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: College, Single lesson Discussion Questions and Tasks

This section is designed for developing 1-day lessons that are part of a larger curricular unit or for the educator who wants to focus on specific themes in the film.

Each section has one or more "engaging" questions to ask the students before showing the film. You may decide to use one or more or create your own. 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 provided to help guide you in 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.

The questions are followed by one or more tasks to extend the learning from the film and discussion. Tasks can generally be completed in one class period but may be extended to include more research or practice more skills.
Below is a sample of a class discussion in an education methods class that might be developed from this section. It uses the BSCS 5E instructional model: engage, explore, explain, extend, and evaluate. This model is based on constructivist theory of how people learn. (More information regarding the 5E instructional model is in Appendix F)

Learning Sequence Concept:	The importance of questioning in the classroom. (Film chapter "The Women with Einstein's Brain," theme 3 Learning)		
5E Phase	**Teacher Does**	**Student Does**	**Concept**
Engage	Ask the whole group: Why do teachers ask their students questions? Does it matter what the question is or how it's asked? Why or why not? Tell the students they will be watching a film chapter about the woman who researched Einstein's brain. As they watch they should pay attention to the importance of asking the right questions.	Discuss questions	Prior knowledge
Explore	Show film chapter	Watch film and record relevant information	Building content
Explain	When the film is over, engage the students in discuss about the information in the film and answer questions they may have. Ask: 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	Take part in discussion	Building content

	answer makes a difference." • can this apply to the questions teachers ask every day? • What makes a question a "good" question? • How do you know if you've asked the right question? • Many educators now recommend that teachers stop using true/false questions. What do you think is their reasoning for this? (*Students can get them right by guessing. The teacher doesn't know if the student guessed or knew the answer.*) • Add other relevant questions as needed. • Review types of questions		
Extend	With students working in cooperative groups, assign the task: -The narrator states, "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." Teachers spend large portion of class time asking questions. Students will often give the simplest	Complete given task	Applying knowledge

	responses, whether written or oral. In the classroom, how does a teacher find her way to the right questions? How does the teacher get more full and complete answers from reluctant students? Develop an explanation for the specific steps you will take in your classroom to ask "the right questions" to illicit a thoughtful response.		
Evaluate	Evaluate student response throughout the lesson, listening for misconceptions. Evaluate students' questioning plan for appropriateness.	Submit explanation.	Assessment
Performance Expectations	Students demonstrate understanding of varying question types to illicit thoughtful responses.		
Safety considerations	none		

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

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 anatomical changes in the brain due to enriched and non-enriched environmental factors. 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
How does science "work"?	Dr. Diamonds hypothesis of brain plasticity was once controversial, but now it is widely accepted. This is a major

	change. What does this tell you about science?
Why does science work?	As Dr. Diamond presented her work, another scientist shouted at Dr Diamond, "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 what investigative research is, specifically reproducibility in an experiment. ✓ What is reproducibility and how does it increase our confidence in our data? ✓ Why do science "facts" change? Is science research ever wrong?
How does science improve our lives?	
Does science improve society? How?	

Task

- Dr. Diamond's brain enrichment research was simple, but profound, producing foundational understandings of neuroscience. 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
What can you do if you damage your brain?	What is enrichment?
	How can I use Dr. Diamond's research to make my brain better?
	What are some environmental factors that harm the brain?

	What can I do to change/reduce the harmful environmental factors from my life, house, community, nation?
	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
How does the brain learn?	Can I continue to enrich my brain as I get older?
Can I improve how I learn?	How can I provide a rich environment for my children, students, family? How can I do it on a budget?
Can I learn more than I think I can?	How can I protect my children/students from the environmental factors that may harm their brain?
	How do I love my students in a way to enrich their brains?
	How do I instill a love of learning in my students/children?
	What is my responsibility as a citizen to ensure enriched environments for all children/students?
	What can I do to change/reduce the harmful environmental factors from my life, house, community, nation?

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 and it was the beginning of the Flint Water Crisis. The new water source caused the water pipes to corrode, releasing large amounts of lead 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 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 the concept of brain plasticity to help the students.

How She Changed Science
Theme 4: Bias

Engaging Questions	Reflection Questions
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 stood in front of a crowded conference room presenting her work, 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?

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
How can I develop a passion for learning?	Dr Diamond's students praised her as a teacher who "made science and learning personal? what does that mean? How could other teachers do the same thing? Give examples.
What makes someone a "good" teacher?	What modes of teaching do we observe Dr. Diamond using? Why use multiple modes of teaching?
	What is kinesthetic learning?
	Dr. Diamond tries to get her students to respond during class, but they are reluctant. She reminds them that 2nd graders *aren't afraid to respond*. Do you agree with that? Why do you think students behave this way?
	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?
	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

- 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.

- There are many modes of learning, but many teachers favor combinations of visual, auditory, reading, or kinesthetic. Research the meaning of each mode. Support a claim, with evidence from your research, that using the modes in combination are more likely to increase student learning than using them independently.

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
What makes an experiment reliable, something that can be trusted?	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? ✓ 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? ✓ Does choosing the right question have meaning for you? ✓ 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.

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

Engaging Questions	Reflection Questions
Who is Albert Einstein? Do you think his brain might be different from yours?	How does the research on Einstein brains support Dr. Diamond's research on brain plasticity?
Is everyone's brain the same? Different? If different, how would they be different?	

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 the same increase in nerve cell connections and 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 3: Learning

Engaging Questions	**Reflection Questions**

Why do teachers ask their students questions? Does it matter what the question is or how it's asked? Why or why not?	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." ✓ Can this apply to the questions teachers ask every day? ✓ What makes a question a "good" question? ✓ How do you know if you've asked the right question? ✓ Many educators now recommend that teachers stop using true/false questions. What do you think is their reasoning for this? (*Students can get them right by guessing. The teacher doesn't know if the student guessed or knew the answer.*)

Task

- The narrator states, "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." Teachers spend large portion of class time asking questions. Students will often give the simplest responses, whether written or oral. In the classroom, how does a teacher find her way to the right questions? How does the teacher get more full and complete answers from reluctant students? Develop an explanation for the specific steps you will take in your classroom to ask "the right questions" to illicit a thoughtful response.

The Woman with Einstein's Brain

Theme 4: Women in Science and Gender Bias

Engaging Questions	Reflection Questions
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?	Does gender bias still exist in the classroom? What does it look like?
	What specific actions will I take in my classroom to reduce/limit gender and racial bias in my classroom?
	Does it really make a difference to encourage girls/women to enter "male-dominated" professions?
	How does gender bias manifest in the workplace? What specific actions can be taken to reduce gender/racial bias in the workplace?
	Do you think gender bias/misogyny is increasing in America? Why or why not? If so, what can/should be done about it?

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 over gender bias.
- Assume you are a teacher at a local elementary school. A student comes to you and states she is being bullied because she is Black. What do you do? Research several schools' policies regarding bulling and racism. Compile and present the best and the worst examples. Justify your answers.

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?

Task

- Dr. Diamond said she provided her rats with love. What did she actual do to demonstrate love to the rats? Research current research on love and 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
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?
	What does this research teach us about the aging brain?

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
How does the brain respond to love? Does love affect a child's ability to learn?	How can a teacher provide love in the classroom?
What is the effect of love on an aging brain?	Dr. Diamond says, "Never learn bitterness, because you are the only one who suffers." What did she mean by that? Do you agree or disagree?

Task

- To show love to the rats, Dr. Diamond and her assistant would hold the rats close to the chest and gently stroke them. While this works well for rats, it's not appropriate for a teacher to replicate this behavior with students. How do teachers demonstrate "love" for their students in the classroom? Examine current research to determine if these demonstrations of love effect student learning.

This is Your Brain on Love
Theme 4: Bias

Engaging Questions	Reflection Questions
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	Why were there so few women at UC Berkley in the 1950's and 60's?

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?	
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

Can science improve society? How?	Dr. Diamond described this trip as applied research. What is the difference between applied research and investigative research?
Is science used to determine government policies? Can you give examples?	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?

Tasks

- Dr. Diamond was not satisfied to conduct brain research and teach. She was compelled to act on her research. She went to Columbia 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
How can learning improve your brain?	How is teaching in the classroom similar to applied research
What does your brain need to be healthy?	Why did Dr. Diamond want to go to Cambodia? Why not somewhere here in the United States?
How is brain research used to improve learning in the classroom?	How can we or our organization use Dr. Diamond’s research to make a difference in our community, state, nation?

Task

- Dr. Diamond research demonstrates that there are 5 factors needed for brain health: healthy diet, exercise, challenge, newness, and love- all parts of an enriched environment. Realistically, a teacher can only control so much of her students’ lives. While keeping in mind the grade level you would like most to teach, develop a plan for incorporating these 5 factors into your classroom and into the lives of the students.

Module 4: College Extended Lessons

My Love Affair with the Brain is an excellent resource for any number of college courses and majors. Biology, education, healthcare, and history are obvious examples. For this section, the tasks are designed to not only inform, but to apply directly to the students' areas of study and, when possible, their future careers.

The tasks are designed to follow the view of the entire film. Professors may add, subtract, or modify the tasks to best fit the needs of their students.

Tasks

Science

Use Dr. Diamond's experiments as models for experimental design.

- 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 the 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.
- Allow students to read and analyze Dr. Diamond's paper, "The Effects of an Enriched Environment on the Histology of the Rat Cerebral Cortex." If this had been your research, describe the *next investigation* you would conduct. State the purpose, hypothesis, procedures/methods, expected results, and conclusion.
- Students investigate the role of ethics in science, science research or, more specifically, the role of ethics when working with animals and/or humans in clinical research.

Brain Plasticity

Use Dr. Diamond's work as a starting point for further research. Research may be presented as a paper, poster, an article for a novice reader, or conduct a conference for research presentations.

- Research how brain plasticity influenced further brain research in neurology, education, and/or healthcare. For example, research specific aspects of plasticity, such as,
  - ✓ Changes in synapses- strengthening and weakening of synaptic connections
  - ✓ Functional plasticity- the brain's ability to move functions from a damaged area to an undamaged area.
  - ✓ Structural plasticity- the brain's ability to change its physical structure as a result of learning.
  - ✓ Brain plasticity and diet.
  - ✓ Brain plasticity and exercise
  - ✓ Brain plasticity and newness
  - ✓ Brain plasticity and challenge

- ✓ Brain plasticity and love
- Research how our understanding of neuron: glial cell ratios have changed since Dr. Diamond published her research on Einstein's brain in 1985.

Learning

Use Dr. Diamond's work as a starting point for further research. Research may be presented as a paper, poster, an article for a novice reader, or conduct a conference for research presentations.

- Research how the concept of enriched environments has influenced education. Develop a plan for how this knowledge will specifically influence your work in the classroom. Research can be submitted as a paper or "grant proposal" for funds to create enriched environments in your classroom or building or a "persuasive paper" for why the community should invest in enriched environments for the "new school" being built.
- Science is a way of knowing. How does this way of knowing differ from other forms of knowing, such as personal experience or religion? Why does it matter?
- Dr. Diamond tries to get her students to respond during class, but they are reluctant. She reminds them that 2nd graders aren't afraid to respond. What do you think causes this change in the behavior of students as they get older? Develop a plan for creating a culture in your classroom or school building that decreases fear of participation in students.
- Does the adult brain need an enriched environment to learn? How would this environment differ from the enriched environment in elementary school or high school?
- Create a variety of brochures for parents on the importance of enriched environments and how to create them at home.
- Use research to write a school policy for the use of enriched environments in the classroom.

Women in Science and Gender/Racial Bias

Science is a human endeavor.

- Students can research gender and race bias throughout science history.
- Research how brain plasticity and enriched environments dispelled the idea of genetic determinism.

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Appendix A: 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.

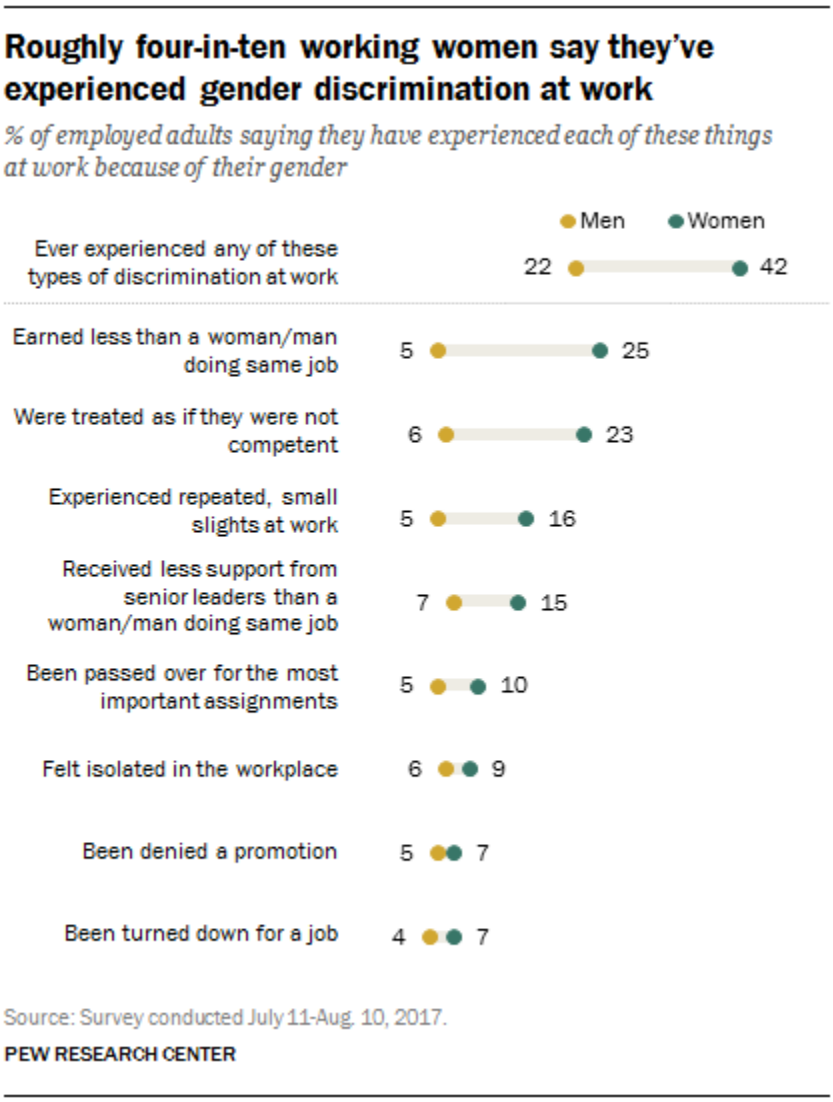
Sterilization laws were introduced in the 1920's in the United States and in the 1930's in Germany. More than half of the U.S. states adopted sterilization laws, which were aimed primarily at compulsory sterilization of those deemed (by white doctors) to be genetically unfit in state and federal institutions.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

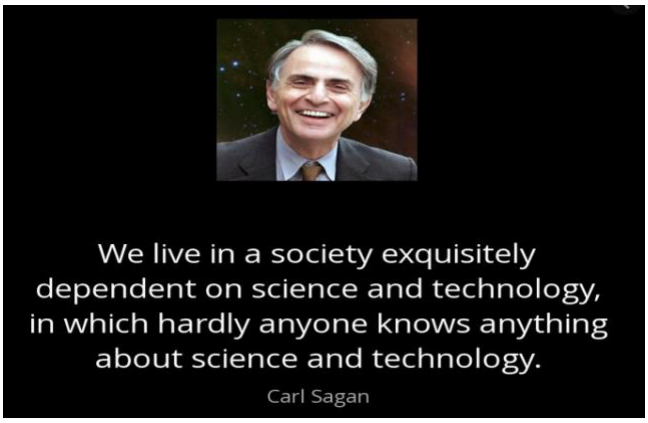
An excellent resource for this topic is Race: The Power of an Illusion, a 3 film documentary on race, science, and society. The website allows you to watch the documentary and has resources for teachers and students.

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 B: 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?

ENGAGING:

_____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)

EXPLORING:

_____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)

EXPLAINING:

_____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 data sets
_____Implemented a cooperative group jigsaw or some other form of peer instruction
_____Other (indicate method)

EXTENDING:

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

EVALUATING:

_____Implemented ongoing assessment throughout the learning cycle
_____Designed an appropriate standard teacher made test
_____Provided the students with a form of alternative assessment (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)