Arkansas ranks first in the world in the production of bromine, the basis for many widely-used chemical compounds. In this lesson students will learn about the formation and history of Arkansas’ bromine reserves in Union and Colombia Counties in the West Gulf Coastal Plain Natural Division. They will also learn about the many uses of bromine-derived compounds and their health and environmental effects as they debate the pros and cons of bromine production in Arkansas.

Grades: 5th – 8th
The lesson may be adapted for students in grades nine through twelve.

Arkansas Curriculum Frameworks:

Arkansas History Student Learning Expectations:
G.3.5.7 Discuss ways in which Arkansans adapted to and modified the environment

G.1.6.2 Examine the location, place, and region of Arkansas and determine the characteristics of each

G.1.7.2 Compare and contrast common regional characteristics of Arkansas and other locations at the same latitude on the globe

G.3.6.7 Analyze the consequences of environmental modification on Arkansas and specific areas of the United States:
* acid rain
* global warming
* ozone depletion
* erosion
* desertification

G.1.AH.7-8.1 Compare and contrast the six geographical land regions of Arkansas:
* Ozark Mountains (plateau)
* Ouachita Mountains
* Arkansas River Valley
* Mississippi Alluvial Plain
* Crowley’s Ridge
* West Gulf Coastal Plain

G.1.AH.7-8.5 Examine the economic effect of Arkansas’ natural resources:
* diamonds
* bauxite
* forestry products
* oil
RP.6.AH.7-8.3 Describe the development of manufacturing and industry in Arkansas using available technology

W.7.AH.7-8.2 Examine the economic effects of the oil boom in southern Arkansas

WWP.9.AH.7-8.6 Examine the economic development of Arkansas after World War II

G.1.AH.9-12.1 Investigate the six geographical land regions of Arkansas:
* Ozark Mountains (plateau)
* Ouachita Mountains
* Arkansas River Valley
* Mississippi Alluvial Plain
* Crowley’s Ridge
* West Gulf Coastal Plain

G.1.AH.9-12.5 Examine the economic effect of Arkansas’ natural resources:
* diamonds
* bauxite
* forestry products
* oil
* lignite
* novacultie

RP.6.AH.9-12.3 Examine the development of manufacturing and industry in Arkansas using available technology

W.7.AH.9-12.3 Examine the economic effects of the oil boom on southern Arkansas

WWP.9.AH.9-12.7 Analyze the economic development of Arkansas after World War II

Social Studies Student Learning Expectations:
E.7.6.2 Demonstrate an understanding that choices have both present and future consequences

E.7.7.2 Evaluate the present and future consequences of choices

E.7.8.2 Analyze the way present choices result in future consequences

School Library Media Student Learning Expectations:
I.1.5.9, I.1.6.9, I.1.7.9, I.1.8.9 – Access various types of information for an overview of a topic, for background information, and as a starting point for research
- print
- non-print
- electronic resources

Related Encyclopedia of Arkansas Entries:
Union County; Columbia County; Oil Industry; Environment

Introduction:
The teacher will select the appropriate student learning expectations for his or her class, review the key terms, and make copies of selected activities included in the lesson. Collaboration with the school library media specialist for assistance with the utilization of the technology resource tool for Arkansas History is suggested. See above links or visit the online Encyclopedia of Arkansas History and Culture at http://www.encyclopediaofarkansas.net.
Key Terms Defined:
bromine: A highly corrosive, reddish-brown, volatile element found in liquid form; chemical symbol Br. Bromine (pronounced “bro-meen”), fluorine, chlorine, and iodine form a family of elements known as the halogens.

brine: Water with a high salt content.

Time Frame: Two Fifty Minute Class Periods (May Be More)

Materials:
- access to a computer lab
- map of the world
- map of Arkansas
- copy of Bromine Production in Arkansas: Pros and Cons for each student (included below)

Background Information:
The West Gulf Coastal Plain Natural Division encompasses most of southern Arkansas. During the Paleozoic Period (570 to 245 million years ago), this natural division was covered by seawater. Bromine, which is found naturally in seawater, was extracted from the water by seaweed and plankton. As these organisms decomposed during the Jurassic Period (208 to 146 million years ago), bromine was released, leaving heavy concentrations in the salt brines of Union and Columbia Counties. The richest of these brines are found in the Smackover Formation at a depth of 7,500 to 8,500 feet.

When oil was discovered in south Arkansas in 1921, oil field brines were considered a worthless by-product of drilling, and the oil producers had problems disposing of the salt water. Then chemists from the Arkansas Geological Commission discovered the Smackover brines had high bromine content—70 times greater than that of ocean water. (Brines in Arkansas showed bromine concentrations of 4,000 to 4,600 parts per million; by comparison seawater contains 65 parts per million.) Bromine production in Union County began in 1957 and has continued ever since. Bromine production in Union and Columbia Counties contributes significantly to the local and state economy and employs many Arkansans.

Bromine is a valuable element that is used extensively in chemical production today. Combined with other elements into compounds, it is used in fire retardants, insect and fungus sprays, antiknock compounds for leaded gasoline, disinfectants, photographic preparations and chemicals, solvents, water-treatment compounds, dyes, insulating foam, hair-care products, and other chemicals. Arkansas is the largest producer of bromine in the world, averaging about 40% of the world’s total production. Israel is the second largest producer of bromine, which it extracts from the Dead Sea. The Arkansas brines and the Dead Sea brines are almost identical except for their geological and geographic locations.

Bromine production is not without controversy, because bromine-derived chemicals negatively affect human health and the environment. According to Corpwatch, an organization that monitors the environmental impact of corporations, Great Lakes Chemical Corporation in Union County, the world’s largest producer of bromine, is the number one polluter in Arkansas. The company was fined $190,000 for water pollution in Arkansas in 1994. Also, bromine is dangerous if it comes in contact with skin, and its vapor is harmful if inhaled. For these reasons, worker safety at the sites of production is a cause for concern.

Bromine is also a potent ozone-depleting element. One of the chief ways bromine is released into the atmosphere is from the burning of leaded gasoline, which is still sold to Third World countries, where it is legal. A report produced by the National Oceanic and
Atmospheric Administration, the National Aeronautics and Space Administration, and the UN Environment Programme, and published by the World Meteorological Organization, estimates the bromine in methyl bromide is about 50 times more efficient in destroying the stratospheric ozone layer than the chlorine in CFCs. With the phase-out of CFCs well underway, the report lists the elimination of methyl bromide emissions “from agricultural, structural, and industrial activities” as being the single most important step that nations can take to reduce future ozone depletion.

Procedure:

Day One Activities/Background Discussion:
1. Ask a student to find the Dead Sea on a world map. Ask another student to point out the West Gulf Coastal Plain and Union and Columbia counties on a map of Arkansas.
2. Ask students, “What does the West Gulf Coastal Plain of Arkansas have in common with the Dead Sea?” List their answers on the board.
3. Ask students, “What do you know about bromine?” List their answers on the board or overhead transparency.
4. Present the “background information” from above about how bromine is formed, how it was discovered in Arkansas, its uses, and health and environmental impacts.

Day Two Activities/Preparation for Debate:
1. Explain how a debate works and tell students they are going to stage a debate about the production of bromine. Depending on the size of the class, the teacher may need to schedule two debates.
2. Divide students into two (or four) teams—those promoting the production of bromine and those against it. Give each student a copy of Bromine Production in Arkansas: Pros and Cons (included below). Explain that points will be awarded for participation, at your discretion, and that you will observe students as they prepare for the debate.
3. Give students ten to 15 minutes to prepare their arguments, and then hold the debate. Not all students should have to speak, but they should be actively involved in the group preparation.

Evaluation: The participation in classroom discussion can be evaluated. The debate can be evaluated as a participation grade or as an organization of information grade.

Extension:
Invite one or more of the following to the class to discuss bromine and bromine production: a chemist from a local university, a speaker from the Arkansas Geological Commission, a representative from one of the chemical plants in Union or Columbia County, a scientist or environmental activist knowledgeable about the health and environmental impacts of bromine-based compounds.

Sources:


Recommended Websites:
Arkansas Geological Commission’s page on bromine: [http://www.state.ar.us/agc/bromine.htm](http://www.state.ar.us/agc/bromine.htm)

Bromine Production in Arkansas: Pros and Cons

**PROS**

- Bromine production provides many jobs for people in Columbia and Union Counties.
- Bromine production benefits the state of Arkansas in the form of tax revenues.
- Bromine production promotes Arkansas as part of the global economy.
- Bromine is a useful element that kills bacteria, viruses, and algae. It is also a superb flame retardant.
- Bromine is used in many water treatment products for personal and commercial pools.

**CONS**

- Great Lakes Chemical Corporation is the number one polluter in Arkansas and was fined $190,000 for water pollution in 1994.
- Chemicals used at production plants can pollute surface and groundwater.
- Poisonous gas that can kill in an instant is located in brine wells. This makes drilling for bromine a dangerous job.
- Bromine released from the burning of leaded gasoline still being sold in Third World countries pollutes the air.
- Bromine is a serious threat to the ozone layer.