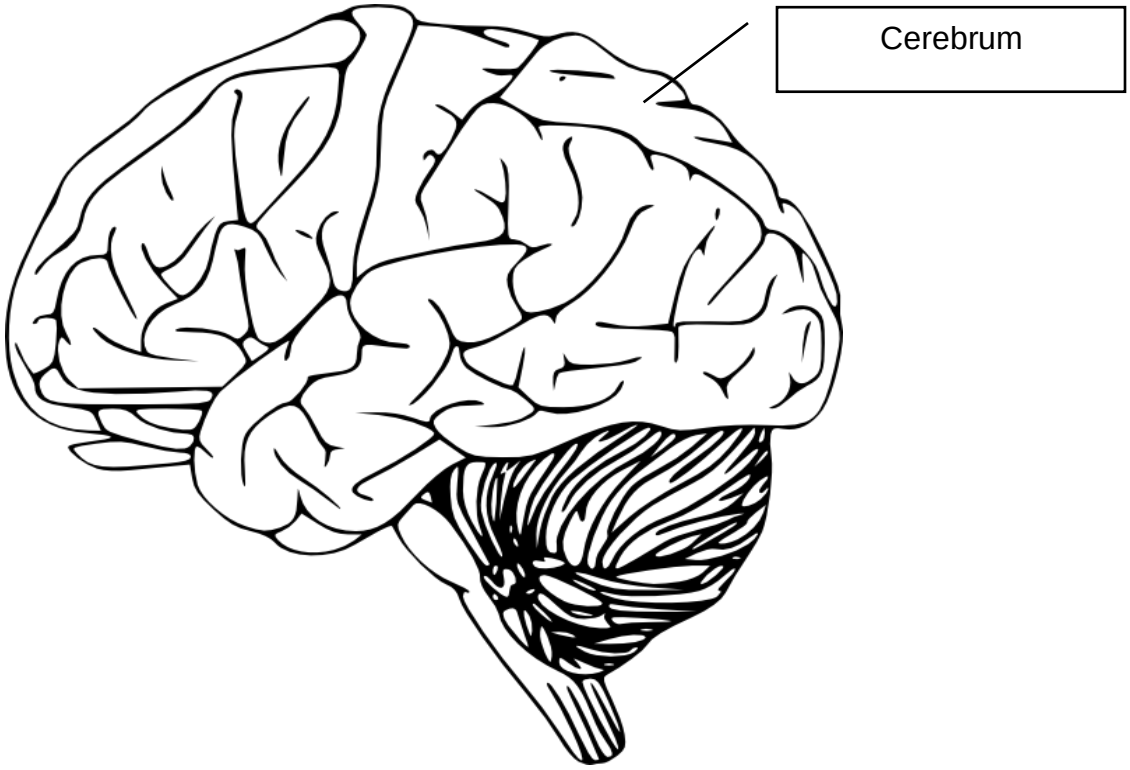
Cerebral cortex- the outer layer of the cerebrum, composed of folded gray matter and playing an important role in consciousness.

Brain plasticity- or neuroplasticity -the brain's ability to reorganize itself by forming new neural connections throughout life

Cerebrum

Information Page

The cerebrum is the largest portion of the brain, as it makes up the top, back and sides of the brain. It's the cream-colored, wrinkled part that you generally think of when you think about the brain.



The cerebrum controls a large variety of functions, including:

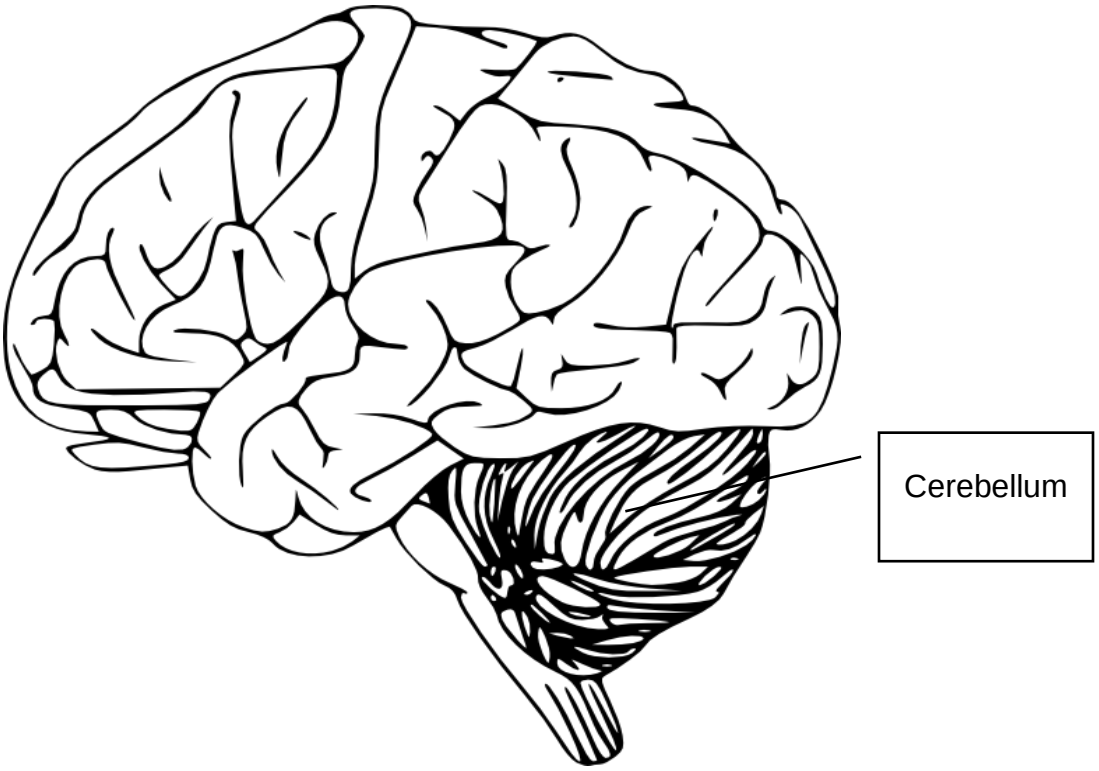
- Thinking and problem solving
- Emotions
- Movement
- Senses (touch, smell, taste, hearing, and sight)
- Understanding language and saying words
- Memory

If a person has a stroke and is paralyzed, this is where the stroke occurred. A stroke means the person's brain didn't get oxygen and some of the nerve cells died. The more cells that die, the more severe the stroke.

Cerebellum

Information Page

The cerebellum is located at the back base of the skull, below the cerebrum.



This is the portion of the brain that controls balance and coordinates muscle movements. This part of the brain doesn't allow you to move, it makes your movements smooth and accurate. The cerebellum also lets you know when you are standing, sitting, or lying down.

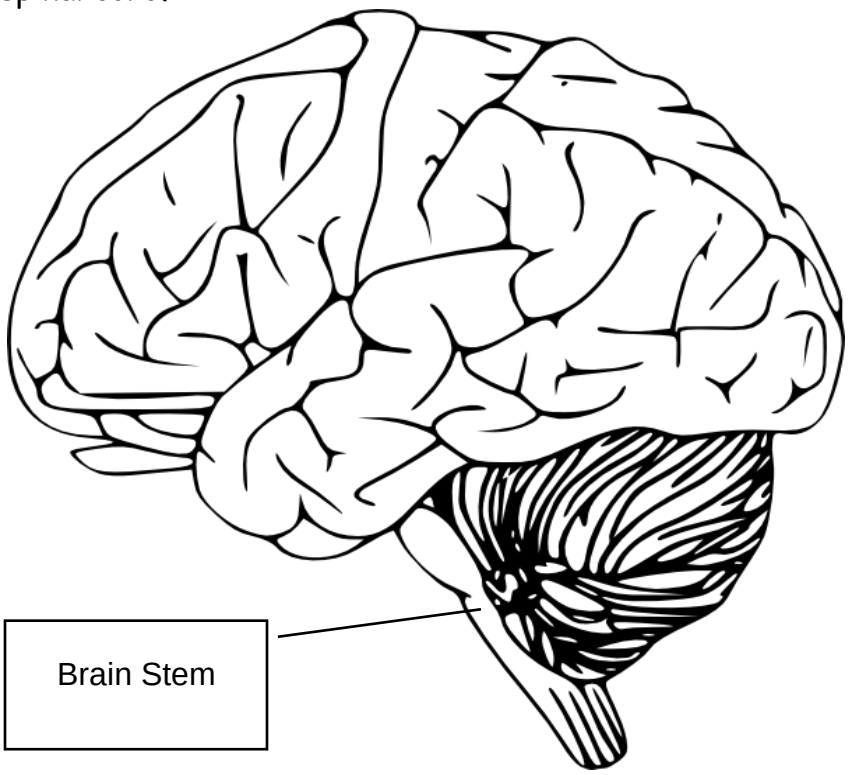
It is also believed to control "motor learning." Motor learning involves improving the smoothness and accuracy of movements, and is necessary for speaking, learning to play basketball, or climb a tree.

If as stroke occurs in this part of the brain, a person would not be paralyzed, but would cause the victim to lose fine motor skills, like sewing, and balance. (A stroke occurs when the brain loses oxygen.)

Brain Stem

Information Page

The brain stem is the stalk-like portion of the brain that continues down and becomes the spinal cord.



The brain stem is the portion of the brain that controls involuntary functions or the things your body does that you don't have to think about, like swallowing, digestion, heartbeat, lungs breathing, etc. It is made of three parts called the midbrain, pons, and medulla oblongata.

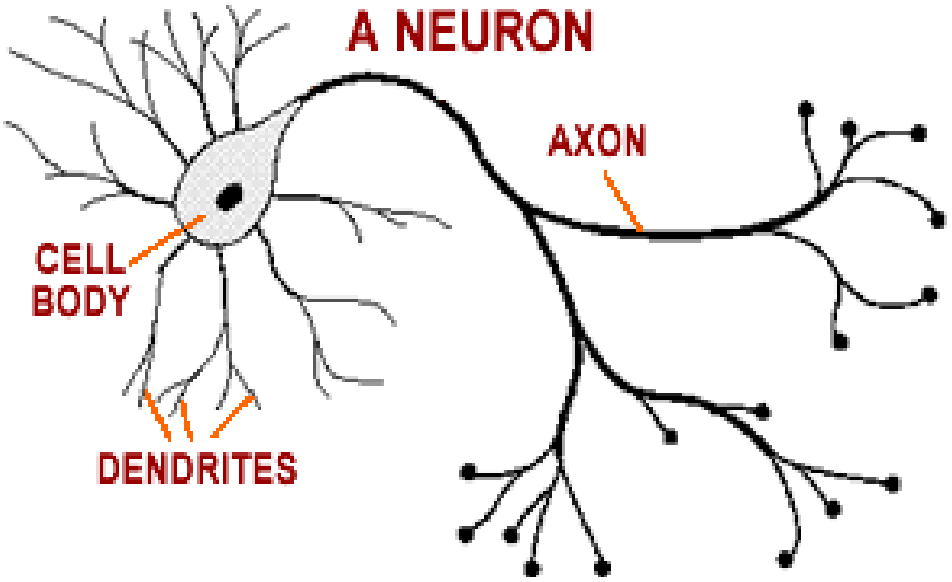
The brain stem sends messages from the body to the correct part of the brain. It tells your heart how hard and how often to beat and your lungs how deeply and often to breath. It even controls things like vomiting, hiccupping, and sneezing.

If anything bad happens to this portion of the brain, the victim will, most likely, die. Though it makes up only 2.5% of the mass of the brain, it is an especially important part.

Neuron

Information Page

Neuron is the science name for a nerve cell. A single neuron may be microscopically small, but over 3 ft long!



Neurons are found throughout the nervous system- from your toes to your brain. They are the electric wires that connect everything to the brain and spinal cord.

The electric signal that travels through the nerve cell is called an impulse. The impulse would start at the dendrites, travel through the cell body, and down the axon. At the end of the axon there will be one of four things:

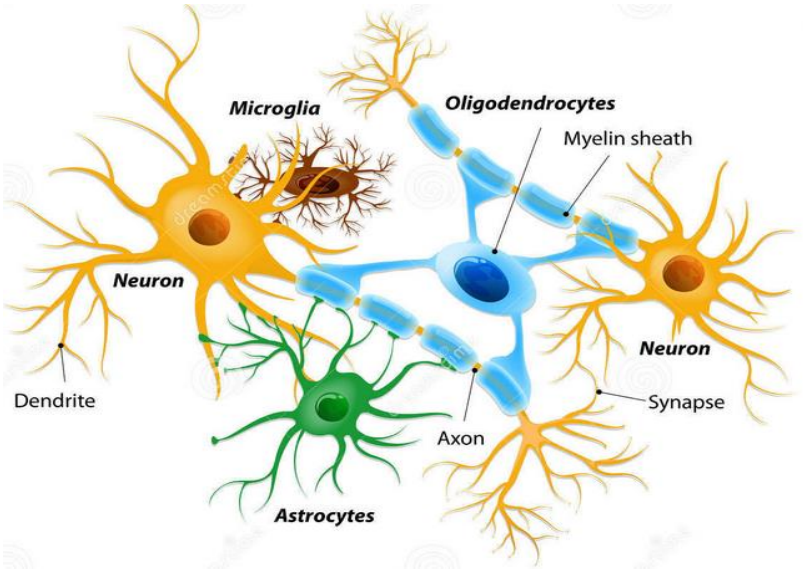
1. Another dendrite, so the impulse can continue its journey,
2. A muscle, so that the signal can tell the muscle how to move,
3. A gland, like the stomach, so it knows to start digesting your lunch, or
4. A part of the brain.

A bundle of neurons makes a nerve. If a nerve is cut or damaged, the victim may lose feeling or the ability to move, even if the brain is fine.

Glial Cells

Information Page

Glial cells, or simply glia, are cells found in the nervous system that do not produce electrical impulses like neurons do, but they do help neurons send signals. Three types are shown below: oligodendrocytes, microglia, and astrocytes.



Glial cells have 4 main jobs or functions.

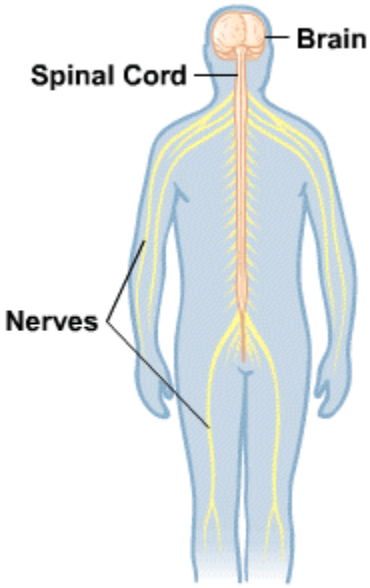
1. Surround neurons and hold them in place.
2. Supply nutrients and oxygen to neurons.
3. Insulate or separate one neuron from another.
4. Destroy disease-causing germs and remove dead neurons.

Glial cells were first discovered in 1856 by Rudolf Virchow (**fir**-khoh) and scientists are still investigating them to learn all the things they do.

Spinal Cord

Information Page

The spinal cord is the main pathway of nerves from the body to the brain. It is protected by small bones known as vertebrae, which form the backbone. The spinal cord is actually shorter than the backbone.

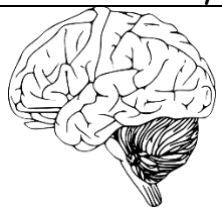
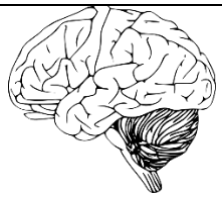
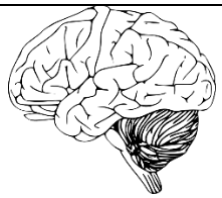


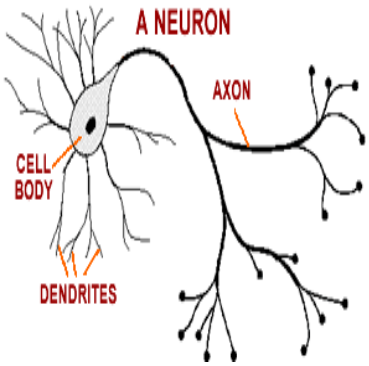
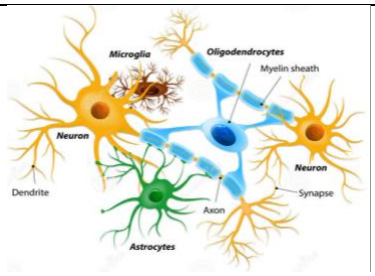
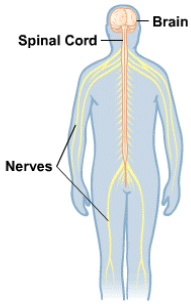
There are 31 pairs of spinal nerves that extend out to all parts of the body. These nerves may pick up sensory information, like "I feel cold," and send it to the brain. The brain may then send a motor (or movement) signal down the spinal cord to your legs that says, "Go get a jacket out of the bedroom." Next thing you know, you're wearing a jacket!

Signals are also carried to organs, like your heart, lungs, and stomach. For example, when your stomach is empty it may "growl." This sends a message from your stomach, through the spinal cord, to the brain that you are hungry. Your brain then sends a message to your muscles to move to the kitchen and make something to eat.

Nervous System

Student Data Sheet

Part of Nervous System	Function/Interesting Facts
	Cerebrum:
	Cerebellum:
	Brain Stem:

	Neuron:
	Glial Cells
	Spinal Cord

Appendix B: Frayer Models

A Frayer Model is a graphic organizer used to help students learn vocabulary and organize notes. Three models are provided here to assist the instructor with using the model.

- The first is a key for using the model for analyzing the film as they would a text.
- The second is a blank model for a student hand-out.
- The third is a student hand-out for analyzing an investigation for the elements of experimental design.

The questions in the prompt and Frayer Model were taken from, *Text-Dependent Questions: Pathways to Close and Critical Reading*, by Douglas Fisher and Nancy Frey (for grades k-5 and 6-12). The books are excellent references for teaching students how to analyze a text and help them develop critical reading skills that will last a lifetime.

Models 1 and 2 are for use with this prompt:

Analyze the film like a text:

- What did the film say?
- How does the film work (vocabulary, structure of the film, directors' craft)?
- What does the film mean (directors' purpose, make inferences)?
- What does the film inspire you to do (create something new)?

Creations might include writing assignments (narrative, explanatory, and argumentative) on the following topics,

- research regarding the brain,
- research on "good" teaching,
- community/national activism,
- gender bias/female scientists,
- anything the students can think of!

Model 3 is for use with this prompt:

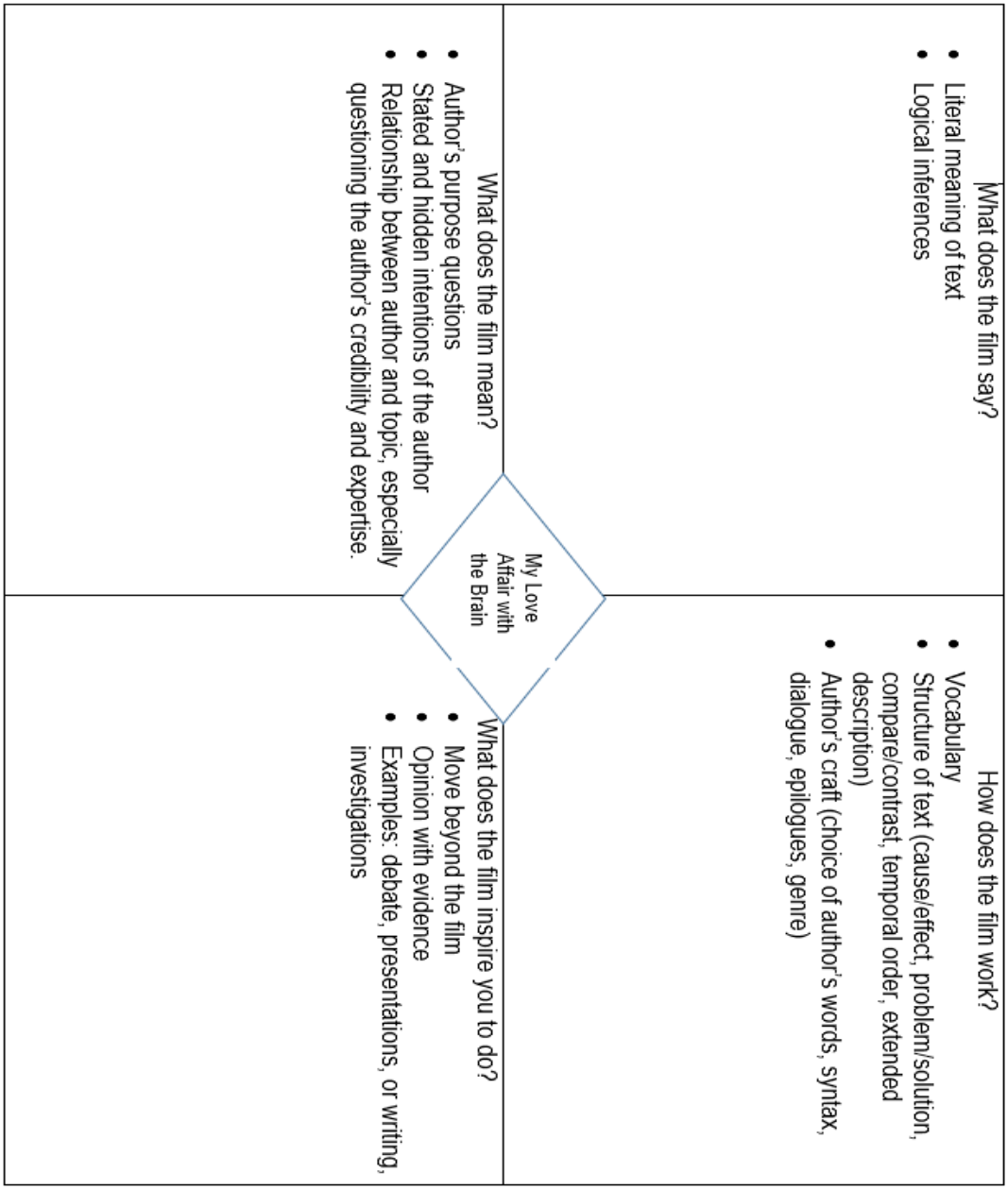
- Have students identify from the film the elements of experimental design: observations, questions, hypothesis, experimental methods, data collection and analysis, results, conclusion, repeat.

Sources

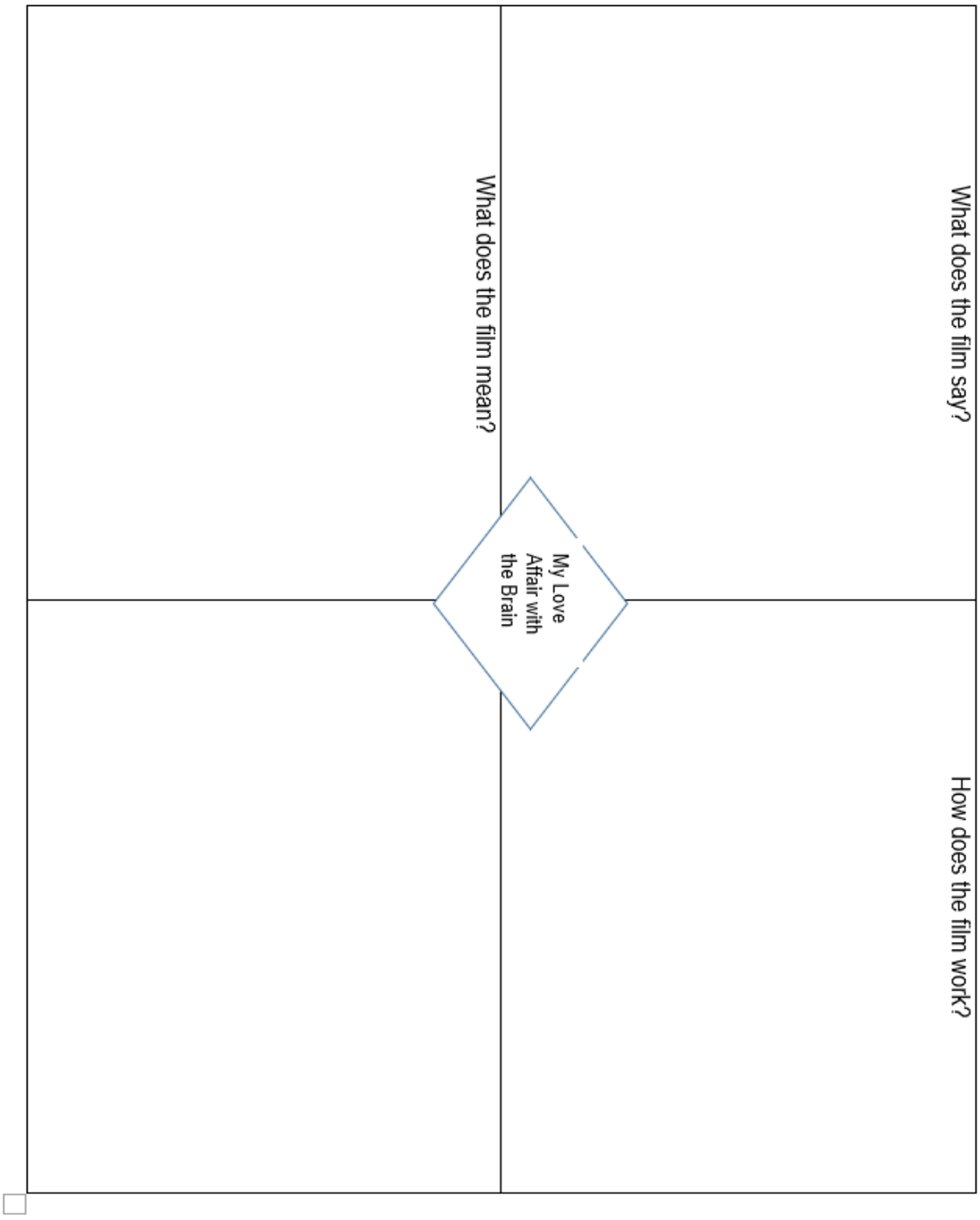
Fisher, D., Frey, N., Anderson, H., & Thayre, M. (2015). *Text-dependent questions, grades k-5: Pathways to close and critical reading*. Thousand Oaks, CA: Corwin.

Fisher, D., Frey, N., Anderson, H., & Thayre, M. (2015). *Text-dependent questions, grades 6-12: Pathways to close and critical reading*. Thousand Oaks, CA: Corwin.

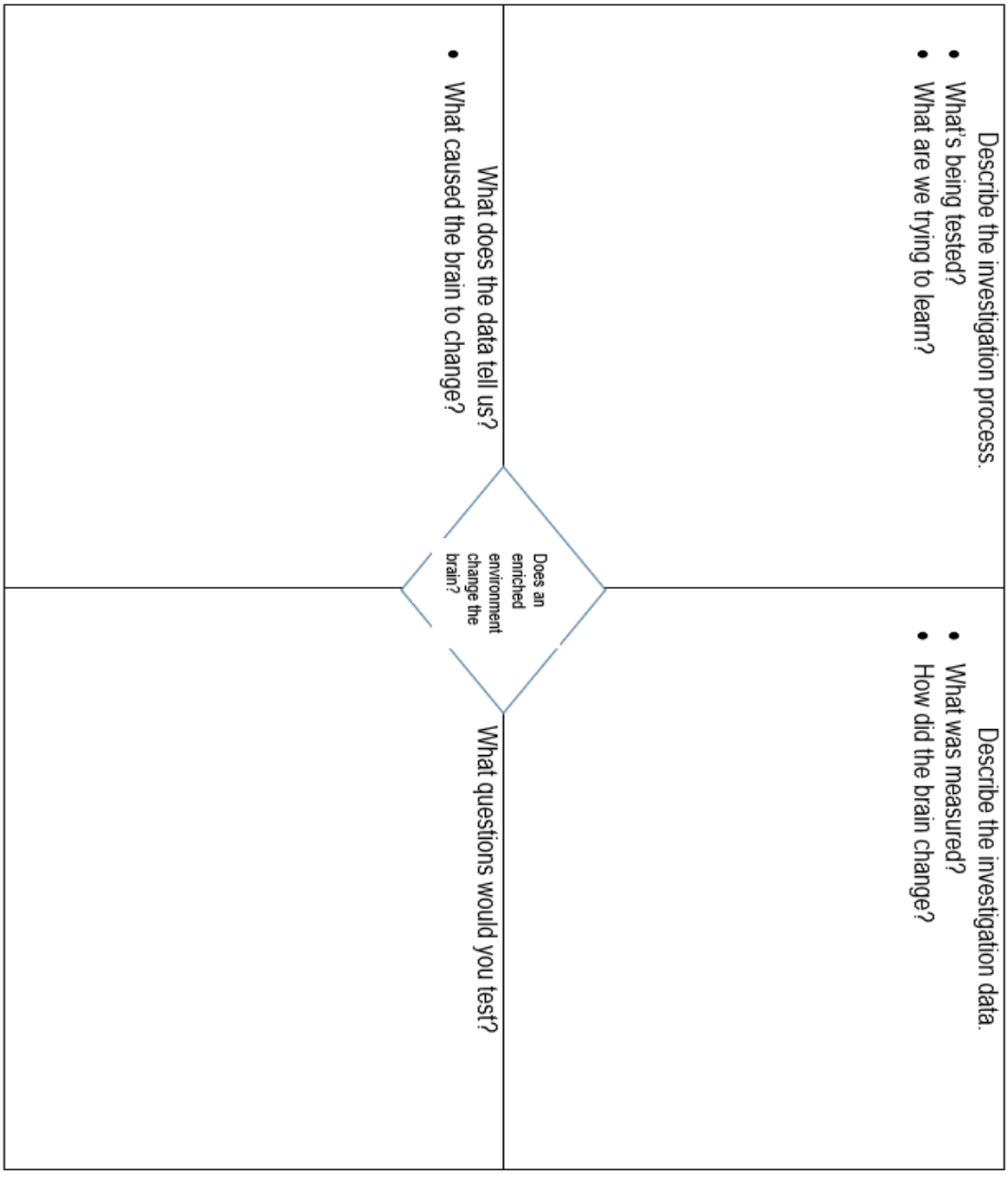
Model 1



Model 2



Model 3



Appendix C: Literacy Standards

Many of the Possibilities presented in this guide are designed to help the educator teach literacy standards by analyzing the film in the same way you would a text. Common Core State Standards (CCSS) require students to analyze informational scientific and historical texts. My Love Affair with the Brain can be tackled from a literary, scientific, and historical point of view.

Below is the complete standard for argumentative writing for grades 9-19: CCSS.ELA-Literacy W.9-10.1. and 2. Please note that argumentative writing requires the student demonstrate a-e and a-f, respectively, of the standard. This is what makes the standard so rigorous for the educator and student. The standards are provided here to assist you as you work to improve your students writing.

Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence.
b. Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns.
c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
e. Provide a concluding statement or section that follows from and supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

a. Introduce a topic; organize complex ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
c. Use appropriate and varied transitions to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
d. Use precise language and domain-specific vocabulary to manage the complexity of the topic.
e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

Below is CCSS standard CCSS.ELA-Literacy.WHST.9-10- specifically for history and science.

Write arguments focused on *discipline-specific content.*

a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
b. Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

All of the literacy standards may be found here. PDF versions are in Appendix A.

Appendix D: Next Generation Science Standards

The Possibilities are designed to assist in the teaching of the Next Generation Science Standards. (NGSS) The standards look like this.

MS-LS3 Heredity: Inheritance and Variation of Traits

MS-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

MS-LS3-1. **Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.** [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]

MS-LS3-2. **Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.** [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)*

LS3.A: Inheritance of Traits

- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

LS3.B: Variation of Traits

- In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2)
- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1)

Connections to other DCIs in this grade-band: **MS.LS1.A** (MS-LS3-1); **MS.LS4.A** (MS-LS3-1)

Articulation across grade-bands: **3.LS3.A** (MS-LS3-1),(MS-LS3-2); **3.LS3.B** (MS-LS3-1),(MS-LS3-2); **HS.LS1.A** (MS-LS3-1); **HS.LS1.B** (MS-LS3-1),(MS-LS3-2); **HS.LS3.A** (MS-LS3-1),(MS-LS3-2); **HS.LS3-B** (MS-LS3-1),(MS-LS3-2)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. *(MS-LS3-1),(MS-LS3-2)*
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. *(MS-LS3-1),(MS-LS3-2)*
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flow chart, diagram, model, graph, or table). (MS-LS3-1),(MS-LS3-2)
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS3-1),(MS-LS3-2)*

Mathematics –

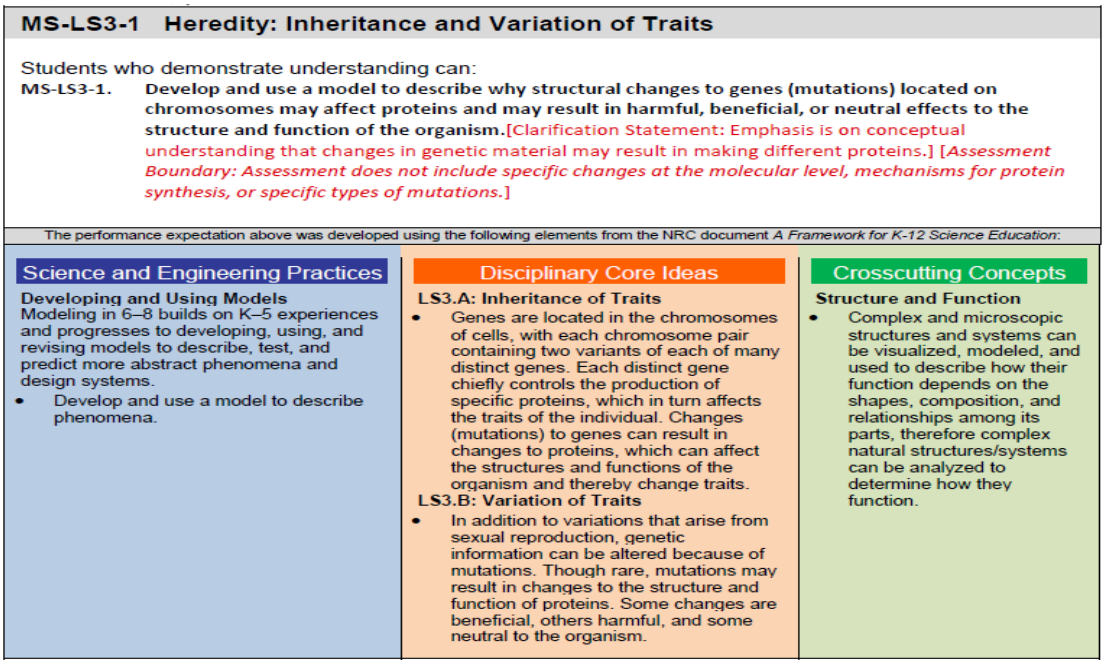
MP.4	Model with mathematics. *(MS-LS3-2)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS3-2)*

Too often educators examine only the information in the top white box and use the numbered statements as daily objectives, such as,

MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects in the structure and function of the organism.

According to Bybee (one of the authors of NGSS) this is not the intent of those statements. The statements in the top box are referred to as “student performance expectations” and “specify a set of learning outcomes-that is, they illustrate the competencies students should develop as a result of classroom instruction” and “they are not instructional units, teaching lessons, or actual tests.” (Bybee, p. 51).

All of this is the standard.



MS-LS3-1 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

MS-LS3-1. **Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.**[Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [*Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

Disciplinary Core Ideas

LS3.A: Inheritance of Traits

- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.

LS3.B: Variation of Traits

- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

Crosscutting Concepts

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Each standard contains a science/engineering practice, disciplinary core ideas, and crosscutting concepts that are to be taught in collaboration with each other. The students are to engage in the practices to learn science content and use the crosscutting concepts to develop an understanding of science across disciplines.

The NGSS require teachers to be experts in their content area and recognize that the Practices and Crosscutting Concepts are student learning outcomes. A standard cannot be reduced to a one-day lesson. Skilled teachers are needed to put everything together for students to develop deep conceptual understandings in science.

Sources:

Bybee, R. W. (2013). *Translating the NGSS for Classroom Instruction*. National Science Teachers Association. Purchase here.

Next Generation Science Standards. (2019, December 20). Retrieved from https://www.nextgenscience.org/

Suggested Reading:

Framework for K-12 Science Education. (2011). Natl Academy Pr.

Appendix E: Moving Beyond the Film

Within the Possibilities are discussion questions that can't be answered directly from the film and, therefore, require additional background knowledge and access to additional sources.

Genetic Determinism

(Adapted from "Biological Determinism" from Encyclopedia Britannica. https://www.britannica.com/topic/biological-determinism/Multifaceted-diseases and "Lies, Damned Lies, and Racist Statistics. https://www.historyworkshop.org.uk/lies-damned-lies-and-racist-statistics/**)**

Genetic Determinism is the idea that both physical and mental human characteristics are determined at conception, passed from parents to offspring. It implies a rigid causation, unaffected by environmental factors. This of course is not true and not supported by science today.

Genetic determinism was usually applied to negative traits such as cleft palate, clubfoot, dwarfism, and gigantism, but was also applied to behavioral traits such as feeblemindedness, pauperism, shiftlessness, promiscuity, bipolar disorder, and hyperactivity. Because these traits were determined by genetics, they couldn't be changed. These ideas were introduced during the late 19th century and continued through the early 20th century.

The term "eugenics" (from the Greek meaning "well-born") was coined by a younger cousin of Charles Darwin, Sir Francis Galton. Eugenics is a "racist, misogynistic pseudoscience used to justify the oppression of anyone who was not an affluent, able-bodied white man. Galton was obsessed with measuring human difference, not for its own sake, but to legitimize and cement his and his contemporaries' belief that they were racially superior to everyone else."

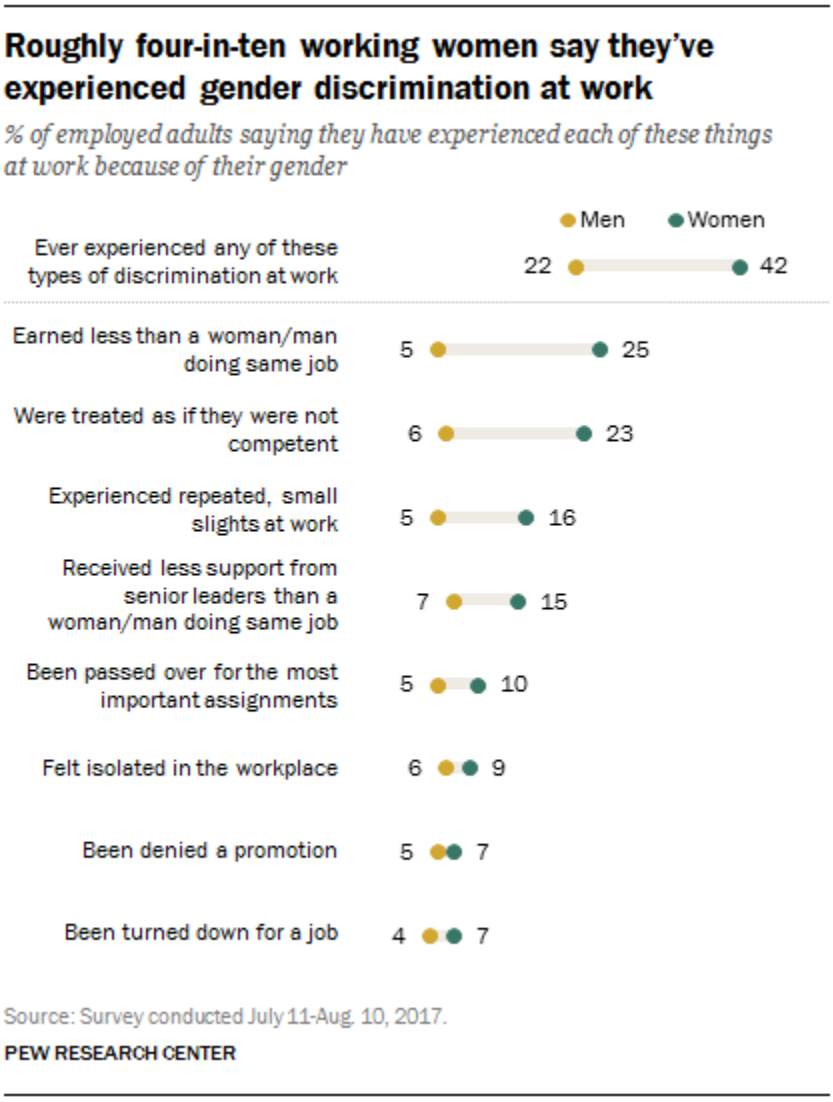
Eugenicists believed that society was deteriorating through the increased reproduction of the disabled, particularly the mentally disabled. It was claimed that low mental ability led to an inability to cope in a complex society, resulting in a turn to antisocial behaviors. It was assumed that the working class were poor because they were lazy, intemperate, and unchaste. These traits, being heritable, would bring about racial decline in left unchecked.

Sterilization laws were introduced in the 1920's in the United States and in the 1930's in Germany. More than half of the U.S. states adopted sterilization laws, which were aimed primarily at compulsory sterilization of those deemed (by white doctors) to be genetically unfit in state and federal institutions. In the early 1970's it was revealed that thousands of people were subjected to involuntary sterilization in the United States

Gender bias

It is clear in the film that Dr. Diamond experienced gender bias/sexism during her career. From the “soft” bias of her male colleague not knowing how to cite a woman in their paper, to her work on Einstein’s brain being described as “tawdry,” to the explicit bias demonstrate when she was yelled at during her presentation of her research.

Data from the Pew Research Center shows that women continue to experience gender discrimination at work.



Gender bias continues in science as well. An article in Scientific American is an excellent source for what gender bias looks like and why it matters.

Racism in Science

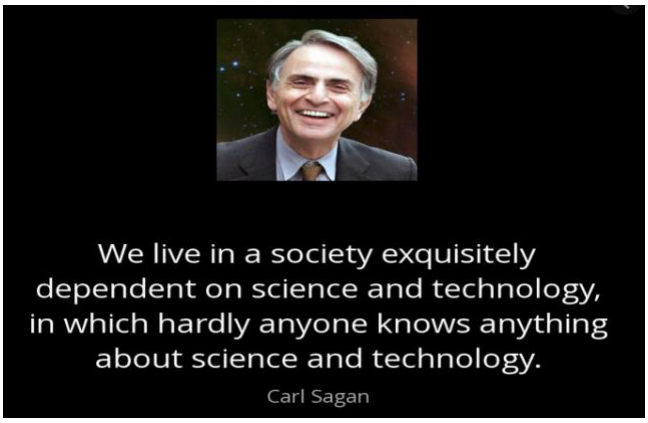
An excellent resource for this topic is Race: The Power of an Illusion, a 3 film documentary on race, science, and society. The website allows you to watch the documentary and has resources for teachers and students.

The first film documents how science was used to explain the "Negro problem"- the higher rates of disease and mortality in impoverished minority populations at the turn of the 20th century. To explain the "problem," Fredrick Hoffman, an insurance statistician, published *Race Traits and Tendencies of the American Negro* in 1896. "In vital capacity.., the tendency of the Negro race has been downward," he wrote. Their extinction was inevitable. Biology became an excuse for social differences.

"Hoffman had made the mistake of aggregating his data, thereby obscuring any relationship between cause and effect other than the single commonality of race itself. Such failing indicated that Hoffman had not adhered to the scientific methods on which he prided himself, and on the basis of which his work claimed special credibility. On the grounds of this methods alone, the bulk of Hoffman's claims and conclusions could be easily toppled." Source

Of course, genetics today tells a different story. *There is not a single gene you can find in a person of one so-called race that you can't find in a person of a different so-called race.* There is no biological justification for racism.

Science and Society



"Science, technology, society and the environment" is a major component of the NGSS (see Appendix J of the NGSS). Students should understand that "scientific discoveries and technological decisions affect human society and the natural environment," and that "people make decisions for social and environmental reasons that ultimately guide the work of scientists and engineers." Hence, a cyclic relationship exists between science/technology and society.

Viewing MyLAB provides educators with the opportunity to clearly illustrate this relationship in the classroom. Dr. Diamond's work on brain plasticity and neuron: glial

cell ratios had a powerful influence on education and healthcare, and in turn lead to additional research and more societal changes.

Two Possibilities from the Nature of Science allow students to expand on this relationship:

- Research other examples of how new discoveries changed science. Possible topics include: the Copernicum System, evolution, investigations of Louis Pasteur, Theory of Relativity, discovery of penicillin, DNA structure, x-rays, Niels Bohr, etc.
- Students investigate the role of ethics in science, science research or, more specifically, the role of ethics when working with animals and/or humans.

Appendix F: The 5E Instructional Model

The 5E instructional model has been used by science educators since the late 1980's and is still one of the best models for designing lessons based on constructivist educational theory. Below is a blank 5E template, followed by descriptions for "what the student" does at each "E," "what the teacher does" for each "E," and a chart that lists activities appropriate for each "E."

Learning Sequence Concept:			
5E Phase	**Teacher Does**	**Student Does**	**Concept**
Engage			Prior knowledge
Explore			Building content
Explain			Building content
Extend		•	Applying
Evaluate			Assessment
Performance Expectation(s)	.		
Safety Considerations			

Table 13. The BSCS 5E Instructional Model: What the Student Does

Stage of the Instructional Model	The BSCS 5E Instructional Model: What the Student Does	
	That Is Consistent with This Model	That Is Inconsistent with This Model
Engagement	▪ Asks questions such as, "Why did this happen?" "What do I already know about this?" "What can I find out about this?" ▪ Shows interest in the topic	▪ Asks for the "right" answer ▪ Offers the "right" answer ▪ Seeks one solution
Exploration	▪ Thinks freely, within the limits of the activity ▪ Tests predictions and hypotheses ▪ Forms new predictions and hypotheses ▪ Tries alternatives and discusses them with others ▪ Records observations and ideas ▪ Asks related questions ▪ Suspends judgment	▪ Lets others do the thinking and exploring (passive involvement) ▪ "Plays around" indiscriminately with no goal in mind ▪ Stops with one solution
Explanation	▪ Explains possible solutions or answers to others ▪ Listens critically to others' explanations ▪ Questions others' explanations ▪ Listens to and tries to comprehend explanations that the teacher offers ▪ Refers to previous activities ▪ Uses recorded observations in explanations ▪ Assesses own understanding	▪ Proposes explanations from "thin air" with no relationship to previous experiences ▪ Brings up irrelevant experiences and examples ▪ Accepts explanations without justification ▪ Does not attend to other plausible explanations
Elaboration	▪ Applies new labels, definitions, explanations, and skills in new but similar situations ▪ Uses previous information to ask questions, propose solutions, make decisions, and design experiments ▪ Draws reasonable conclusions from evidence ▪ Records observations and explanations ▪ Checks for understanding among peers	▪ Plays around with no goal in mind ▪ Ignores previous information or evidence ▪ Draws conclusions from thin air ▪ In discussion, uses only those labels that the teacher provided
Evaluation	▪ Answers open-ended questions by using observations, evidence, and previously accepted explanations ▪ Demonstrates an understanding or knowledge of the concept or skill ▪ Evaluates his or her own progress and knowledge ▪ Asks related questions that would encourage future investigations	▪ Draws conclusions, not using evidence or previously accepted explanations ▪ Offers only yes-or-no answers and memorized definitions or explanations as answers ▪ Fails to express satisfactory explanations in his or her own words

R W Bybee et al. The BCSC 5E Instructional Model: Origins, Effectiveness, and Applications. 2006.

Table 14. The BSCS 5E Instructional Model: What the Teacher Does

Stage of the Instructional Model	The BSCS 5E Instructional Model: What the Teacher Does	
	That Is Consistent with This Model	**That Is Inconsistent with This Model**
Engagement	▪ Creates interest ▪ Generates curiosity ▪ Raises questions ▪ Elicits responses that uncover what the students know or think about the concept or topic	▪ Explains concepts ▪ Provides definitions and answers ▪ States conclusions ▪ Provides closure ▪ Lectures
Exploration	▪ Encourages the students to work together without direct instruction from the teacher ▪ Observes and listens to the students as they interact ▪ Asks probing questions to redirect the students' investigations when necessary ▪ Provides time for the students to puzzle through problems ▪ Acts as a consultant for students ▪ Creates a "need to know" setting	▪ Provides answers ▪ Tells or explains how to work through the problem ▪ Provides closure ▪ Directly tells the students that they are wrong ▪ Gives information or facts that solve the problem ▪ Leads the students step by step to a solution
Explanation	▪ Encourages the students to explain concepts and definitions in their own words ▪ Asks for justification (evidence) and clarification from students ▪ Formally clarifies definitions, explanations, and new labels when needed ▪ Uses students' previous experiences as the basis for explaining concepts ▪ Assesses students' growing understanding	▪ Accepts explanations that have no justification ▪ Neglects to solicit the students' explanations ▪ Introduces unrelated concepts or skills
Elaboration	▪ Expects the students to use formal labels, definitions, and explanations provided previously ▪ Encourages the students to apply or extend the concepts and skills in new situations ▪ Reminds the students of alternate explanations ▪ Refers the students to existing data and evidence and asks, "What do you already know?" "Why do you think …?" (Strategies from exploration also apply here.)	▪ Provides definitive answers ▪ Directly tells the students that they are wrong ▪ Lectures ▪ Leads students step by step to a solution ▪ Explains how to work through the problem
Evaluation	▪ Observes the students as they apply new concepts and skills ▪ Assesses students' knowledge and skills ▪ Looks for evidence that the students have changed their thinking or behaviors ▪ Allows students to assess their own learning and group-process skills ▪ Asks open-ended questions such as, "Why do you think …?" "What evidence do you have?" "What do you know about *x*?" "How would you explain *x*?"	▪ Tests vocabulary words, terms, and isolated facts ▪ Introduces new ideas or concepts ▪ Creates ambiguity ▪ Promotes open-ended discussion unrelated to the concept or skill

R W Bybee et al. The BCSC 5E Instructional Model: Origins, Effectiveness, and Applications. 2006.

LEARNING CYCLE CHECKBRIC

Have I effectively planned for learning cycle implementation in this learning experience by including any of the following?

NG:

_____Asked a probing or prompting question
_____Engaged the student in a discrepant event
_____Told or read a story
_____Used an appropriate visual (transparency, filmstrip, picture, video clip, etc.)
_____Involved the students in a puzzle, brainteaser, or problem solving experience
_____Presented a KWL chart
_____Other (indicate method)

NG:

_____Provided a hands-on/minds-on experience
_____Used some type of manipulatives
_____Allowed the students to search for the answer to an open-ended question or problem
_____Allowed the students to search for the answer to a question or problem that may be more specifically guided or directed
_____Provided an opportunity for students to use process skills (modeling, researching, experimenting, graphing, collecting data, observing, classifying, organizing, etc)
_____Engaged the students in a cooperative learning experience
_____Other (indicate method)

ING:

_____Facilitated an active discussion based on the students' previous experiences
_____Introduced appropriate terminology or vocabulary associated with events that occurred during the previous experiences
_____Allowed students to reject or accept hypotheses through the collection and recording of data
_____Guiding students through the graphing and analysis of
_____Implemented a cooperative group jigsaw or some other peer instruction
_____Other (indicate method)

EXTENDING:

_____Engaged the students in an application of the previous experiences
_____Provided an opportunity for the students to perform a that takes place over an extended period of time
_____Allowed the students to engage in a creative experienc reflects conceptual understanding—drama, writing, dr
_____Involved the students in an individual or group project the concepts developed
_____Integrated the science concepts with other subject ar
_____Facilitated further research or peer instruction
_____Other (indicate method)

EVALUATING:

_____Implemented ongoing assessment throughout the learr
_____Designed an appropriate standard teacher made test
_____Provided the students with a form of alternative asses (concept map, card sort, gallery walk, demonstration assessment, pictorial assessment, portfolio, journal entries or other student writing, performance assessment, etc.)
_____Utilized student checkbrics/checklists
_____Assessed through teacher observations
_____Implemented student self-assessments
_____Other (indicate method)