



PEABODY

THE SCIENCE FAIR AFFAIR

STUDY GUIDE

Peabody: The Science Fair Affair is a fast-paced and fun play that is sure to provoke some deep thinking about science and the nature of the world around us.

Included in this study guide are activities geared toward intermediate and middle school students, short biographies of the scientists highlighted in the play, resources for teachers and students involved in science fairs, and tips on how to make your theater visit more enjoyable.

What Is the Process of Inquiry?

The process of inquiry is the process by which all scientific discoveries occur, both in and out of the classroom.

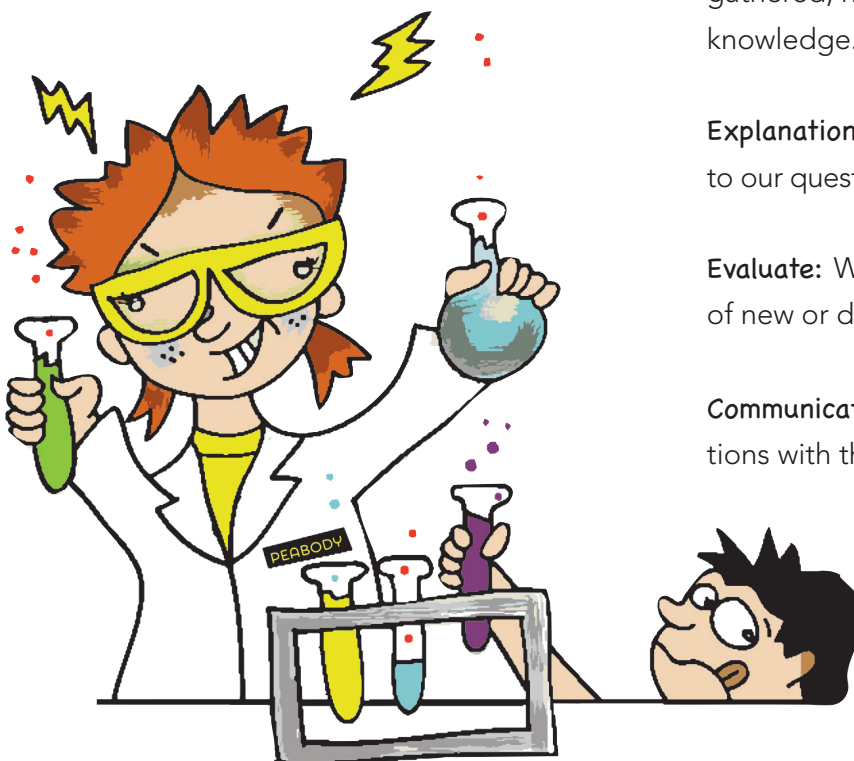
Question: All scientific discovery begins with scientifically-oriented questions.

Priority to Evidence: When attempting to answer our scientifically oriented questions, we must give priority to the evidence gathered. Scientific knowledge comes from data and evidence gathered, not from assumptions or false knowledge.

Explanation: We create explanations (or answers) to our questions based on the evidence gathered.

Evaluate: We evaluate our explanations in light of new or differing evidence.

Communication: We communicate our explanations with the world and the scientific community.





Activities for Lesson Planning

Scientifically Oriented Questions vs. Non-Scientific Questions

Time: 20-30 minutes

Supplies Needed: None

Preparation: Create a list of questions, some scientifically-oriented, some not.

Background Knowledge: Scientifically oriented questions are questions that are able to be answered through a scientific process.

Some examples of scientific questions are:

- What fertilizer works best for growing sunflowers?
- What percentage of our students want to be able to wear costumes on Halloween?
- How can we provide fresh water to communities hit by hurricanes?

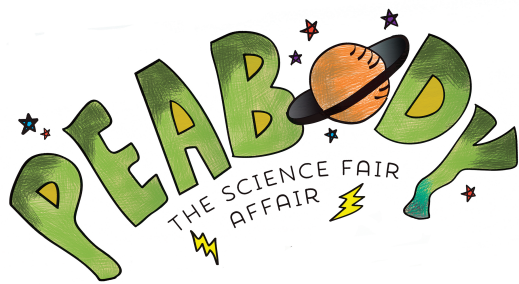
Non-scientific questions are usually questions related to emotions, theology, opinion, or are unable to be answered through a scientific process.

Non-scientific questions might include:

- Why does God exist?
- How come my parents had to have another baby?
- Why does Johnny pick on me?

Activity:

- ① Introduce the process of inquiry to students.
- ② Focus on the idea that all science begins with questions. Ask students, "What are some questions that science could answer?" Prompt students with some of the prepared scientific questions if needed.
- ③ If/when a student suggests a non-scientifically-oriented question, write the question on the board or re-direct the discussion by asking students, "Do you think science can answer that question? If so, how?"
- ④ Guide students toward the idea that some questions cannot be answered by science, and create a list if desired of scientific questions and non-scientific questions.
- ⑤ When you have a list of some scientific questions, you can continue the activity by encouraging students to develop methods to answer these questions. Depending on your age group/time available, this can be done as a whole class discussion or in groups.
- ⑥ Encourage your students to write out the steps needed to answer these questions, thus creating procedures for the hypothetical scenarios.



Activities for Lesson Planning

Charlie Brown "Little Known Facts" Investigation Activity

Time: 40-60 minutes

Supplies Needed: Internet access for you and students, speakers, and attached worksheet

Preparation: None

Background Knowledge: The musical *You're a Good Man Charlie Brown* is a comedy based on the comic strip "Peanuts." The song "Little Known Facts" involves the character Lucy trying to teach her little brother, Linus, about nature, but she is wildly uninformed about the content and continually gives Linus incorrect information, much to Charlie Brown's dismay.

Activity:

- ① Inform students that they are going to hear a song from the Broadway musical, *You're a Good Man Charlie Brown*. Ask if anyone has seen the musical or is familiar with the comic strip "Peanuts."
- ② Give students a synopsis of the song, then ask them to write down as many incorrect facts or questions Linus is asking as they can while listening to the song.
- ③ Play the song twice using YouTube to give students a chance to write down 3-4 incorrect facts or questions. Review the incorrect facts/statements when finished. These might include:
 - Fir trees produce animal fur to be made into coats. During winter, they produce wool.
 - Elm trees grow into oak trees as they get older and larger. You can also determine a young elm tree's age by counting its leaves.
 - Clouds are the cause of blowing wind.
 - The way grass grows involves insects tugging seedlings to the point that they grow to their adult state.
 - A fire hydrant is like a plant and for reasons unknown and gives off tremendous amounts of water.
 - Lucy points to Woodstock says that he is an eagle but since he is still little, he is called a sparrow. Also, humans consume eagles as a meal for Christmas and Thanksgiving.
 - Galactic forms, such as stars and planets, are the cause of rain.
 - Snow comes up out of the ground like grass and the wind blows it around to make it look like it's falling.
 - If someone bangs their head on a tree, it is to loosen the bark for the tree to grow faster.
- ④ Once you have reviewed all the incorrect facts, help students turn the incorrect statements into questions. For example:
 - Where does wool come from?
 - How can you tell how old a tree is?
 - What does grass need to grow?
- ⑤ Once you have a list of questions, either group students or let them work individually on investigating the questions created. You can use the attached worksheet or create your own project guidelines.

Names:

Date:

“Little Known Facts” Activity

Question I’m Investigating:

What Lucy thought:

The Truth (My Explanation):

Where I found my answer:



Activities for Lesson Planning

Discover a Scientist Research Project

Time: 40+ minutes (depending on age of students and scope of project)

Supplies Needed: Attached worksheet, scientist biographies (see resources included in this study guide), and Internet access for students

Preparation: Have a discussion with students about the process of inquiry. Highlight that all scientific discovery begins with a question. Determine the scope of the project, and create project guidelines if desired.

Activity:

- ① Have students read the biographies of the scientists included in this study guide.
- ② Divide students into groups to research more about each scientist using the resources provided. You can create your own research guidelines, or use the worksheet provided. One of the primary focuses should be what questions the scientists were asking. You can help students create these by asking, "What were the scientists trying to discover?"

This project can be as elaborate or as simple as you want. You can have the students simply fill out the worksheet, or you can have the students deepen their research and create presentations to share with the class. Make it work to fit with your class!

Names:

Date:

Discover a Scientist!

Name of Scientist:

Date Born:

Date Died:

Areas of Scientific Study:

Major Achievements / What he or she is known for:

Why do we remember this scientist today?

What questions was he or she asking?



Ideas and Resources for Science Fairs

Students interested in the science, technology, engineering and mathematics fields (STEM) often find a science fair is the inspiration for exploring their solutions to real world issues. Science fair competitions require students to engage in legitimate STEM research, present findings and communicate results. The impact of science fair work can go far beyond the classroom. A directory of major science fair competitions and organizations is available here:

<http://www.sciencebuddies.org/science-fair-projects/scifair.shtml>

The **Intel International Science and Engineering Fair** (Intel ISEF), a program of Society for Science & the Public (SSP), is the world's largest international pre-college science competition. Almost 2000 high school students from around the world participate and share their independent research each year. Visit: <http://www.societyforscience.org/intel-international-science-and-engineering-fair>

These projects address real world problems. Participants develop imaginative, unique and workable solutions. Often students address needs that require simple and durable solutions.

A few examples of project abstracts are highlighted below:

- A study on how to best reclaim desert soil:
<http://apps2.societyforscience.org/abstracts/project.cfm?PID=EM001&Year=2014>
- The use of microbial fuel cells to generate electricity and clean wastewater: <https://apps2.societyforscience.org/abstracts/project.cfm?PID=EM001&Year=2008>
- Creating solar powered water filtration systems:
<http://apps2.societyforscience.org/abstracts/project.cfm?PID=EM002&Year=2010>
- The impact of recycled newspaper on agricultural land:
<http://apps2.societyforscience.org/abstracts/project.cfm?PID=EV066&Year=2003>

For educators, the potential may lie in the replication of these award winning projects with your students. A comprehensive searchable database for ISEF project abstracts is available here:

<http://apps2.societyforscience.org/abstracts/index.asp>

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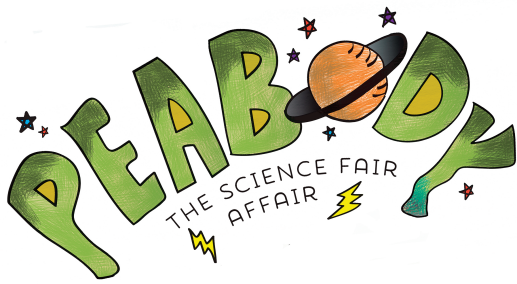
Ideas and Resources for Science Fairs, continued

The **Conrad Spirit of Innovation Challenge** is an annual competition that challenges high school students (ages 13-18) from across the globe to use STEM, innovation and entrepreneurship to develop technologies and solutions to real-world needs. Visit: <http://www.conradchallenge.org>. The competition is in four categories. Recent winning project videos are available here:

- In aerospace & aviation, a project that provides clean water for extended space travel
http://www.youtube.com/watch?v=JFtG_7pWKUQ&feature=youtube
- In energy & environment, a process for detecting ozone levels
<http://vimeo.com/62056552>
- In energy & environment, a product that helps clean up oil spills
http://www.youtube.com/watch?v=b_u7xNRzUzg&feature=youtube
- In health & nutrition, an invention that assists person's with hand tremors,
<http://www.youtube.com/watch?v=hWr4HU6jKlg&feature=youtube>

Project-based STEM investigations allow for focused study, differentiation across abilities, and cooperative learning. Potential ideas for projects at varying academic levels are available here: http://www.sciencebuddies.org/science-fair-projects/project_ideas.shtml#browseallprojects





Science Topics to Investigate

The play presents many science topics that you may be interested in investigating with your students. Below you can find a few selected topics and some resources to get you started.

Life Science Topics

Kidney Function

- Key Questions: What jobs do our kidneys do? How do they function?
- Resources:
<http://www.niddk.nih.gov/health-information/health-topics/Anatomy/kidneys-how-they-work/Pages/anatomy.aspx>

Pasteurization

- Key Questions: What is pasteurization? Why does this process have such a weird name? When and how was it developed? What does it have to do with modern life?
- Resources: <http://humantouchofchemistry.com/the-promise-of-pasteurization.htm>

Importance of Water for Human Health

- Key Questions: Why do our bodies need water? What happens if we do not get enough water?
- Resources: http://kidshealth.org/kid/stay_healthy/food/water.html

Chemistry Topics

Oxidation, Saltpeter, Ammonia, or Phosphorus

- Resources:
<http://cavemanchemistry.com/oldcave/projects/gunpowder/>
<http://www.livescience.com/45986-what-is-chemistry.html>

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Science Topics to Investigate, continued

Physical and Applied Science Topics

Gravity

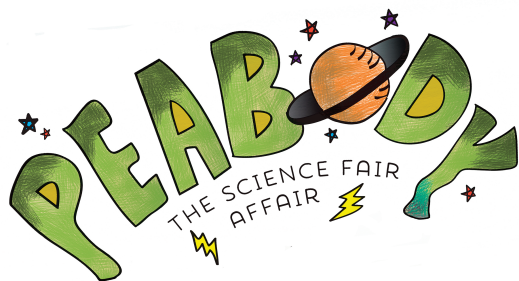
- Key Questions: What is gravity? How did Newton really come up with this idea (is the apple story fact or fiction)?
- Resources: <http://www.sciencekids.co.nz/sciencefacts/scientists/isaacnewton.html>

Solar Distillation

- Key Questions: What is solar distillation and how does it work? Could this be a way to provide fresh, clean water to people on Earth who need it? Can you really drink water that is distilled from human urine? How is solar distillation similar to the process that happens naturally during the water cycle?
- Resources:
<http://energyinformative.org/how-solar-powered-distillation-of-water-works/>
<http://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.solarstill1/solar-still-part-i-salt-water/>

Access to Fresh Water as a Global Issue

- Key Questions: Where is fresh water found on Earth? Where on Earth is access to fresh water a problem? What are the many ways in which a shortage of fresh water may affect people and society? Consider human health, hunger, agriculture, economic impacts, soils, and so on. How does a shortage of fresh water affect ecosystems? How does global climate change impact the availability of fresh water on Earth? What can we do here to help conserve Earth's fresh water?
- Resources:
<http://environment.nationalgeographic.com/environment/freshwater/freshwater-crisis/>
<http://water.usgs.gov/edu/earthwherewater.html>



Brief Biographies of Scientists Mentioned in the Play

Hasan Al-Rammah (d. 1295 AD), a thirteenth-century military engineer, described the first process for the purification of potassium nitrate in his book *al-furusiyya wa al-manasib al-harbiyya* (The Book of Military Horsemanship and Ingenious War Devices).

Source: "Hasan Al-Rammah." Hasan Al-Rammah. <http://www.muslimheritage.com/scholars/hasan-al-rammah> 1 Sept. 2015.

More Information:

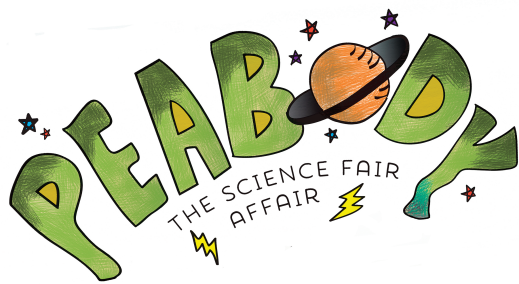
- Hassani, Salim T. S. 1001 Inventions: The Enduring Legacy of Muslim Civilization. 3rd ed. Washington, D.C.: National Geographic, 2012. Print.
- "Model, Rocket Torpedo, Hassan Er-Rammah or Hasan Al-Rammah, Ca. 1280 A.D." Model, Rocket Torpedo, Hassan Er-Rammah or Hasan Al-Rammah, Ca. 1280 A.D. Smithsonian National Air and Space Museum. http://airandspace.si.edu/collections/artifact.cfm?object=nasm_A19762056000 1 Sept. 2015.
- "Muslim Rocket Technology." Muslim Rocket Technology. <http://www.muslimheritage.com/article/muslim-rocket-technology> 1 Sept. 2015.
- Samuels, Charlie. Medieval Science, 500-1500. New York: Gareth Stevens Pub., 2011. Print.

Robert Boyle was born on January 25th, 1627. He was the youngest of 14 children! Robert studied at Eton starting at age 8 and attended Oxford later in life. His most influential scientific discovery was that the universe is made up of tiny particles of various shapes and sizes. His experimental approach made chemistry into the modern science it is today.

Source: "Robert Boyle." Great Lives from History: The Seventeenth Century. Salem Press. 2006.

More Information:

- Cobb, Cathy, and Monty L. Fetterolf. The Chemistry of Alchemy: From Dragon's Blood to Donkey Dung, How Chemistry Was Forged. Print.
- Curley, Robert. Scientists and Inventors of the Renaissance. New York: Britannica Educational Pub. in Association with Rosen Educational Services, 2013. Print.
- Gow, Mary. Robert Boyle: Pioneer of Experimental Chemistry. Berkeley Heights, NJ: Enslow, 2005. Print.
- Hakim, Joy. The Story of Science: Newton at the Center. Washington: Smithsonian, 2005. Print.
- BBC News. BBC. http://www.bbc.co.uk/history/historic_figures/boyle_robert.shtml 1 Sept. 2015.



Brief Biographies of Scientists Mentioned in the Play, continued

Edward Drinker Cope was born in 1840. He studied at the Academy of Natural Sciences and the Smithsonian Institution. He was a paleontologist who studied evolution and fossils. His collection is housed in the American Museum of Natural History in New York.

Source: Edward Drinker Cope. Columbia Electronic Encyclopedia, 6Th Edition [serial online]. June 2015;:1. Available from: Middle Search Plus, Ipswich, MA. Accessed September 1, 2015

More Information:

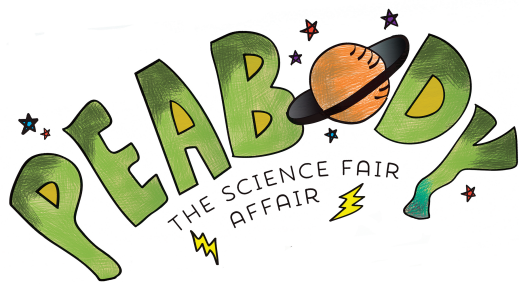
- Dinosaur Wars. PBS, 2011. DVD.
- "Edward Drinker Cope | Biography - American Paleontologist." Encyclopedia Britannica Online. Encyclopedia Britannica. <http://www.britannica.com/biography/Edward-Drinker-Cope> 1 Sept. 2015.
- "Edward Drinker Cope and the Story of the Paleontologist's Wandering Skull." Mental Floss. <http://mentalfloss.com/article/60125/edward-drinker-cope-and-story-paleontologists-wandering-skull> 1 Sept. 2015.
- Johnson, Rebecca L. Battle of the Dinosaur Bones: Othniel Charles Marsh vs. Edward Drinker Cope. Minneapolis: Twenty-First Century, 2013. Print.
- Kimmel, Elizabeth Cody. Dinosaur Bone War: Cope and Marsh's Fossil Feud. New York: Random House, 2006. Print.

Galileo was born on February 15, 1564 in what is now Italy. He enrolled in the University of Pisa in 1581 to study medicine, but it was math that really interested him. He studied mathematical theories on his own while ignoring medicine and eventually left the university without a degree to follow his interest. Galileo designed and built his own telescope to examine the stars and concluded that the Sun was the center of the solar system, not the Earth as the church believed. Galileo was convicted of heresy and spent the rest of his life under house arrest.

Source: "Galileo." Great Lives from History: The Seventeenth Century. Salem Press. 2006.

More information:

- Heilbron, J. L. Galileo. Oxford [England: Oxford UP, 2010. Print.
- Numbers, Ronald L. Galileo Goes to Jail: And Other Myths about Science and Religion. Cambridge, Mass.: Harvard UP, 2009. Print.
- Panchyk, Richard. Galileo for Kids His Life and Ideas. Chicago, Ill.: Chicago Review, 2005. Print.
- Rogers, Kara. The 100 Most Influential Scientists of All Time. New York, NY: Britannica Educational Pub. in Association with Rosen Educational Services, 2010. Print.
- Steele, Philip. Galileo: The Genius Who Faced the Inquisition. Washington, D.C.: National Geographic, 2005. Print.



Brief Biographies of Scientists Mentioned in the Play, continued

Margaret Hamilton, who won NASA's Exceptional Space Act Award for her work on the Apollo systems, was a software engineer and a member of the MIT team working with NASA on the Apollo space missions. She helped to develop Apollo 11's on-board flight software. Her hard work helped man walk on the moon in 1969.

Source: "Remembering the Apollo 11 Moon Landing With the Woman Who Made It Happen." Time.

<http://time.com/3948364/moon-landing-apollo-11-margaret-hamilton/> 1 Sept. 2015.

More Information:

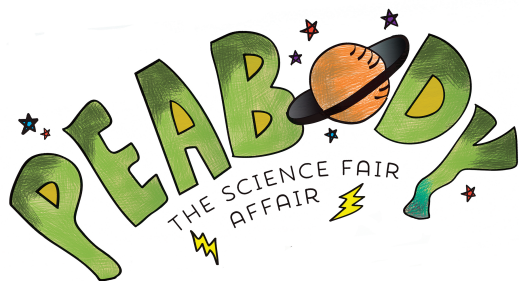
- Floca, Brian. Moonshot: The Flight of Apollo 11. New York: Atheneum for Young Readers, 2009. Print.
- "Margaret Hamilton." NASA. <http://www.hq.nasa.gov/alsj/a11/a11Hamilton.html> 1 Sept. 2015.
- Rothman, Lily. "Remembering The Apollo 11 Moon Landing With The Woman Who Made It Happen." Time.Com (2015): N.PAG. Corporate ResourceNet. Web. 1 Sept. 2015.
- "Software — and a Woman — at the Heart of Lunar Triumph." Wired.com. Conde Nast Digital. <http://www.wired.com/insights/2014/08/software-woman-heart-lunar-triumph/> 1 Sept. 2015.
- Thimmesh, Catherine. Team Moon: How 400,000 People Landed Apollo 11 on the Moon. Boston: Houghton Mifflin, 2006. Print.

Charles Marsh was born in 1831 and studied at Yale University. He discovered many dinosaur fossils including pterodactyls and early ancestors of the horse. His discoveries are on display at the Peabody Museum of Natural History.

Source: "Marsh, Othniel Charles." Funk & Wagnalls New World Encyclopedia (2014): 1p. 1. Funk & Wagnalls New World Encyclopedia. Web. 1 Sept. 2015.

More Information:

- Dinosaur Wars. PBS, 2011. DVD.
- Engber, Daniel. "A Brilliant Paleontologist, Unfit for Battle in the Bone Wars." http://www.slate.com/articles/business/rivalries/2013/08/dinosaur_bone_wars_othniel_charles_marshall_edward_drinker_cope_and_their_forgotten.html 1 Sept. 2015.
- Johnson, Rebecca L. Battle of the Dinosaur Bones: Othniel Charles Marsh vs. Edward Drinker Cope. Minneapolis: Twenty-First Century, 2013. Print.
- "O.C. Marsh, Before the Bone Wars." Wired.com. Conde Nast Digital. <http://www.wired.com/2011/08/o-c-marsh-before-the-bone-wars/> 1 Sept. 2015.
- "Othniel Charles Marsh | Biography—American Paleontologist." Encyclopedia Britannica Online. Encyclopedia Britannica. <http://www.britannica.com/biography/Othniel-Charles-Marsh> 1 Sept. 2015.



Brief Biographies of Scientists Mentioned in the Play, continued

Isaac Newton was born on December 25th, 1642. He attended Cambridge University and actually waited tables to help finance his studies. Newton's contributions to math and science include; differential calculus, the reflecting telescope, and his theory of gravity.

Source: "Sir Isaac Newton." Great Lives from History: The Seventeenth Century. Salem Press. 2006.

More information:

- Hollihan, Kerrie Logan. Isaac Newton and Physics for Kids: His Life and Ideas with 21 Activities. Chicago, Ill.: Chicago Review, 2009. Print.
- Krull, Kathleen, and Boris Kulikov. Isaac Newton. New York: Viking, 2006. Print.
- Numbers, Ronald L. Galileo Goes to Jail: And Other Myths about Science and Religion. Cambridge, Mass.: Harvard UP, 2009. Print.
- Rogers, Kara. The 100 Most Influential Scientists of All Time. New York, NY: Britannica Educational Pub. in Association with Rosen Educational Services, 2010. Print.
- White, Michael. Isaac Newton: The Last Sorcerer. Reading, Mass.: Addison-Wesley, 1997. Print.
- Wilkinson, Philip, and Michael Pollard. Scientists Who Changed the World. New York: Chelsea House, 1994. Print.

Friedrich Wohler was born on July 31st, 1800. Friedrich showed an early interest in science, conducting chemistry experiments on his own. He attended the University of Marburg to study medicine. He was able to create urea in a lab without, "the kidney of a human or a dog."

Source: "Friedrich Wöhler." Great Lives from History: The Nineteenth Century. Salem Press. 2007.

More Information:

- "Friedrich Wohler | German Chemist." Encyclopedia Britannica Online. Encyclopedia Britannica. <http://www.britannica.com/biography/Friedrich-Wohler> 1 Sept. 2015.
- HowStuffWorks. HowStuffWorks.com. <http://science.howstuffworks.com/dictionary/famous-scientists/chemists/friedrich-wohler-info.htm> 1 Sept. 2015.
- Watson, Peter. The German Genius: Europe's Third Renaissance, the Second Scientific Revolution, and the Twentieth Century. New York: Harper, 2010. Print.
- Balchin, Jon. Science: 100 Scientists Who Changed the World. New York: Enchanted Lion, 2003. Print.
- Bonnet, Robert L., and Dan Keen. 46 Science Fair Projects for the Evil Genius. New York: McGraw-Hill, 2009. Print.
- Bragg, Georgia, and Kevin Malley. How They Croaked: The Awful Ends of the Awfully Famous. New York: Walker, 2011. Print.



Additional Resources

Learn to Code

Increasingly, computer science skills are becoming an essential component of a S.T.E.M. (Science, Technology, Engineering and Math) curriculum. Learning to code helps students develop logic and problem-solving skills, and exercise their creativity. Free resources for learning how to code are available online. See resources below:

- Code.org® is a non-profit dedicated to expanding access to computer science. All curriculum resources and tutorials are free to use under a Creative Commons license.
<http://code.org>
- Learn core coding concepts and how to make your own games with Hopscotch, available as a free app for the iPhone and iPad.
<http://www.gethopscotch.com>
- Developed by the MIT Media Lab, Scratch is a programming language and online community where you can create your own interactive stories, games, and animations.
<http://scratch.mit.edu>
- Tynker is a creative computing platform where kids learn to program and build games, apps and more. Both online courses and free apps for tablets available.
<http://www.tynker.com>

Books About Pee, Poop, and Other Gross Stuff

- *Gee Whiz, It's All About Pee!* by Susan Goodman
- *Poop: A Natural History of the Unmentionable* by Nicola Davies
- *The Truth About Poop* Susan Goodman
- *Why Is Snot Green? And Other Extremely Important Questions (and Answers)* by Glenn Murphy

Find these books and more with **Gross-out Reads!** at the Monroe County Public Library

<http://mcpl.info/staff-picks/Gross-out%20Reads%21>



Tips for Enjoying Your Theatre Experience

"All the world's a stage, And all the men and women merely players."

—William Shakespeare, *As You Like It*

- ① Going to the theater is a lot like going to the movies. It's important to turn off your cell phone the whole time you're there. It can be tempting to take a selfie for your Instagram, especially if the theater is historic or particularly picture worthy, but make sure to do that long before the play starts. The sound from your phone is distracting to everyone around you, but even if you silence it, the light from the screen is just as bad as the sound. Your best bet is to take your cute pic, post it, turn off your phone completely, and then turn it back on after the play is over to check all your likes and comments.
- ② You're probably at the theater with friends, family, or a date. They're really fun people who you want to chat with, but save your conversations until intermission. Pay attention to the play, and you can easily lose yourself in the story. Whispering to your friends is not only distracting to the people around you, but also to you—and even to the actors. Actors are real, live people putting their all into this performance, and they deserve our respectful attention.
- ③ Another thing that's very distracting to everyone is getting up to leave in the middle of the play. Make sure to use the restroom before the show starts and then wait until intermission to check your hair or your #OOTD (outfit of the day). While you're watching the play, just relax and focus on the sets, lighting, costumes, and all the expressions, gestures and inflections actors use to communicate emotion and draw you into the story. Enjoy yourself and make sure you don't get in the way of anyone else's enjoyment. Seeing a play is an amazing experience, unlike any other entertainment out there.