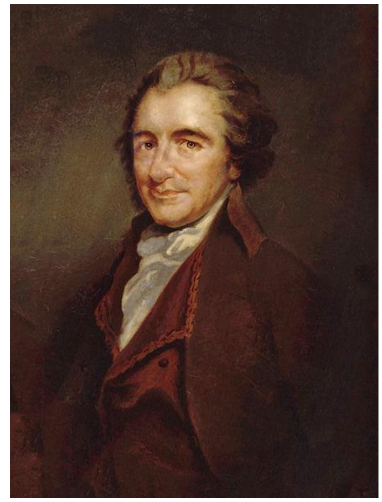
**new jersey 350**

innovation • diversity • liberty

# The First Science Experiment in the United States



**Thomas Paine**
copy by Auguste Millière, after an engraving by William Sharp, after George Romney
oil on canvas, circa 1876 (1792)
16 in. x 12 in. (406 mm x 305 mm)
Given by Henry Willett, 1892
Primary Collection
NPG 897

Target Age: High School
Time Period: 18th Century
Featured County: Somerset
NJ 350th Theme: Innovation

Common Core State Standards for English Language Arts:

R.CCR.7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.

W.CCR.7: Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under consideration.

SL.CCR.4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

NJ Common Core Standards:
Social Studies: 6.1.12.C.3, 6.2.12.C.3, 6.2.12.D.3

**FOCUS QUESTION:** How important was science to the nation's founding fathers?

**BACKGROUND:**
In 1783, while the Continental Congress met in Princeton, Rockingham, NJ served as General George Washington's final Revolutionary War headquarters. A local resident, Mrs. Margaret Berrien, had put her estate up for sale, but agreed to rent the estate and furnishings on a monthly basis. That August, General Washington, his wife, three aides-de-camp, a small guard of two to three dozen soldiers, and several servants and slaves took up residence. And so it was in New Jersey on October 31, 1783 that Washington and Congress received the long awaited news that the final version of the Treaty of Paris had been signed and the thirteen colonies independent from Great Britain.

Just a week later Thomas Paine paid a visit to Washington in Rockingham, in part to discuss Washington's ideas about military pensions. One night Paine and Washington spoke with two colonels about the will-o-the-wisp, fiery globes that people sometimes claimed to see floating over marshes. They came up with two plausible hypotheses. The colonels thought that the light came from some kind of matter in the marshes, such as turpentine. Washington and Paine thought it was a gas.

The next night the men sought to test their theory. They set sail on Millstone River in a scow with some soldiers who poked poles into the mud while Washington and Paine held torches nearby. They saw bubbles rise, and then a flash of light broke out across the water, as flames danced between the water's surface and scraps of paper held by each man. Washington and Paine were right. The gas would turn out to be methane, produced by the microbes in the mud. This experiment happened within weeks of the end of the American Revolution, making it the first scientific undertaking of the new United States of America.

**ACTIVITY:**

Swamp gas has been called several names: *will-o'-the-wisp*, *corpse candles*, *jack-o'-lantern*, and *marsh gas*. It is most often found in peat bogs, mud flats, marshes, and swamps—wherever stagnant water meets the decay of organic matter, and science journals include accounts of the natural phenomenon which produced an otherworldly glow as early as the late eighteenth century. The following excerpt, for example, appeared in an 1832 edition of the *Edinburgh New Philosophical Journal*:

> *The water of the marsh is ferruginous, and covered with an iridescent crust. During the day bubbles of air were seen rising from it, and in the night blue flames were observed shooting from and playing over its surface. As I suspected that there was some connection between these flames and the bubbles of air, I marked during the day-time the place where the latter rose up most abundantly, and repaired thither during the night; to my great joy I actually observed bluish-purple flames, and did not hesitate to approach them. On reaching the spot they retired, and I pursued them in vain; all attempts to examine them closely were ineffectual. On another day, in the twilight, I went to the place, where I waited the approach of night; the flames became gradually visible, but redder than formerly, thus showing that they burnt also during the day; I approached nearer and they retired. Convinced that they would return again to their place of origin, when the agitation of the air ceased, I remained stationary and motionless, and observed them again gradually approach. As I could easily reach them, it occurred to me to attempt to light paper by means of them, but for some time I did not succeed in this experiment, which I found was owing to my breathing. I therefore held my face from the flame, and also interposed a piece of cloth as a screen; on doing which I was able to singe paper, which became brown-colored, and covered with a viscous moisture. I next used a narrow slip of paper, and enjoyed the pleasure of seeing it take fire. The gas was evidently flammable, and not a phosphorescent one, as some have maintained. But how do these lights originate?*

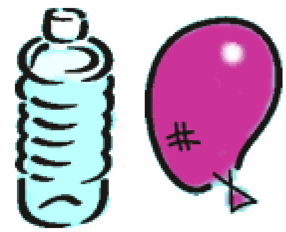
To provide students with a sense of what Washington and Paine might have seen that night, show a brief 30-second modern video available on Youtube: https://www.youtube.com/watch?v=opc__Ioy014 . A more dramatic demonstration, complete with a simple overview of what swamp gas is and how it forms, is available in this 2-minute segment from the University of Alaska, Fairbanks: https://www.youtube.com/watch?v=YegdEOSQotE .

Methane ($CH_4$), a odorless, colorless, and highly flammable gas, is the primary constituent of swamp gas. In nature, swamp gas results from the breakdown of fats, cellulose, and proteins by anaerobic bacteria (those not requiring oxygen) in mud and sediment on the marsh floor. The gas is lighter than air and will burn with a pale blue or yellow flame. At a stagnant pool, bubbles of swamp gas can be induced to ignite with a lighted match. The gas will burn with a brief flame and often emit a "pop" like report.

Today, methane appears in the news in both good and bad contexts. It is the gas that builds up in landfills and can result in noxious fumes if left uncontained. But it is also a highly powerful gas that can be created from natural waste and compost—what scientists call "biogas" and which they hope to harvest as a potential source of future energy.

This experiment allows students to recreate the effects of methane gas in a controlled environment, and recreates one element of the marshland Washington and Paine explored, the impact of decomposing natural matter. While methane gas experiments are common in both high school and college classrooms, they require proper oversight as methane is highly flammable and can be dangerous if used improperly.

**Materials:**



- 6 identical small-necked bottles (plastic water bottles work well)
- 6 balloons of the same size and shape
- 1 1/2 cups of soil
- 2 cups of a mixture of vegetable scraps and grass clippings
- Duct tape
- Funnel
- Measuring cup
- Permanent marker

**Directions:**

1. Mix the soil and vegetable scraps well. Divide up the mixture into six equal portions of a little more than 1/2 cup each. Put one portion into each bottle.
2. Stretch a balloon over the opening of each bottle and secure it with duct tape.
3. Use the marker to write on each bottle the level of the mixture. Put the date by your mark.
4. Place the bottles upright in the following places:
    - In the fridge
    - In the freezer
    - In direct sunlight
    - In artificial light
    - Under the kitchen sink
    - Near a heat source
5. Observe the bottles every other day for 10 days. When you observe them, use the marker to indicate on each bottle the level of the mixture (put the date by your mark). Also measure the circumference of each balloon daily and record this along with the date.
6. Chart your results
7. Dispose of the mixtures outdoors, away from flames.

Have students create graphs of their bottle level results for each of the five observation days, then use the attached "Analysis Worksheet" to compile results (guidelines for what to expect appear below). Students might work in groups to compile 5-10 page reports that combine their individual results and drawn collective conclusions.

<u>What was the relationship between the levels of the mixtures and what happened to the balloons?</u>: The balloons that inflated with gas should have gotten bigger as the level of the mixture in their bottles got lower. Ask students to share their results. Were the results the same? If not, why not? Answers will vary. Be sure the experimental setup was not at fault.

<u>In which locations did the balloons grow biggest, and why? In which locations did the balloons grow the least, and why?</u>: The locations where the balloons grew biggest should have been those with the most heat: i.e., in sunlight, near a heat source. The balloons should have grown the least in the colder areas:

i.e., in the refrigerator and freezer. Again, ask students to share their results and to determine whether their experiment setup could account for any extreme differences in findings.

Compare your experiment's results and the conditions that allowed for the formation of natural gas in the environment: How are the conditions that allowed natural gas to form in organic matter set in simulated hot and cold conditions similar or different than the natural environments of swamps or marshes?

**WANT TO LEARN MORE?**

***Places to Visit***

Rockingham State Historic Site: http://rockingham.net/

Dismal Swamp Conservation Area, Edison, NJ (a non-profit, environmental and educational organization which conducts a variety of tours on swamp habitat and ecology): http://njdismalswamp.org

***More Classroom Activities***

"From Trash to Gas: Biogas Energy," designed for elementary school students and available at Science Buddies: http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p027.shtml

"Methane/Oxygen Balloon Explosions," designed for college chemistry lab courses, Indiana University: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=14&ved=0CG0QFjAN&url=http%3A%2F%2Fwww.chem.indiana.edu%2Ffaculty-research%2Ffaculty-resources%2Fdemos%2F4-2%2520Methane.doc&ei=p9LOU97hN4uoyAT_1ILYBw&usg=AFQjCNF05902cvRgDb2c4QZXV-9s-juGsg&sig2=wThNDMTa8y-BIRF1t8IZBw

***For More Information***

National Grid, *National Gas Safety World: Teacher's Guide* (LLC: Culver City, 2005).

Wyndham D. Miles (ed.), "The Mysterious Gas of the New Jersey Lakes," *Proceedings of the New Jersey Historical Society* 74: 4 (October 1956): 255-259.

Jeanette Muser, *Images of America: Rocky Hill, Kingston, and Griggstown* (Charleston, SC: Arcadia Publishing, 1998).

Carl Zimmer, "Science and Politics: The Tale of George Washington's Swamp Gas," *Discover Magazine* (Oct. 2008).

**Methane Gas Analysis Worksheet:**

- What was the relationship between the levels of the mixtures and what happened to the balloons?
  ______________________________________________________________________________

  ______________________________________________________________________________

  ______________________________________________________________________________

- In which locations did the balloons grow biggest, and why?
  In which locations did the balloons grow the least, and why?

  ______________________________________________________________________________

  ______________________________________________________________________________

  ______________________________________________________________________________

- Compare your experiment's results and the conditions that allowed for the formation of natural gas deposits millions of years ago.

  ______________________________________________________________________________

  ______________________________________________________________________________

  ______________________________________________________________________________

**CREDIT INFORMATION:**

p. 1: Thomas Paine; copy by Auguste Millière, after an engraving by William Sharp, after George Romney oil on canvas, circa 1876 (1792) 16 in. x 12 in. (406 mm x 305 mm) Given by Henry Willett, 1892 Primary Collection NPG 897.

*It Happened Here: New Jersey* is a program of the New Jersey Historical Commission made possible by a grant from the New Jersey Council for the Humanities, a state partner of the National Endowment for the Humanities. Any views, findings, conclusions, or recommendations expressed in the program do not necessarily represent those of the National Endowment for the Humanities or the New Jersey Council for the Humanities. To access more teaching resources created for this program visit www.officialnj350.com.