

QUESTION EVERYTHING

-The Scientific Method



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Question Everything - The Scientific Method

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Suggested Lesson Plan

These materials may be used in a variety of ways. For maximum benefit, we suggest the following lesson plan:

- As a class, discuss the Preview Questions OR you might assign one of the Preview Questions as an opening journal activity, then discuss.
- Distribute copies of the Viewing Guide for students to use as a note-taking tool during the video.
- Play the video, pausing if needed to facilitate understanding and note-taking.
- Review and discuss the answers to the Viewing Guide using the Answer Key as a guide.
- Use [Discussion Questions](#) to spark class discussion or assign these questions as homework. Feel free to pick and choose among the questions.
- Administer and grade the [quiz](#) using the Answer Key as a guide or use the online quiz version for immediate, autoscored feedback. (Students should log in to izzit.org as a student using your CLASS CODE – found on the MY ACCOUNT page – to take the online quiz.)

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Preview Questions

(These are meant to be read aloud by the teacher and discussed by the class prior to viewing the video)

1. If you were a medical researcher, would you be willing to use yourself as a “Guinea pig” to test your theory, even if you knew it would make you very sick?
2. What do you know about ulcers?
3. Why would a scientist and/or the medical community not be open to new ideas and choose to follow settled dogma or other old ideas?
4. What can a medical professional do when his/her peers reject their research and theories about an illness and the possible cure for the illness?

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Key Terms

Acid - A corrosive liquid that dissolves some materials

Acid blocker - A substance that inhibits or stops the action of another substance, in this case, acid

Antibiotic - A medication (such as penicillin) that inhibits the growth of, or destroys, micro-organisms

Bacteria - One-celled organisms, spherical, spiral, or rod-shaped and appearing singly or in chains, certain species of which can cause infectious diseases

Biopsy - To remove tissue from a living body for a diagnostic evaluation

Circulate - To pass from place to place or from person to person

Classical Mechanics - The branch of mechanics that is based on Newton's laws of motion

Conclusion – The summary of the results of an experiment, the findings or end results

Cure - A method or substance that ends/heals a medical condition

Curiosity - The desire to learn or know about something

Data - Individual facts, statistics, or items of information

Diagnosis - The process of determining the nature and circumstances of a diseased condition through an examination

Diagnostic - A device or substance used for the analysis or detection of diseases or other medical conditions

Disease - A disordered or incorrectly functioning organ, part, structure, or system of the body, an illness or sickness

Dogma - Prescribed doctrine proclaimed as unquestionably true by a particular group: a settled or established opinion, belief, or principle

Duodenal Ulcer - A peptic ulcer located in the duodenum

Duodenum - The first portion of the small intestine

Endoscope - A slender, tubular optical instrument used as a viewing system for examining an inner part of the body and, with an attached instrument, for biopsy or surgery

Endoscopy - An examination by means of an endoscope

Experiment - A test, trial, or tentative procedure; an act or operation for the purpose of discovering something unknown or of testing a principle, theory, or idea

Fallible - Liable to be erroneous or false; not accurate

Fiberoptic - Using thin, flexible fibers with a glass core through which light signals are sent

Gastritis - An inflammation of the stomach, especially of its mucous membrane

Gastrointestinal - Relating to or affecting the stomach and intestines

Helicobacter Pylori - (pronounced Hel-ee-koh-BAK-ter Pie-LORE-ee) H. pylori - a type of bacteria that infects your stomach. Pylori is common. Many people have it. Most people who have it won't get ulcers or show any symptoms. But it is the main cause of ulcers. Due to H. pylori your stomach can't protect itself very well.

Hypothesis - A proposed explanation made on the basis of limited evidence as the starting point for further investigation

Immune - Protected from a disease

Infect - To affect or contaminate a person, organ, wound, etc. with disease-producing germs

Inflammation - Redness, swelling, pain, tenderness, heat, and/or disturbed function of an area of the body, especially as a reaction of tissues to damaging agents or injury

Intrinsic - Belonging to a thing by its very nature

Irregular - Not conforming to established rules or customs

Microscope - An optical instrument having a magnifying lens or a combination of lenses for inspecting objects too small to be seen or too small to be seen distinctly and in detail by the unaided eye

Natural Philosophy - The rational investigation of the truths and principles of being, knowledge, or conduct. (Originally the phrase Natural Philosophy was used to describe Natural Science)

Nobel Prize - Any of various awards made annually, beginning in 1901, from funds originally established by Alfred B. Nobel for outstanding achievement in physics, chemistry, physiology or medicine, literature, and the promotion of peace

Objective - Not influenced by one's personal feelings, opinions, or thoughts; a true fact

Observation - An act or instance of viewing or noting a fact or occurrence for some scientific or other special purpose

Paradigm - A set of ideas, a way of looking at something

Pathology - The science or the study of the origin, nature, and the conditions and processes and course of a disease

Pharmaceutical - Relating to preparing and dispensing drugs and medicines.

Principles - An accepted or professed rule of action or conduct

Process - A systematic series of actions directed to some end

Progress - Growth or development; continuous improvement

Pylorus - The opening between the stomach and the duodenum

Reject - To refuse to have, take, recognize, accept

Reliable - Trusted; dependable in achievement, accuracy, and honesty

Research - A diligent systematic investigation into a subject in order to discover or revise facts, theories, applications, etc.

Reward - Something given or received in return or recompense for service, merit, hardship

Science - A branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws

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Scientific Method - A method of research in which a problem is identified, relevant data are gathered, a hypothesis is formulated from these data, and the hypothesis is empirically (in a way that is based on or guided by experience or experiment) tested.

Stress - Anxiety, worry

Theory - A coherent group of tested general propositions, commonly regarded as correct, that can be used as principles of explanation and prediction for a class of phenomena: *Einstein's theory of relativity*. A proposed explanation whose status is still conjecture (opinion) and subject to experimentation. A theory is in contrast to well-established propositions that are regarded as matters of actual fact.

Ulcer - A sore on the skin or a mucous membrane

PEOPLE

Sir Francis Bacon (1561-1626): - Credited with the development of the scientific method, which is still used today by scientists around the world. In this sense, Bacon could be considered the father of modern science. He discovered and popularized the scientific method, whereby the laws of science are discovered by gathering and analyzing data from experiments and observations.

Sir Issac Newton (1642-1726) - An English scientist and mathematician of the seventeenth and early eighteenth centuries. Newton made major contributions to the understanding of motion, gravity, and light. He is said to have discovered the principle of gravity when he saw an apple fall to the ground at the same time that the moon was visible in the sky. He also invented calculus.

Dr. J. Robin Warren (1937-Present) - An Australian pathologist who was a co-recipient, with Barry J. Marshall, of the 2005 Nobel Prize for Physiology or Medicine for their discovery that stomach ulcers are an infectious disease caused by bacteria.

Dr. Barry Marshall (1951-Present) - Born in Kalgoorlie, Australia, but spent his childhood from the age of eight in Perth, where he also studied to become a doctor. It was during his employment at the Royal Perth Hospital that he carried out the work with colleague Robin Warren that led to his receiving the Nobel Prize. Marshall has continued his affiliation with the hospital and university in Perth, Australia but is also connected to U.S. universities, including the University of Virginia in Charlottesville.

SAYINGS

Blink of an Eye - A very short span of time

Gold Mine - A source of great wealth or profit

Guinea Pig - Someone or something used as the subject of an experiment

Needle in a Haystack - An item that is very hard or impossible to find because it is concealed by so many other similar things

Question Everything - The Scientific Method Viewing Guide

Student Name: _____

1. The commonest type of ulcer is a _____.
2. A _____ is a little hole in the lining of the stomach.
3. The story of Barry Marshall and stomach ulcers is a very good example of _____ getting in the way of scientific progress.
4. Everything we consider true was learned through a process of curiosity, _____ experimentation, and doubt. This process is called science.
5. Science is the most reliable form of _____.
6. In 1620 the English philosopher _____ (1561-1626) asserted that all knowledge is derived from _____ and _____.
7. Bacon described the scientific method. The basics steps of the scientific method are:
 - A. make an _____ that describes a problem,
 - B. create a _____,
 - C. test the hypothesis through _____, and
 - D. draw conclusions.
8. The principles of the _____ have characterized the scientific progress for hundreds of years and they still do.
9. Barry Marshall teamed up with Dr. Warren who has seen some stomach _____ on _____ samples.
10. If people had any kind of stomach problem, you would put the _____ in the scope with the camera on it and look around in the stomach to see if people had an ulcer.
11. Discovering the *Helicobacter pylori* in patients with stomach ulcers could mean changing the way ulcers are treated with an _____ instead of acid blockers.
12. In the 80s, everyone with ulcers was being put on these _____ tablets.

13. The problem was that they did not _____ you, they would just heal the ulcer and if you stop taking the treatment, a month later your ulcer would come back.
14. The big pharmaceutical _____ could see that it was a gold mine. So, by 1987 they were selling \$5 billion worth of the main drugs. Everyone was so focused on acid and acid blockers, they couldn't really admit that they had been on the wrong track.
15. The whole point of science is you change your mind if the facts change. But in practice _____ behaves in a much more dogmatic fashion than it should and this has been a constant problem in science over the centuries.
16. In order to be taken seriously by the scientific community Marshall and Warren would need to prove that h. pylori _____ causes ulcers in live animals.
17. Marshall and Warren had to _____ an experimental animal with the bacteria and see if ulcers developed.
18. "We tried it on guinea pigs and pigs and rabbits and no luck. They were _____ to these bacteria. So, we decided to do an experiment."
19. And after some discussion with Dr. Warren, we decided that I was going to be the _____. I had to see if a healthy person could be infected.
20. I took the bacteria from a patient who had gastritis or _____ in the stomach.
21. I had a very, very thick infection with these bacteria in the stomach and on the _____, we saw exactly the kind of inflammation that we saw in the ulcer patients.
22. In 2005, the scientific community that had previously ignored their work honored Marshall and Warren with the _____ Prize in medicine.
23. Against prevailing dogmas, Marshall and Warren discovered that one of the most common and important diseases of mankind now can be permanently cured by antibiotics to the benefit of millions of _____.
24. _____ makes its mistakes incredibly quickly.
25. Science throws up millions of _____ every day the vast majority of which will be wrong and then it finds its mistakes incredibly quickly.

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Viewing Guide Answer Key

1. Duodenal ulcer
2. stomach ulcer
3. dogma
4. observation
5. knowledge
6. Francis Bacon, observation and experimentation
7. A. Observation B. Hypothesis C. Experimentation D. Conclusions
8. scientific method
9. bacteria, biopsy
10. fiber optic
11. antibiotic
12. acid blocker
13. cure
14. companies
15. science
16. bacteria
17. infect
18. immune
19. Guinea pig
20. inflammation
21. biopsy
22. Nobel
23. patients
24. Science
25. hypothesis

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Discussion Questions

(These can be used for discussion after the film. Or use them as essay questions and have students respond in writing.)

1. Do you think it takes courage to challenge authority/dogma? Why or why not?
2. Would you have been willing to infect yourself with the bacteria to prove your hypothesis was correct? Why or why not?
3. Why was the medical community unwilling to listen to Dr. Marshall and Dr. Warren's new findings?
4. Who suffered as a result of the delay in accepting the results of their experiments?
5. What role do pharmaceutical companies play in either promoting or deterring research to find a cure for an illness? What does the saying, "follow the money" have to do with it?
6. Who benefits from continuing the current/routine treatments as the standard for medical conditions? Who loses when the medical community overlooks new or different treatments?
7. When the pharmaceutical companies make money from the treatment of a disease or condition, is there less of an incentive for them to try to find a cure for it? Why or why not?
8. What would happen if there was no financial incentive at all for drug companies to create new medications? What would happen to our society and the world in general?
9. If there is no financial benefit in creating a new drug or treatment because few people are affected by a given condition (often called orphan diseases), who should fund the research needed to combat these conditions? Why?
10. If a new drug or treatment is created using taxpayers' money (because it is funded by the government, i.e., the taxpayers), should the drug company still be allowed to profit from it? Why or why not? How would you propose to handle this?
11. Is there a possibility that medical professionals do not readily embrace new ideas about medical research because they do not want to know about or to challenge settled dogma?
12. What are the risks to a doctor who suggests a new form of treatment for their patient? What are the risks to the doctor when the patient requests (or demands) a new form of treatment? What are the risks to a patient when their doctor refuses to explore alternative solutions?
13. Ultimately, who should choose the treatment a patient receives? Why?
14. Why is it so difficult for anyone to have their research and discovery accepted by the medical community?
15. Given the steps of the scientific method, can we ever say that anything is "settled science?" Why or why not?

16. How do you think a person becomes infected with the Helicobacter Pylori bacteria?
***Teacher's Note: (About half the world's population is infected with the Helicobacter Pylori bacteria. You may already have it in your body! You can be infected your whole life with age, predisposition to illness and other factors you can become a candidate for an ulcer flare up.) (You can catch the bacteria by eating dirty things, playing with dirty brothers and sisters or any number of ways in your daily existence).
17. Have any other inventions been created that were the direct result of Dr. Warren's and Dr Marshall's discovery?
***Teacher's Note (The Kimberly-Clark Company has developed a modern approach and is now marketing a Helicobacter Pylori type breathalyzer for use by the medical community to detect the presence of Helicobacter Pylori in an individual's breath.) (Please see the article <https://www.buzzrx.com/blog/how-does-an-h-pylori-breath-test-work>)
18. Did the awarding of the Nobel Prize validate Dr. Warren and Dr. Marshall's research and quest to find a cure for ulcers?

Question Everything - The Scientific Method Comprehension Quiz

Name _____

1. Who were the two researchers who challenged the accepted theory on the causes of ulcers?
 - A. Thomas Edison and Robin Warren
 - B. Isaac Newton and Albert Einstein
 - C. Barry Marshall and Robin Warren
 - D. Barry Marshall and Louis Pasteur
2. What was the widely accepted theory on the causes of ulcers before Marshall and Warren's discovery?
 - A. Bacterial infection
 - B. Stress and anxiety
 - C. Genetic predisposition
 - D. Over-consumption of spicy food
3. What is the name of the bacteria that Marshall and Warren discovered to be the cause of ulcers?
 - A. Helicobacter pylori
 - B. Staphylococcus aureus
 - C. Escherichia coli
 - D. Streptococcus pneumoniae
4. What did Marshall do to prove that the bacteria caused ulcers?
 - A. Infected himself with the bacteria
 - B. Infected mice with the bacteria
 - C. Conducted experiments on human subjects
 - D. Conducted experiments on dogs
5. In the past it used to be that _____ of everybody in the US would get an ulcer sometime in their lifetime.
 - A. 10%
 - B. 25%
 - C. 75%
 - D. 50%
6. How long did it take for the medical community to accept Marshall and Warren's discovery?
 - A. A few weeks
 - B. A few months
 - C. A few years
 - D. A few decades

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7. What lesson can we learn from Marshall and Warren's discovery?
 - A. Scientific research is not important
 - B. Trust in the opinions of authority figures
 - C. Don't challenge the status quo
 - D. Always question accepted theories and dogma
8. What impact did Marshall and Warren's discovery have on the treatment of ulcers?
 - A. Antibiotics became the primary treatment for ulcers
 - B. Surgery became the primary treatment for ulcers
 - C. Home remedies became the primary treatment for ulcers
 - D. No significant impact on treatment
9. Dr. Marshall drank the bacteria and gave himself an ulcer because _____.
 - A. testing on animals is wrong
 - B. the usual testing animals turned out to be immune to the bacteria
 - C. a pharmaceutical company paid him a lot of money to do so
 - D. he believed the bacteria wouldn't give him an ulcer
10. Which of the following is the correct sequence of steps in the scientific method?
 - A. Experimentation, hypothesis, observation, conclusion
 - B. Hypothesis, experimentation, conclusion, observation
 - C. Observation, hypothesis, experimentation, conclusion
 - D. Observation, experimentation, hypothesis, conclusion

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Quiz Answer Key

1. C
2. B
3. A
4. A
5. A
6. D
7. D
8. A
9. B
10. C

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Activity: Who Chooses? Who Benefits? Who Pays? What's Fair?

The four questions above can be a useful tool for evaluating any policy or system. Posing the questions is a great way to stimulate critical thinking. As a class, or in small groups, discuss the following:

(For each question, think broadly about all the possible people or groups of people who may be affected, and remember there may be non-monetary costs and benefits.)

1. Who pays (financially) for scientific research? Why does it matter who is paying? Why is it important to consider who paid for a study when reviewing the results of it?
2. Who “pays” (in a non-financial way) for scientific research that is not shared at first, like Dr. Marshall and Dr. Warren’s research on ulcers? What costs did those people pay? What are the ripple effects of people not having the treatment they need and suffering with ulcers instead of being cured?
3. If a government (i.e. the country’s taxpayers) pays for scientific research, who should benefit financially from the results? What would be fair in that case?
4. Who chooses what research should be done? Who chooses if scientific research is released to the public?
5. Who benefits from scientific research? Who benefited from Dr. Marshall and Dr. Warren’s research? Who benefits from restricting research?

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Enrichment and Integration Activities

- A. Have students discuss this quote as a class and why it is an important theme in the video.

“If I see further, it is by standing on the shoulders of giants.” Sir Issac Newton

- B. For the quotes below, students may be assigned to write a short response paragraph in explaining the meaning of the quote. Students may select two quotes or the teacher may assign a Think, Pair, and Share activity for specific quotes. (A video explanation of Think, Pair, Share: <https://www.teachingchannel.org/videos/think-pair-share-lesson-idea>) Students should recognize that in order to achieve a goal, sometimes it takes courage in action to do so.

“Hope lies in the dream in imagination, and the courage of those who dare to make dreams into reality” Jonas Salk

“I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forgo their use.” Galileo Galilei

“In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual.” Galileo Galilei

“I wish, my dear Kepler, that we could have a good laugh together at the extraordinary stupidity of the mob. What do you think of the foremost philosophers of this University? In spite of my oft-repeated efforts and invitations, they have refused, with the obstinacy of a glutted adder, to look at the planets or moon or my telescope.” Galileo Galilei

“All truths are easy to understand once they are discovered; the point is to discover them.” Galileo Galilei

“I can easily conceive, most Holy Father, that as soon as some people learn that in this book which I have written concerning the revolutions of the heavenly bodies, I ascribe certain motions to the Earth, they will cry out at once that I and my theory should be rejected.” Nicolaus Copernicus

“We all have dreams. But in order to make dreams come into reality, it takes an awful lot of determination, dedication, self-discipline, and effort.” Jesse Owens

“Mendel’s contemporaries failed to recognize the importance of his work because his findings went against prevailing (popular) ideas about inheritance.” Anonymous

- C. LESSON EXTENSION: Have the students, either in pairs or a group, create a “What Would They Say” quote, reflecting on what happened to Dr. Marshall and Dr. Warren.

Activity: Dr. Warren and Dr. Marshall were not the first scientists to have their ideas rejected. Students may work with a partner or individually research two individuals who also had their ideas rejected by the prevailing dogma of their era.

Some suggested individuals are DaVinci, Galileo, Copernicus, Kepler, Mendel, Walter Reed, Louis Pasteur, Jonas Salk, Warner Forssman.

Others to consider that self-experimented and were successful: 1. Ramsey - anesthetic gases, 2. Lawrence - radioactive sodium 3. Metchnikoff - He injected himself with the spirochetes of relapsing fever. Forssman - cardiac catheterization. (Each won a Nobel Prize.)

An extension of this idea would be for students to create a biography poster of the individual listing the following information:

Name

Dates

Discovery

Reason the discovery was rejected

Students will also report in a paragraph consisting of a minimum of 5 sentences on the result the discovery and any other inventions created as a result from the discovery.

Students could present their information to the class or create a gallery walk where one piece of information that is learned is recorded on a name card and a teacher drawing is held for a small prize or a free homework pass.

D. Cartoon Analysis

See comic image on next page

When a message is conveyed by a visualization, one positive take away is that students become invested in looking beyond the words posted on paper. Students begin to see the invidious message that not just the words, but an image portrays.

In this cartoon, what people, and things are represented?

List all that you can identify:

Observation (What details stand out to you?)

Analysis (What do the details reveal/suggest? What main idea do you take away from the cartoon?)

- Analyze the items you identified above.
- What does each person, place, or thing symbolize?
- What message is the artist trying to convey to the reader?
- If you wish, students can then share their responses with a partner or peer group.
- Review answers together as a class.

IT'S NOW JULY 1984. MARSHALL IS FED TO THE TEETH WITH ANIMAL EXPERIMENTS. HE HAS NO MORE TIME TO WASTE.



WITH A WILD GLINT IN HIS EYE, MARSHALL DOWNS THE SWARMING BREW—A COCKTAIL BRIMMING WITH A BILLION BACTERIA!



To interject some humor and to provide examples of how ulcers have been portrayed in the comic book medium, the teacher may have the students check out the article listed below. Rather entertaining and informative: re Spiderman!

Published May 22, 2022

<https://www.cbr.com/spider-man-ulcer-returns/>

E. MORE EXTENDED LEARNING ACTIVITIES

This activity may be determined by the class composition student abilities and creativity.

1. Ask students to imagine they are advisers to The American Medical Association and have been asked to create a story board, picture graphic comic book with a minimum of 20 slides the tells the story of the Cure for Ulcers.” Students should use at least 12 of the vocabulary words from the vocabulary list. (The teacher may create a rubric for grading the student creations.)

- A. Students may create a poster, song or a poem about the discovery for the “Ulcer Cure.”

- B. Student incentive if the student creates a “RAP or Hip-Hop Beat”-the teacher will perform the lyrics or allow the student to so. This activity will encourage not only creativity but encourage the student to engage in a manner of public speaking and delivery.

The site <http://rubistar.4teachers.org> is an excellent source for creating a rubric styled to your classroom.

- C. Students will create a (on paper) Facebook page for the scientist that they choose to research. The choice is not limited to the medical profession listing their information, idea(s) and what inventions we have in 2023 due to this individuals research.

2. Have the students create a Top seven list of Illnesses Cured or eradicated(eliminated) in the last 100 years. (Examples: Polio, Small Pox,etc.) Students should note the illness, the parties who discovered the cure and the impact the cure has had on society. Students will also create and also create a Top Seven Rotten Tomato list of illnesses that the medical profession has not been able to conquer. (Examples: Cancer, Leukemia, COVID etc). Query Question: Respond in a 5-sentence paragraph: Why do you think our medical professionals and scientists have not found a cure for these illnesses?

3. Have students role play the scenario of Dr. Williams and Dr. Warren appearing before a medical panel with their research and the Medical Review Committee rejects their ideas. Students on the review panel will prepare logical questions to ask of the doctors. The doctors will need to prepare their responses to questions.

*** (This activity allows students to gain an insight into the simulated real time experiences of the doctors and perhaps comprehend why Dr. Warren was so intent of proving their research to the medical authorities-despite the accepted dogma. The class should debrief the scenario and vocalize their reaction and evaluation of what happened.)

4. Have the students create a three or four paragraph letter to the “Acid Mafia” informing them that the new way to treat an ulcer will be with antibiotics and explain why in your letter.
5. Working in groups of four have the students’ become journalists. Students will create an informational news column describing Dr. Warren and Dr. Marshall’s discovery of the cure for ulcers. Students may also create a mock interview with questions and responses posed to the doctors to include their perspectives on their quest to find a cure for ulcers.

***** For this activity the teacher may use a text to speech version of the video dialogue to help students construct interview questions.

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