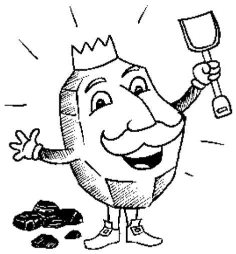
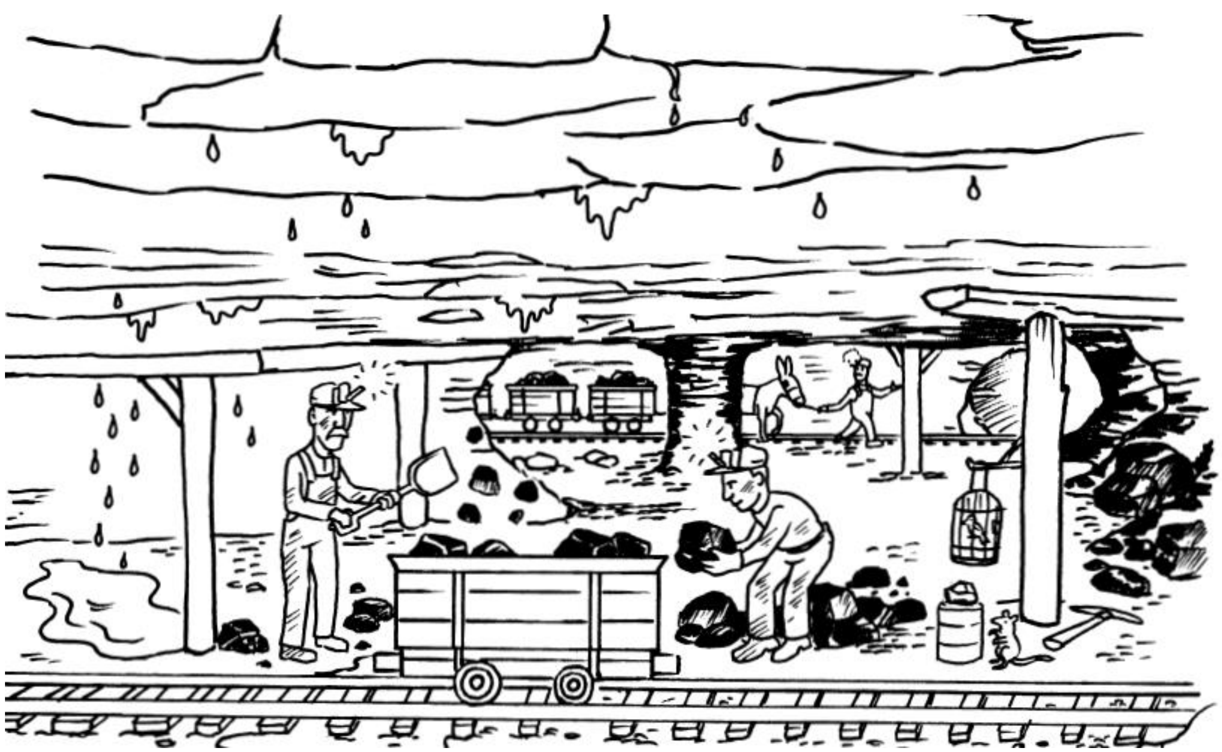
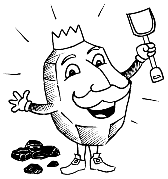


Goodbye Orange Water Activity Book Lessons





Uses of Coal

A Goodbye Orange Water Activity Booklet Lesson

Background

Coal is the most plentiful fuel in the fossil family, and it has the longest and perhaps the most varied history. Coal has been used for heating since the cave man. Archeologists have also found evidence that the Romans in England used it in the second and third centuries (100-200 AD). Coal is second only to oil as an energy source in the world. America has more coal than any other fossil fuel resource; ¼ of all the known coal in the world is in the United States.

There are enough minable coal reserves in the world to last over 200 years at the current rate of consumption. Whereas, there are 45 years of oil and 70 years of natural gas, which also tend to be concentrated in specific regions unlike coal. The United States generates 50% of its electricity from coal.

Coal formation is dependent upon many things: material, pressure, heat and time. The type of coal formed depends upon the mix of the requirements. The four types of coal are: Lignite, Sub-bituminous, Bituminous, and Anthracite.

Warm-up

Show a piece of coal to the students and ask them:
What could you use this for?
Brainstorm with them to list uses for coal.

Activity

- After the students have brainstormed, have them search with the internet or library resources and magazines from home to discover the numerous uses of coal.
- Using their list, have the students use the designated magazines and cut out things that would remove, transport, use coal, or show the effects of coal. In the event magazine to do not have such items, have the students draw the associated items.
- After gathering the cut outs, have the students prepare a poster displaying all their uses. The poster should be at least the size of a piece of construction paper. Encourage embellishments to make the poster jazzy.
- Students should also understand how the items they cut out relate to coal.

Wrap-up

Students will describe their poster to the class explaining what each item is and how it relates to coal.

Assessment

- Teacher will visually check number of examples of coal cut out of magazines.
- Teacher will evaluate the poster for completeness and effort.
- Teacher will listen to the student describe the poster and the uses of coal to determine understanding.

Extensions

- Students could interview a coal miner.
- Students could interview anyone who still uses coal to heat their house.

Accompanying Page (s)
Page 2-3

Objectives

- Given the necessary research time and old magazines, the student will cut out examples of at least 10 uses for coal.
- Given the necessary time and construction paper, the student will attach the pictures to make a display.
- Using the poster just created, students will describe the poster and the uses of coal.

Duration of Activity

- 1-2 hours

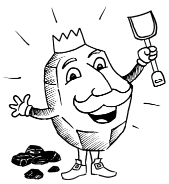
Pennsylvania Standards Addressed:
3.3.5.A2, 9.1.V.K.B1

Materials

- Library/Internet Access
- Old Magazines
- Construction Paper
- Glue
- Scissors

Setting

- Classroom



Coal Formation Model

Goodbye Orange Water
Activity Booklet Lesson

Background

Over 300 million years ago, Pennsylvania was positioned near the equator and nearly flat with no ridges or mountains. The temperature and landscape of Pennsylvania was much different than today, the climate was tropical and there were no common trees like oak, pine, maple, and no grass. The area was covered with giant trees and ferns, up to 100 feet with large leaves, sometimes 30 inches to 3 feet long. Primitive animals, such as amphibians and reptiles were beginning to appear and insects, like dragonflies loved the lush swampy forests.

When the seas would rise, the sand would bury the decomposing plants, which contained carbon, hydrogen and oxygen. The sediment caused the decomposition to stop and the pressure from the sediment assisted in the coal formation. Also assisting with the formation of coal is heat, which is associated with the formation of mountains. Coal, the final product of all this decomposition, pressure and heat, has different classifications depending on the stage it is (peat, lignite, bituminous or anthracite coal) and the composition (amounts of Carbon, hydrogen and hydrogen).

Warm-up

Adapted from DCNR Ohiopyle State Park program by Barbara Drbal Wallace

What are the three things needed to "make" coal?

1. Decaying plants (peat),
2. A way to protect the dead plant material from destruction through decay (sediment),
3. A process to alter the plant material into coal (pressure).

Give each student a piece of clay to make a tree from the Pennsylvanian Period swamps. Discuss how each time the leaves would fall and the inland sea would rise, the leaves would be covered with sediment.

Have some students place their tree on a tray.
Cover the plants with a piece of foam representing sediment.
Add another layer of plants and cover with sediment.
Add another layer of plants and cover with sediment.
Continue adding layers and sediment until all plants have been used.
Discuss what happens when the sediment continues to build up.
Add another tray to represent pressure compacting the peat.
Place the "system" on the floor and have a student stand on the top tray to provide the pressure.

What is happening to the plants? They are being altered, as they are smashed, the oxygen and hydrogen are squeezed out and the decaying plant material that is left is the Carbon. PA Bituminous coal is between 82-91% Carbon.

The more pressure, the better the coal, also making better coal is when mountains are formed because they cause excess pressure and heat.

Accompanying Page (s)
Page 4

Objectives

- Demonstrate how the inland sea assisted with the formation of coal.
- Using the timeline and class discussion, the student will explain how, when and where coal formed.

Duration of Activity
2-3 class periods

Pennsylvania Standards Addressed:
3.3.8.A3, 9.1.V.K.B1

Materials

- Formation of Coal – Paint tray/Aluminum-baking pan, 30 if working individually, less if working in groups, Flour, Salt, Water, Food coloring, Sand/Sediment, Leaves and Twigs, Water
- Miscellaneous - Coal in Pennsylvania – Bureau of Topographic and Geologic Survey Education Series No. 7, The Geological Story of Pennsylvania – Bureau of Topographic and Geologic Survey Education Series No. 4

Setting
Classroom/Artroom

Activity

EXPLORE – How did Pennsylvania look 300 million years ago?

1. You can have the students search the Internet, use resources and other forms of material to discover what Pennsylvania looked like, especially Southwestern Pennsylvania.
   - Trees - 20 to 40 feet tall
   - Very humid tropical climate
   - No mountains, ridges or valleys.
   - PA land was low and flat with streams leading to coastal swamps and marshes in the west. East of Pennsylvania there was an inland sea covering the central states
2. What elements are common constituents found in plants?
   - Carbon
   - Hydrogen
   - Oxygen

Discuss what the plants were like during this time. Use of the Bureau of Topographic and Geologic Survey Education Series No. 7 – Coal in Pennsylvania is very beneficial.
It is available at http://www.dcnr.state.pa.us/topogeo/education/ed.htm

- Lepidodendron – Very tall slender trees up to 100 feet high with narrow leaves up to 30 inches long.
- Cordaites – an ancestor of the modern pines and spruces, sometimes topping 100 feet, with large, straplike leaves up to 3 feet long.
- Calamites – a tree-like relative of the inconspicuous modern horsetails, grew to a height of 20 to 40 feet.
- Sphenophyllum – a low shrub that formed much of the underbrush of Pennsylvanian time.
- Ferns (True and Seed) – Pecopteris, Alethopteris, Odontopteris, Linoteris, Mariopteris, Neuropteris, up to 40 feet high

HANDS-ON - Have the students begin making a mock Pennsylvania with the homemade play dough made by them or by the teacher.

1. Use a pan, a disposable baking pan or plastic basin or paint tray will work.
2. Have the students begin developing what a section of Southwestern Pennsylvania would look like with the homemade play dough (see recipe in notes). Emphasizing that this was chosen because SW Pennsylvania has a great and rich coal history. (SHOW PICTURE FROM NRCS - COAL IN PENNSYLVANIA, Educational Series No.7.)
3. One side of the section should be partial inland sea, called the Appalachian Sea (preferably at the left of the pan, since SW PA was an inland sea), then a swampy area (where a beach would be in current times), and then the land with streams, but not high mountains…
   Streams in Pennsylvania were braided and meandering.
   - Braided streams had many interconnected channels and deposited mainly sand and some gravel.
   - Meandering streams had a single channel wandering in a curved path and deposited sand, silt and clay.
4. At the swampy area and into the sea, place a layer of sand, then a layer of dirt.

The Decomposition of Leaves

1. Many of the swamp-like trees would loose leaves and die.
2. The leaves would settle to the bottom of the swamp and begin decomposing.
3. The decomposition is not complete because the stagnant water in the swamps stops the decaying process.
   - Who has a compost pile at home? If it is too wet, does the material decompose as quickly? No.
4. This partially decomposed material is peat, the beginning of coal.

HANDS-ON - Have the students add the following to their model.

1. Plants if you wish to have them create the look of the swamps in Southwestern Pennsylvania. They can be made from the play dough or use actual twigs.
2. Add crushed up leaves where there would be swamps.
3. Add water to the model to show a couple things:
   - Where the water will drain to-the inland sea
4. Have the students add more leaves and water to the swamps.

Explain how coastal erosion works (it is very similar to how coal is formed).

1. As waves near the shore or in this case the swamps, it breaks and releases stored energy, which causes erosion and the transport and deposition of sediments.
   - As the wave curls over, the sediment is pulled out into the sea with the undercurrent. Have the students think of the wave as a circle, it will curl over than continue on back out to sea.
   - Rivers can also supply new sediment to the coast.

Formation of Coal

3. Peat – The leaves fall into the swamps where, the bacteria and break down the cell structure and reduce the plant material to rotted wood and leaves or peat. How long the material is in this stage depends on how much the oxygen could work until the oxygen is cut off.
4. Burial of Peat – The peat is buried by the sediment, sand and mud in the swamp and the bacteria action will stop.
   - This can happen numerous times causing several layers of peat to accumulate underneath the ground.
   - 10 feet of peat produces a 1-foot coal seam. Therefore, the vegetation must have been immense to produce the large coal seams we have in the region.
3. Coal and Pressure –
   - The sediment buries the peat and the weight compacts the peat into a small fraction of its original thickness.
   - Mountain formation is also another source of pressure. As the mountain chains are pushed up, there is great force exerted.
4. Coal and Heat – When mountains are formed, the temperature usually increases due to the grinding and rubbing together of the rocks.

Hands-On

1. Using the mock Southwestern Pennsylvania coastal system.
2. Use a sprinkler bottle or other item to add water to the system to show students where the water would be.
3. The water should end up in the ocean and swamp.
4. Add leaves, twigs, and branches to the swamps and show the students that it will sink into the waters of the swamp where they grew, bacterial will break down the cell structure and reduce the plant material to rotted wood and leaves (peat).
5. Add sediment either sand or mud to bury the peat and cut off oxygen.

Wrap-up

What was Pennsylvania like during the Pennsylvanian and Mississippian Period? Southwestern Pennsylvania had an inland sea covering the entire region; it was very humid and tropical. Very large trees and no mountains like today.

What happened that caused the coal to be formed? Coal is formed from the peat, which comes from the decomposing plant material in the swamps. The peat is then buried with sediment, which applies pressure and compacts the decomposing material. Also assisting in the formation of coal is the heat that was produced during mountain formation.

Are we able to replace the coal that has been removed over the years? No, coal took millions of years to be formed, and the temperature, plants and landscape shaped the formation of coal. The current day Pennsylvania's climate, landscape and plant life are not the appropriate ingredients to coal formation.

Assessment

- Teacher will evaluate the coal formation model developed by the student.
- Teacher will test the student's knowledge about how, when and where coal formed through the use of a quiz.

Extensions

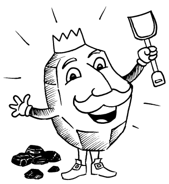
NOTES:

Play Dough

- 1 cup of salt
- 1 cup of flour
- 1/2 cup of water
- Food coloring (optional)

Directions

Put salt and flour in a deep unbreakable bowl. Mix the dry ingredients thoroughly with hands or a wooden spoon. Slowly add water. Continue to mix, and then knead dough until it is smooth and elastic without being sticky. Have students flour their hands to avoid a large mess. Add flour if necessary to produce a play dough like consistency.



Coal Formation Timeline

Goodbye Orange Water
Activity Booklet Lesson

Background
Over 300 million years ago, Pennsylvania was positioned near the equator and nearly flat with no ridges or mountains. The temperature and landscape of Pennsylvania was much different than today, the climate was tropical and there were no common trees like oak, pine, maple, and no grass. The area was covered with giant trees and ferns, up to 100 feet with large leaves, sometimes 30 inches to 3 feet long. Primitive animals, such as amphibians and reptiles were beginning to appear and insects, like dragonflies loved the lush swampy forests.

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Warm-up

Show a piece of coal to the students and ask them:
How long did it take to make that piece of coal?
Who was the first person to discover King Coal?
How and why was it first used?

Activity
Coal Time Line (Adapted from Project WET – Old Water)
Create a yarn time line
1. Hang a 33-foot (10 meter) section of rope on the wall or across the room. – This represents 5 billion years – every 2 meters equals 1 billion years, every 2 cm equals 10 million years.
2. Attach index cards to label each end of the rope as "Earth formed" and "Now" respectively and a card at 7.5 meters from "Now" labeled "Water on Earth".
3. Label index cards for the time periods listed below.
4. Label an index card "Earliest forms of life" and attach it 7 meters from the end marked "Now".
5. Label an index card "Formation of Coal" and attach it 60 cm from the end marked "Now".
6. Label an index card "Dinosaurs Dominated the Earth" and attach at 40 cm from the end marked "Now".
7. Hang the 4-foot piece of rope at the end marked "Now" so that it hangs vertically.
8. At the top of this piece, draw a line on an index card that measures 2mm in length and label it "Existence of man" and hang it on "Now".
9. Pass out index cards to each student and ask them to label key events in the Earth's history to be placed on the timeline. Also ask students to label events that have happened since the "Existence of man". (Use the attached timeline to show the formation of coal and mining.)

Accompanying Page (s)
Page 4

Objectives
- Given dates and materials, the student will work cooperatively to develop a timeline depicting the beginning of the earth to current day, emphasizing the formation of coal.
- Describe the plants that existed during the Pennsylvania period.

Duration of Activity
- 45 minutes

Pennsylvania Standards Addressed:
8.1.K-2.A

Materials
- Timeline -10 meters of yarn, Index cards or slips of paper for each student to add to the timeline, Clothespins (spring type)
- Miscellaneous - Coal in Pennsylvania – Bureau of Topographic and Geologic Survey Education Series No. 7, The Geological Story of Pennsylvania – Bureau of Topographic and Geologic Survey Education Series No. 4

Setting
Classroom

Some Coal Dates for NOW Time Period – All of Human History

1. 4th Cent. BC – Aristotle mentioned coal in his book, Meteorology
2. 13th Century – Coal used commonly in Europe
3. 1672 – Coal mentioned on Cape Breton Island, Canada
4. 1673 – Map by explorer Joliet shows coal location in Illinois
5. End of 17th Century – Long Wall Mining Discovered and Developed in Shiropshire, England
6. 1701 – Coal found along James River
7. 1752 – Coal found along the Kiskiminetas River by Joe Pattin
8. 1755 – Coal was utilized in U.S.
9. 1761 – Earliest record of actual coal mining in PA on "Plan of Fort Pitt and Parts Adjacent"
10. 1762 – First clear record of anthracite coal by John Jenkins Sr.
11. 1769 – First use of anthracite coal by the Gore Brothers in their blacksmith shop at Wilkes-Barre, PA
12. 1816 – Baltimore Maryland, first city to light streets with gas made from coal
13. 1830 – numerous small mining operations in U.S.
14. 1839 – Steam Shovel Invented
15. 1866 – Strip Mining Began – horse drawn plows
16. 1875 – Coal replaced charcoal as chief fuel for iron blast furnaces
17. 1896 – General Electric Company build first power plant
18. Late 18th Century – Coal Mining appeared in the US.
19. 1917 – Pennsylvania produced 278 million tons of coal worth $705 million
20. 1990 – US Coal production 1 billion tons/year

Discuss that we know when coal was formed, but do we know how?

1. Was it formed when the earth was formed?
2. Did it appear when the continents shifted?
3. What was coal originally before it was converted into coal?

Wrap-up

Was coal here from the beginning of the earth?
Coal wasn't here from the beginning of the earth; it was formed during the Pennsylvanian and Mississippian Periods from 290 – 354 million years ago.

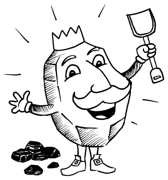
Assessment

Evaluate the students understanding through their response to the questions and the design of their model.

- Teacher will visually assess the ability to work cooperatively and develop a timeline depicting the beginning of the earth to current day, emphasizing the formation of coal.
- Teacher will use verbal checking to evaluate the student's knowledge of the plants that existed during the Pennsylvania period.

Extensions

1. Bottle Biology (ISBN – 084038601X)– The decomposition of leaves can be see with an activity in the Bottle Biology Book, but in contrast, it can also demonstrate what can happen when the leaves are left in stagnant water like in a swamp, the decomposition will not take place as rapidly, because it creates an anaerobic environment.
2. A visit to a Coal Mine – Tour Ed Mine in Tarentum, PA; Seldom Seen Mine, Patton, PA; Lackawanna Coal Mine, Lackawanna County, PA



A Day in the Life of a Coal Miner

A Goodbye Orange Water Activity Booklet Lesson

Background

Coal mining is a very hard and dangerous occupation. Not only did the miners experience hardship in the mine, but the families of the coal miners often times had sub standard houses, little or no food, and the areas where the patch towns were laid out were often next to the mine or the coke ovens and caused the town to be dirty.

Many young boys had to begin working in the coalmines to help support the family, especially if the father got hurt in the mine.

Warm-up

Have the students write a paragraph or two about what they think a day as a miner, or a family member of a miner might be like. Encourage them to include adjectives and descriptive stories.

Collect these paragraphs.

Activity

- Have the students watch the video or read the book October Sky (the book is sometimes Rocket Boys). Students should take note of the obstacles of the mother, father and children as well as the community. This can be complete by requiring note taking or just watching.
- Students will write a short story about their day in a coal mining community. They may take on the role of mother, father, or a child that had to work in the coal mine.
- The story should assume that the father was the miner since women didn't commonly work in the mine.

Wrap-up

Students will read their story to the class.

Assessment

- Teacher will visually observe the student's attention to the movie or collect the notes that were taken.
- Teacher will evaluate the story for effort, correctness, and completeness.
- Teacher will listen to the student to determine understanding.

Extensions

Accompanying Page (s)
Page 5

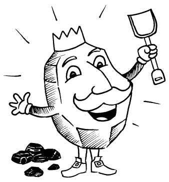
Objectives
- Learn the hard life coal miners and their families experienced.
- Complete a short story about a day in the life of a coal miner, his/her spouse or child.

Duration of Activity
- 2-4 hours

Pennsylvania Standards Addressed:
3.4.6-7.B1, 3.4.6-8.B3, 3.4.6.B4, 3.4.8.B4, 3.4.10.B1, 3.4.12.B1, 3.4.10.C3, 3.4.10.D3, 4.5.7.E, 4.5.10.E

Materials
- Book or video – October Sky

Setting
- Classroom



Silver Cinders

Goodbye Orange Water
Activity Booklet Lesson

Background

Civil War

- War created increased demand for iron products
  - Artillery
  - Railroads
  - Ammunitions
- Pittsburgh industry boomed
  - “Iron City”-iron capital of America
  - Becomes “Steel City” after Civil War
- The Connellsville Coke District becomes major factor due to railroad access
  - Henry Clay Frick
  - First “Coal Barron”
- Mission to buy coal and coke in Connellsville
  - Bought with the aid of a few investors one of the first coal mine/coke oven communities
  - Partnered with Carnegie to form the H.C. Frick Coke Company
- Coal/Coke industry caused a great dispersion of wealth
  - A few had much, many had little

Industry Growth

- The new growth brought mass job opportunities to the region
  - Jobs were filled by immigrants searching for a better life
    - First Northern and Western Europeans
    - Then Southern and Eastern Europeans
  - Immigrants moved into small patch towns
    - Owned by the company
    - Pay came in money only good at the company store
    - “Houses built like bags, only to hold”
      - 1880’s new housing
        - Sturdy ordered patch towns
        - Incentive to recruit better workers
        - Construction around priority
          - 1st reservoir
          - 2nd Coke ovens/Mine Buildings
          - 3rd Waste Area
          - 4th Housing
        - Contained: Company Store, School, Houses
          - Very dirty, smoky
          - People accepted filth as part of life
          - Women: cooked, cleaned, gardened

In the Mine

- Unsafe/Unhealthy
  - Black Lung
  - Back Pain
  - Many dead by fifty
- Confusion:
  - Mixed Language
  - Miners were often farmers displaced in the mines

Accompanying Page (s)
Page 5

Objectives

- After watching the movie, the student will examine the life of a coal mining family through discussion within a group.
- Given the necessary time and questions, the students will present their discussion to the class.

Duration of Activity
Possibly 3 hours

Pennsylvania Standards Addressed:
8.2.2.C

Materials
TV/VCR
Silver Cinders *The Legacy of Coal and Coke in Southwestern PA* (56Minutes)
63 Men Down (30 Minutes)

Setting

- Classroom

Mechanization

- New products expedite extraction
  - More dangerous, less labor
  - Increased productivity
- New rectangular oven
  - Coal entered at one-end moves through oven exits onto train bed
  - Labor saving coke production (decreased need for labor)
  - Coke production reached height during WWI

Miners/Coke Workers and Unions

- Began to strike
  - Little success = strikers often killed
  - Strikers easily replaced with those that wanted to work
  - African Americans replaced strikers (not well excepted)
- United Mine Workers Association
  - Half of all miners joined after WWII
  - Beloved union president – John Lewis
    - 1919 Strike = won wage increase
- F.D. Roosevelt also helped the Mineworkers during the depression
  - The New Deal

Industry changes

- New technology again made mining more efficient
  - More efficiency meant less work
- New coke ovens
  - Very expensive but more profitable
  - Collected gases previously released into the atmosphere
    - Gases then sold as by-product
  - Produced cleaner/better coke
  - Largest of new ovens found at US Steel plant in Clairton, PA
- By the 1950's Beehive Coke Ovens obsolete

Strip Mining

- Advent of larger and stronger machinery
- Overburden (Soil/rock covering coal) removable
- More economically feasible

Environmental Degradation

- Mine waste
  - High walls
  - Orange streams – acid/alkaline
- Department of Environmental Protection (DEP)
  - Bureau of Abandoned Mine Reclamation (BAMR)
    - Attempting to clean up years of abuse

Results of years of mining have left a mangled culture in its wake!

Warm-up

Discuss perceptions of coal mining. Show some artifacts and pictures. Walk student through a day in the life of a miner from awakening to returning to sleep. Find out which students have visited a mine or have miners in their heritage. Ask them for stories they might have heard. Discuss briefly the role of the patch town and eventually unionization.

Activity

1. Watch the movie Silver Cinders.
2. Divide the class into six groups. Give each group a card with one of the question written on it. Each group should discuss the question, write the answer, and be prepared to read them to the entire class.

Wrap-up

Conduct a full class discussion on the coal and coke era, i.e. hardships of being a coal miner and a member of the coal mining family, the environment, the benefit to the nation…

Assessment

Extensions

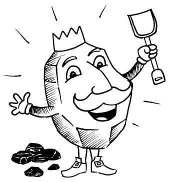
1. What is meant by the phrases *Coal is King* and *Coke is Queen*? How many years ago did PA coal deposits begin to form? What was the name of that period? Explain the difference between Anthracite and Bituminous coal and where they are found. When coal was first discovered, why was it not immediately harvested for use?

2. Name three types of coalmines discussed in the movie and describe them? What techniques were employed to keep mines from caving in? Another form of mining was strip mining, why did it take so long to become an effective process? What happened as new technologies entered into the coal extraction process and how is it associated with subsidence?

3. What is coke and how is it formed? How did the first coke ovens get their name? What did new coke ovens do that previous ovens did not? What part of PA was a major player in coke production? What role did the Connellsville Coke District play in the steel industry? Who were three of the first "Coal Barons"?

4. What countries did the principal immigrant population who worked in the mines originate? What was the name of the towns where coal workers lived? Describe the look of the town and the living conditions of a coal community. How were the workers paid? What was the "company store"? Describe the working conditions in the mine. What were the dangers of working in the mine?

5. Describe the working conditions in the mine. What were the dangers of working in the mine? What was the miner's check and what function did it serve? When did the UMWA become a Union? Who was the first and most beloved UMWA president? What happened to those that participated in strikes?



Mining Mix-Up

Goodbye Orange Water
Activity Booklet Lesson

Background

Beginning in the mid-1700's coal mining in Pennsylvania fueled the Industrial Revolution in the United States. It began to support the Colonial iron industry, then Andrew Carnegie's steel mills in the 1800's and finally electric power plants of more modern times. Pennsylvania is now the fourth largest coal producer in the United States, following Wyoming, West Virginia and Kentucky. Over 69.5 million tons of coal was mined in the state in 1995 (about 6.7 percent of U.S. production) in 878 mining operations directly employing 10,165 people.
Two kinds of coal are mined in Pennsylvania- ANTHRICITE (hard coal) and BITUMINOUS (softer coal).

Over 60.8 million tons of bituminous coal was mined in 1995 and 8.7 million tons of anthracite.
Since 1870, Pennsylvania's Annual Report on Mining Activities has recorded 51,483 deaths from mining accidents-- 31,113 deaths in anthracite mines and 20,370 deaths in bituminous mines.
Modern mining methods, safety training and inspections in the mining industry have dramatically improved the safety record on the industry to the point where it is about equal to agriculture and the construction industry.

The environmental legacy of hundreds of years of coal mining in Pennsylvania is over 2,400 miles of Pennsylvania's 54,000 miles of streams polluted by abandoned mine drainage from old mining operations. Abandoned mine drainage is the single largest source of water pollution by far in the state. Modern laws and regulations require that present day mining cannot begin if it might result in harm to the environment.

TYPES OF MINING
The major types of underground mining conducted in Pennsylvania's bituminous coalfields are:

- ✓ room-and-pillar mining
- ✓ room-and-pillar with retreat mining
- ✓ long wall mining

Warm-up

1. As students enter the room, the teacher will randomly hand the student a card that has one of the following: Pyrite, Coal, Limestone, Water, Soil, Methane, Carbon Monoxide, Darkness, Aluminum, and Manganese.
2. The teacher will ask the students to list some of the items handed to them.
3. What do all these items have in common? Where would you find them?
4. Today we will discuss how all of these things are found in a coal mine.

Accompanying Page (s)
Page 6

Objectives

- Through a timeline game, students will determine how mine drainage forms from past mining operations.
- Students will expand their understanding of coal mining and mine drainage formation.

Duration of Activity
~ 50 minutes

Pennsylvania Standards Addressed:
8.1.K.A, 8.1.2.C

Materials

- Anticipatory Set Cards
- Mining Match Game Cards
- Old Time Coal Miners at Work – Overhead
- How Mine Water Gets In and How Mine Water Gets Out - Overhead
- String
- Clothe Pins

Setting
Classroom

Activity

1. Students will form a semi-circle in middle of the room.
2. Students should brainstorm what it was like to be a coalminer?
    a. *Where do they work?*
    b. *What do they find underground?*
    c. *What are the dangers?*
    d. *When mines are "played-out", what is left behind?*
3. The teacher will then prompt the students to begin to visualize what a Room and Pillar Mine would look like. The teacher will place the picture of "*Old Time Coal Miners at Work*" on the overhead.
4. Have the students list as many things they see happening or present in the mine. The teacher should write those on the board.
5. The teacher will place all the *Mining Match Game Cards* in a box.
6. The teacher should tell the students that we are going to form a MINING TIMELINE from Active Coal Mining to the Formation of Mine Drainage to help them understand what is happening inside the coalmine.
7. Students will take turns reaching into the box and decide where on the timeline their story card fits and place the card in the approximate position.
8. The teacher should stretch the clothesline out on the floor. The teacher should position the following *Mining Game Cards* on the line from left to right on the Red marks: **Pre-Mining, Mining, Abandoning a Coal Mine, and Mine Drainage Formation**. The rest of the *Mining Game Cards* will fill in between these cards.

Wrap-up

1. The teacher will ask each student to point put the underlined words on the *Mining Match Game Cards*. *Why are these terms important? What do these terms mean?*
2. The teacher will refer back to the terms at the beginning from the Anticipatory set. *How do these terms relate to coal mining or the formation of mine water discharge?*
3. The teacher will review the process using *How Mine Water Gets In and How Mine Water Gets Out – Overheads.*

Assessment

1. The teacher will verbally prompt students to explain the game cards as they work through the timeline game. Students should be able to expand upon their reasoning for placing the cards.
2. Students will be able to "Tell the Story" of mine drainage through pictures, writing, or orally.

Recommended Resources and Referenced information

http://www.dep.state.pa.us/dep/deputate/minres/bmr/act54/sec6.htm
http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Coal_Mining_in_Pennsylvania.htm

Edmunds, William E., and Edwin F. Koope. **Coal in Pennsylvania**, *Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Topographic and Geologic Survey:* Educational Series No.7: 1968.

Commonwealth of Pennsylvania: Bureau of Topographic and Geologic Survey. **Rocks and Minerals of Pennsylvania**. 1991

Accepting the Challenge: A Primer about the history, cause, and solutions to abandoned mine drainage. Slippery Rock Watershed Coalition, 2001.

Anticipatory Set Game Cards

PYRITE	**PYRITE**
WATER	**WATER**
MANGANESE	**MANGANESE**
ALUMINUM	**ALUMINUM**
SOIL	**SOIL**
METHANE	**METHANE**

CARBON MONOXIDE	**CARBON MONOXIDE**
DARKNESS	**DARKNESS**
LIMESTONE	**LIMESTONE**
PYRITE	**PYRITE**
WATER	**WATER**
MANGANESE	**MANGANESE**

ALUMINUM	**ALUMINUM**
SOIL	**SOIL**
DARKNESS	**LIMESTONE**

Pre-MINING
Miners <u>blast</u> an area.
MINING
Miners excavate an area to create the Coal Mine Room.
Miners use pumps to remove <u>groundwater</u>.
Miners position wooden beams to support <u>overburden</u>.
Miners use pick axes, shovels, and dynamite to break coal into smaller pieces.
Miners separate <u>pyrite</u> from <u>bituminous coal.</u>

Abandoning a Coal Mine
Miners remove coal pillar supports.
Miners exit the room and pillar mine.
Mine Drainage Formation
Groundwater begins to fill the abandoned coal mine.
Mine begins to flood.
Pressure increases inside the abandoned coalmine.
Wooden supports rot and weaken.

Wooden supports collapse and overburden subsides.

Pyrite weathers in groundwater.

Pyrite dissolves iron and sulfide into the water producing sulfuric acid.

The Abandoned Coal Mine floods with groundwater.

Pressure inside the mine forces mine water upward, which is contaminated with acid and minerals.

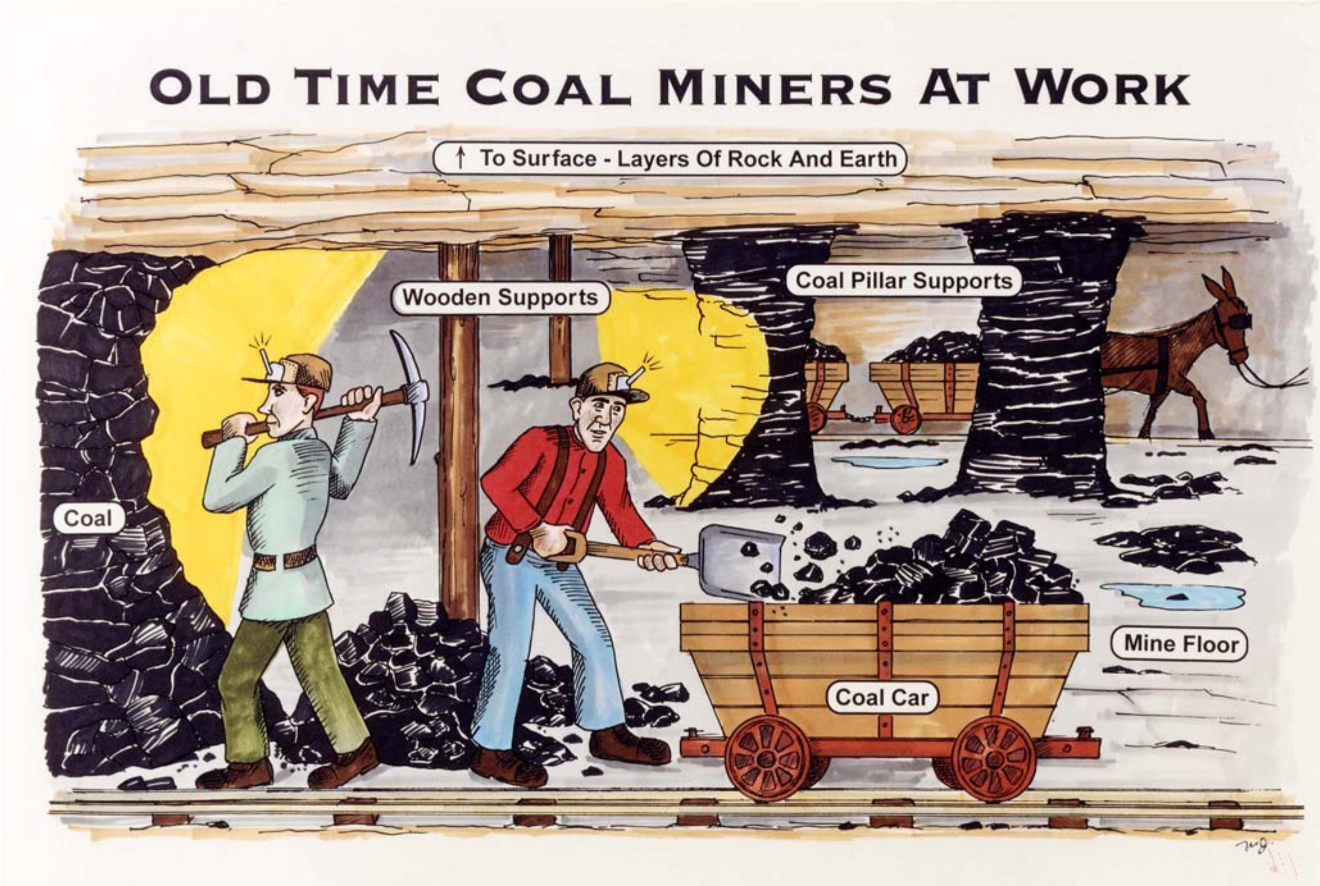
Mine water pushes upward out of abandoned mine and percolates through a limestone layer, sulfuric acid present in mine water is neutralized.

Mine water reaches the surface through seeps, boreholes, or outcropping.

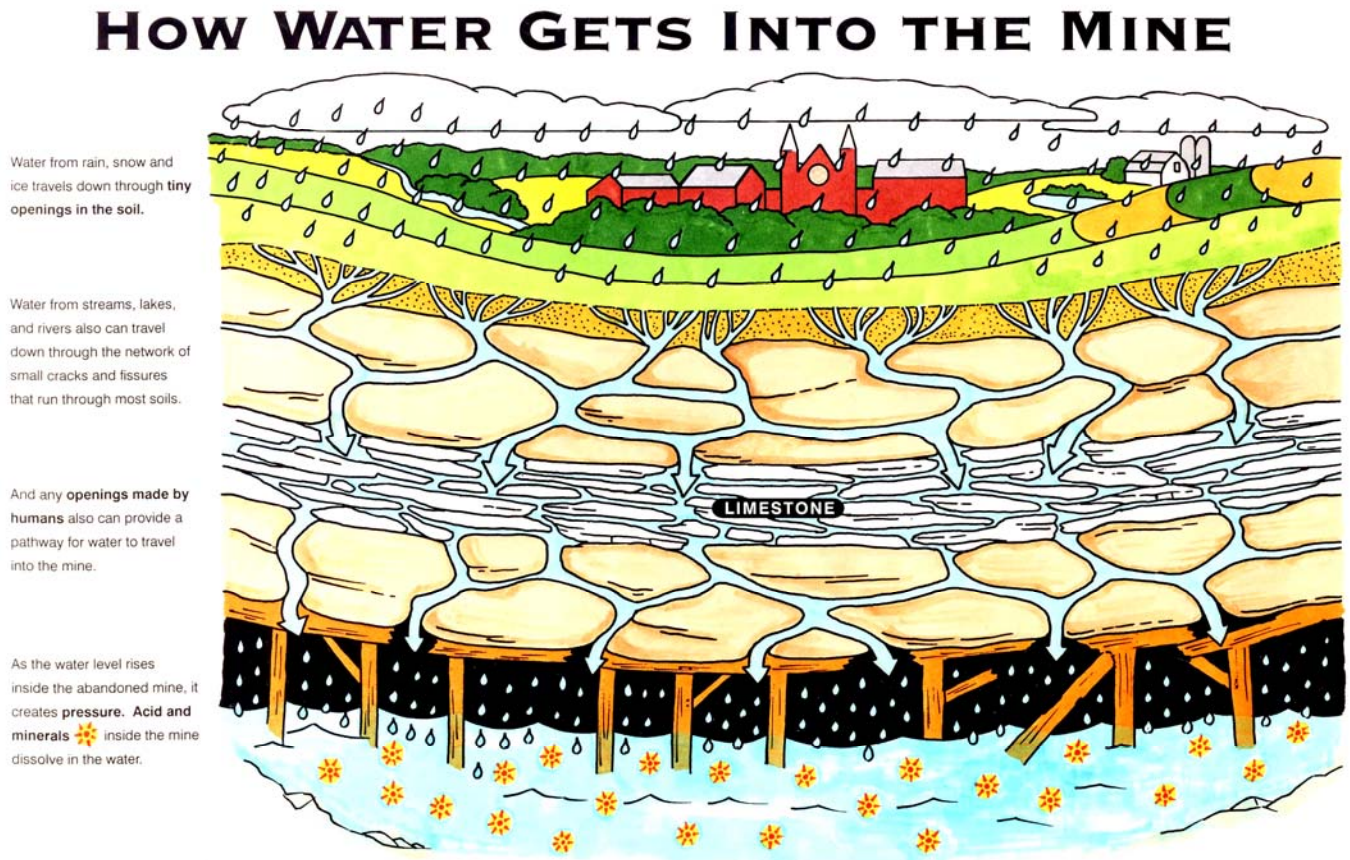
Iron and sulfide react with oxygen present in the air.

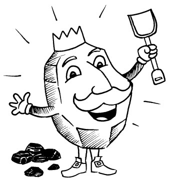
Iron is precipitated and rust is created.
The mine water turns from a clear-transparent color to a cloudy-orange color.
The particles of iron or IRON HYDROXIDE discolor the soil and stream water.

Old Time Coal Miners at Work Overhead



How Water Gets Into the Mine Overhead





Mine Water Drop

Goodbye Orange Water
Activity Booklet Lesson

Background

Coal seams were often located near or below the groundwater level. Groundwater is water that is found underground in cracks and spaces between particles of rock and soil or in crevices and cracks in rocks. The area where the cracks and crevices are filled with both air and water, this is called the unsaturated zone. The level below which all the spaces are filled with water is called the water table. The area below the water table is the saturated zone. The water in the saturated zone is called the ground water. The water table may be only a foot below the ground's surface or it may be hundreds of feet down. Because the mine was near the water table or ground water, the mine would fill up with water if the company did not pump the water out of the mine during the mining operation.

In Early mining operations, when the mine was "played out", the company abandoned the mine and stopped pumping the water out of the mine. In the roof of the mine, was pyrite or fool's gold, The two elements that make up pyrite are Iron and Sulfide. Pyrite is commonly found in the rock layers overlying coal seams.

Eventually, the roof would collapse, if not from retreat mining, from stress, and the mine would be filled with the rocks and minerals that were in the roof, things such as pyrite, sandstone, shale and limestone. Just as water dissolving sugar, the groundwater will begin to dissolve the minerals, and the pyrite will dissolve into iron (Fe^{+2}) particles and sulfate (SO_4^{-2}) particles. Also produced in the weathering or dissolving of pyrite is the production of acid, specifically H_2SO_4.

(1) $2\ FeS_2 + 7\ O_2 + 2\ H_2O \rightarrow 2\ Fe^{2+} + 4\ SO_4^{2-} + 4\ H^+$
(1) Pyrite + Oxygen + Water → Ferrous Iron + Sulfate + Acidity

When the mine water comes in contact with oxygen, the ferrous iron is oxidized to ferric iron. Certain bacteria increase this rate of oxidation from ferrous to ferric iron, but this reaction rate is pH dependant with the reaction proceeding slowly under acidic conditions (pH 2-3) with no bacteria present and several orders of magnitude faster at pH values near 5. This reaction is referred to as the "rate determining step" in the overall acid-generating sequence.

(2) $4\ Fe^{2+} + O_2 + 4\ H^+ \rightarrow 4\ Fe^{3+} + 2\ H_2O$
(2) Ferrous Iron + Oxygen + Acidity → Ferric Iron + Water

The third reaction, which may occur, is the hydrolysis of iron. Hydrolysis is a reaction which splits the water molecule into one hydrogen ion(H^+) and one hydroxide ion(OH^-). The hydroxide ion reacts with the ferric ion to form ferric hydroxide, a precipitate (solid) which is commonly know as yellow boy. This reaction is also pH dependent. Solids form if the pH is above about 3.5 but below pH 3.5 little or no solids will precipitate.

Accompanying Page (s)
Page 7, 11-12

Objectives

- Through a card game, students will identify substances involved in mine drainage formation and remediation.
- Students will expand their understanding of coal mine drainage formation.

Duration of Activity
~ 30 minutes

Pennsylvania Standards Addressed:
4.5.K.C

Materials/Equipment

- Mine Drop Cards (Cut each in half)
- Blackboard or Overhead

Setting
Classroom

(3) $4\ Fe^{3+} + 12\ H_2O \rightarrow 4\ Fe(OH)_3^{-} + 12\ H^+$

(3) Ferric Iron + Water → Ferric Hydroxide (yellowboy) + Acidity

Many areas also contain naturally occurring limestone ($CaCO_3$) deposits which neutralizes acidity. When the water is alkaline or above a pH of 3.5, the formation of yellowboy or the characteristic orange color associated with mine drainage will occur.

The products of AMD formation, acidity and iron, can devastate water resources by lowering the pH and coating stream bottoms with iron hydroxide, forming the familiar orange colored "yellow boy" common in areas with abandoned mine drainage. The strict regulations currently used provide an opportunity to determine if the mine will produce Acidic or Alkaline drainage. To determine this coal companies must analyze how much pyrite and neutralizers are in the rocks which will be disturbed by mining. Then DEP can determine whether or not a site can be mined without harming the environment. By law, DEP cannot issue a permit for new coal mining where it is determined mining will cause acid mine drainage. Other laws and regulation require the cleanup of the site prior to closing the mine, to ensure that there will be no mine drainage to harm local waterways.

Warm-up

1. The teacher will introduce mine drainage by asking students if anyone has ever seen a “colored” stream.
2. The teacher will discuss where students have seen orange streams in their neighborhood.
3. Students will then be directed to the playing area.

Activity

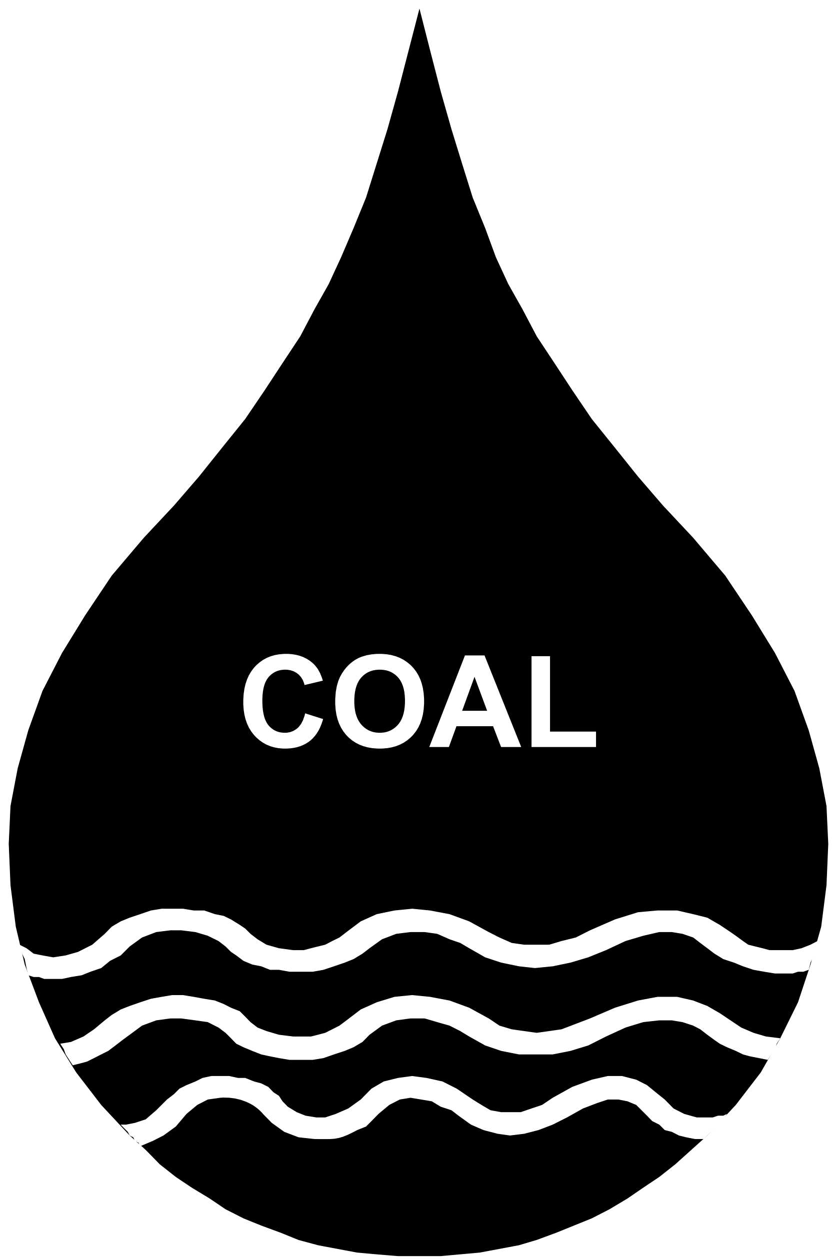
1. The teacher should randomly scatter the Mine Water Drop halves upside down on the classroom floor.
2. Each student should then be directed to pick-up one Mine Water half found scattered throughout the classroom.
3. Each student should find the student that has the other matching piece to their Mine Water Drop.
4. Each Mine Water Drop “partner” should determine the word created by combining their halves.
5. Each Mine Water Drop “partner” should discuss how or why their word is associated with mine drainage formation or remediation.

Wrap-up

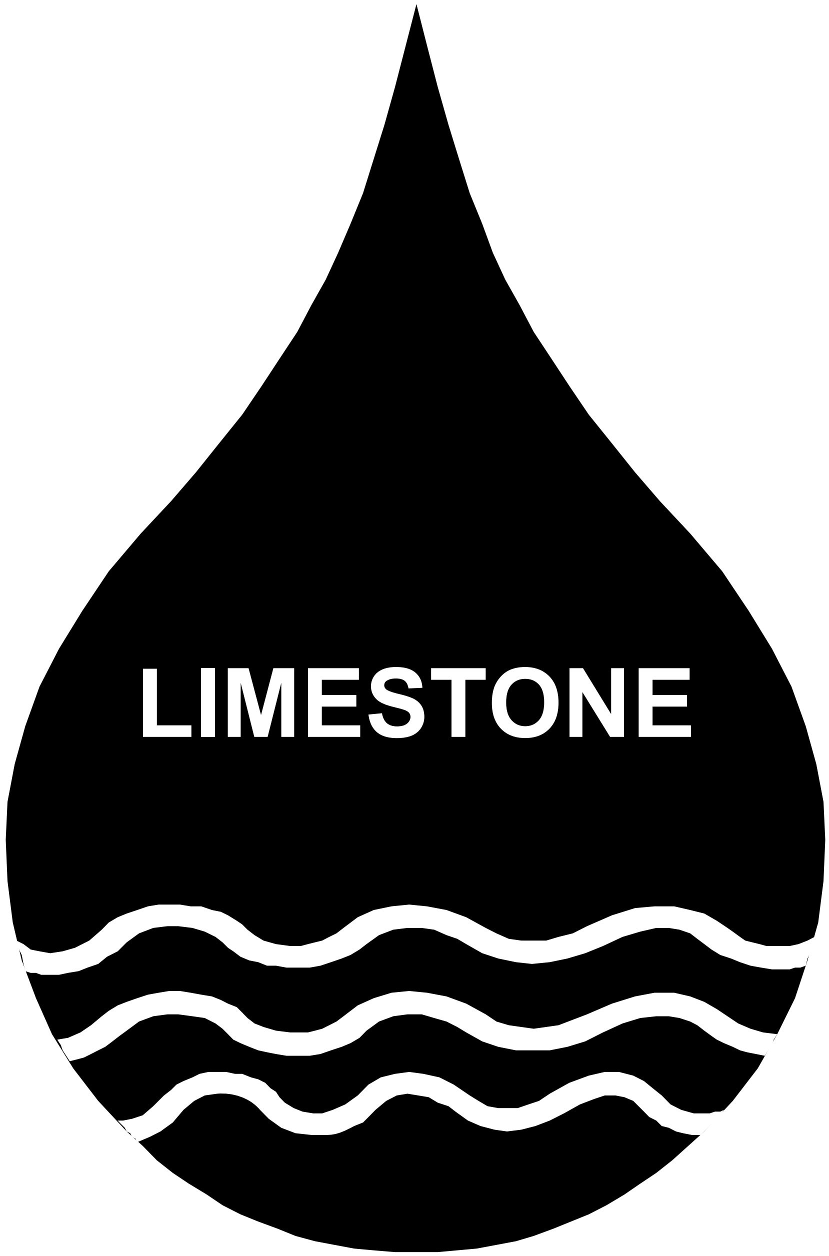
1. The teacher will ask each student to discuss how their Mine Water Drop “word” is associated with mine drainage formation or remediation.
2. The teacher will refer back to the discussion on “colored” streams at the beginning from the Anticipatory set. *How do these terms relate to coal mining or the formation of mine water discharge?*

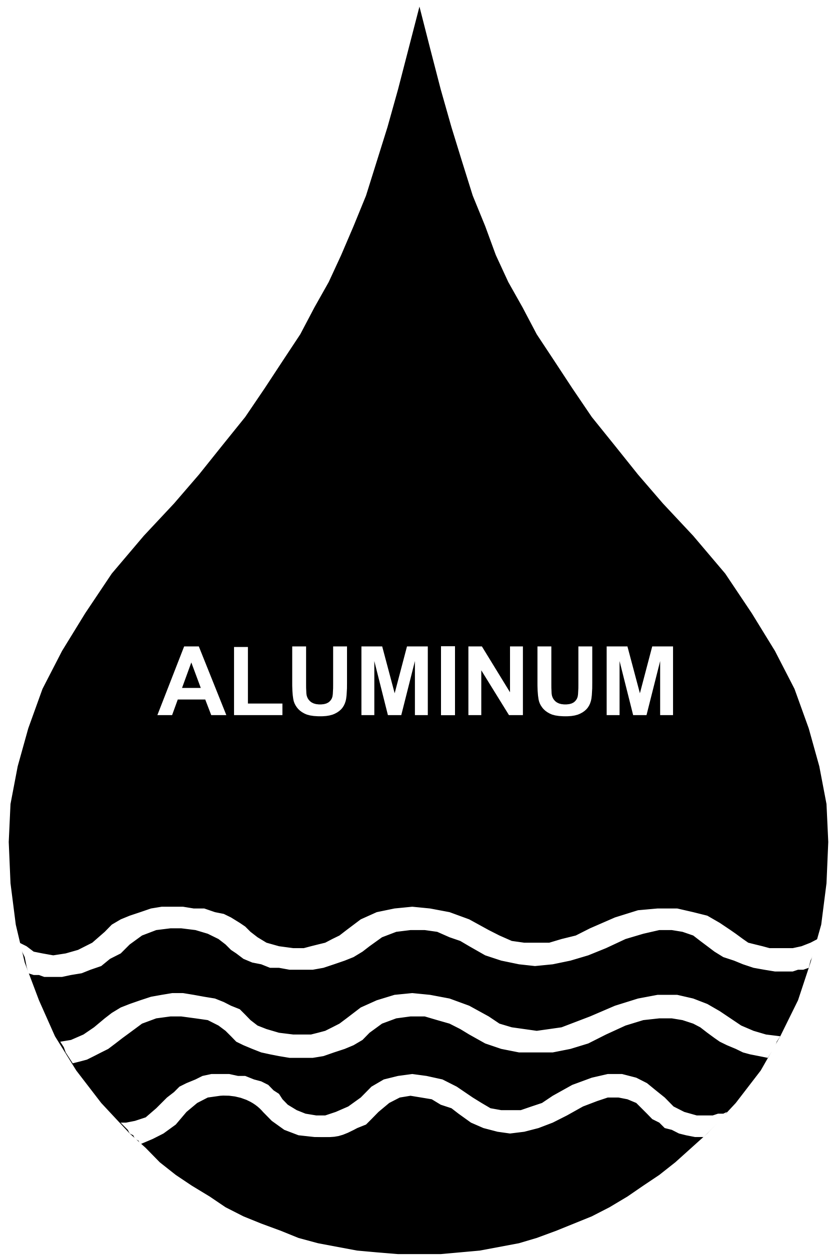
References Used:

http://www.dep.state.pa.us/dep/deputate/minres/bamr/amd/science_of_AMD.htm
http://www.dep.state.pa.us/dep/deputate/minres/bmr/act54/sec6.htm
http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Coal_Mining_in_Pennsylvania.htm

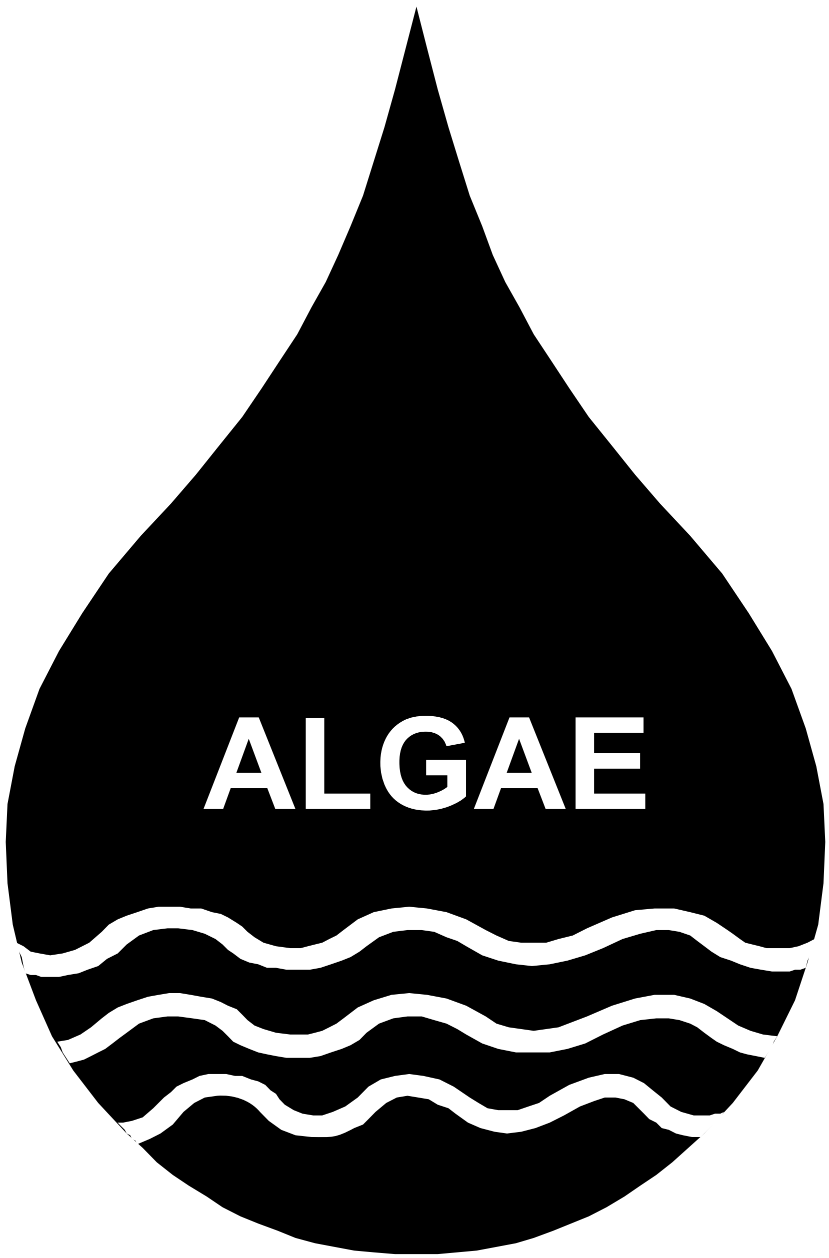

COAL

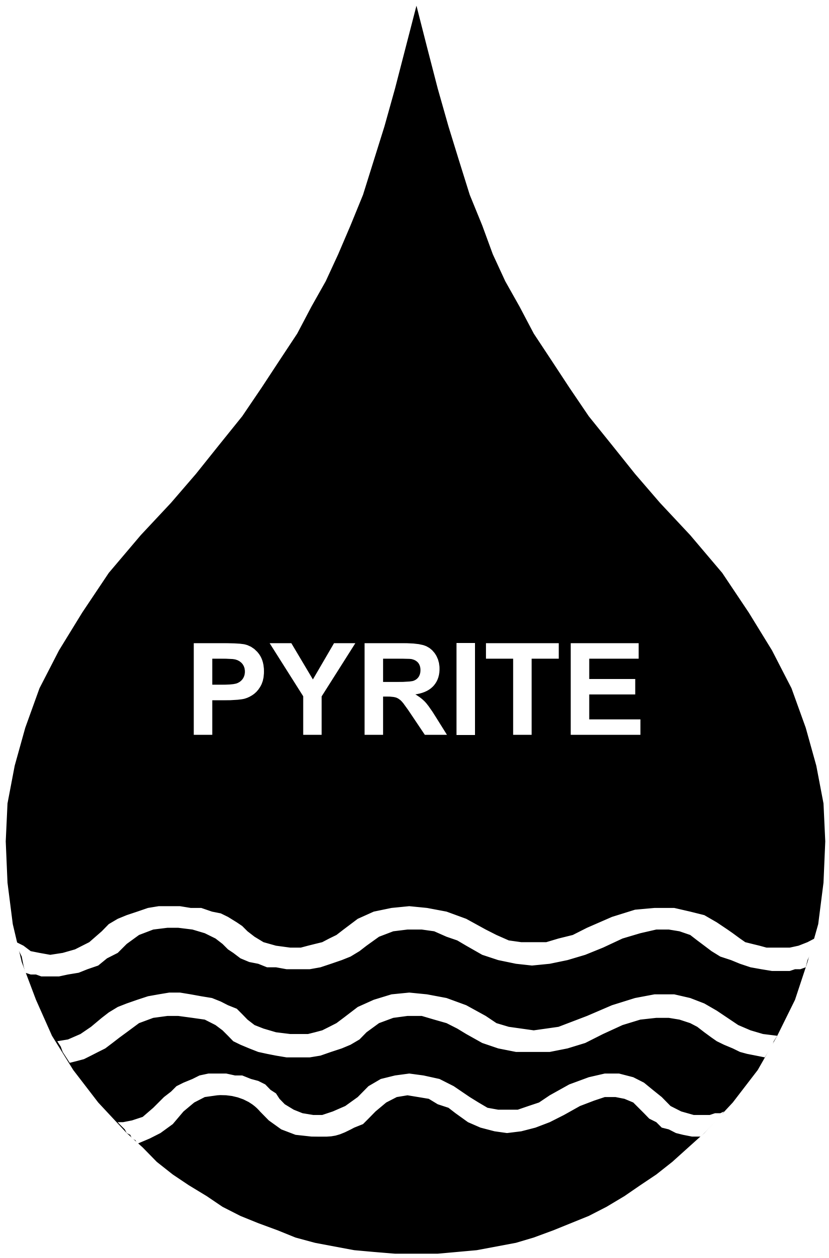

MANGANESE

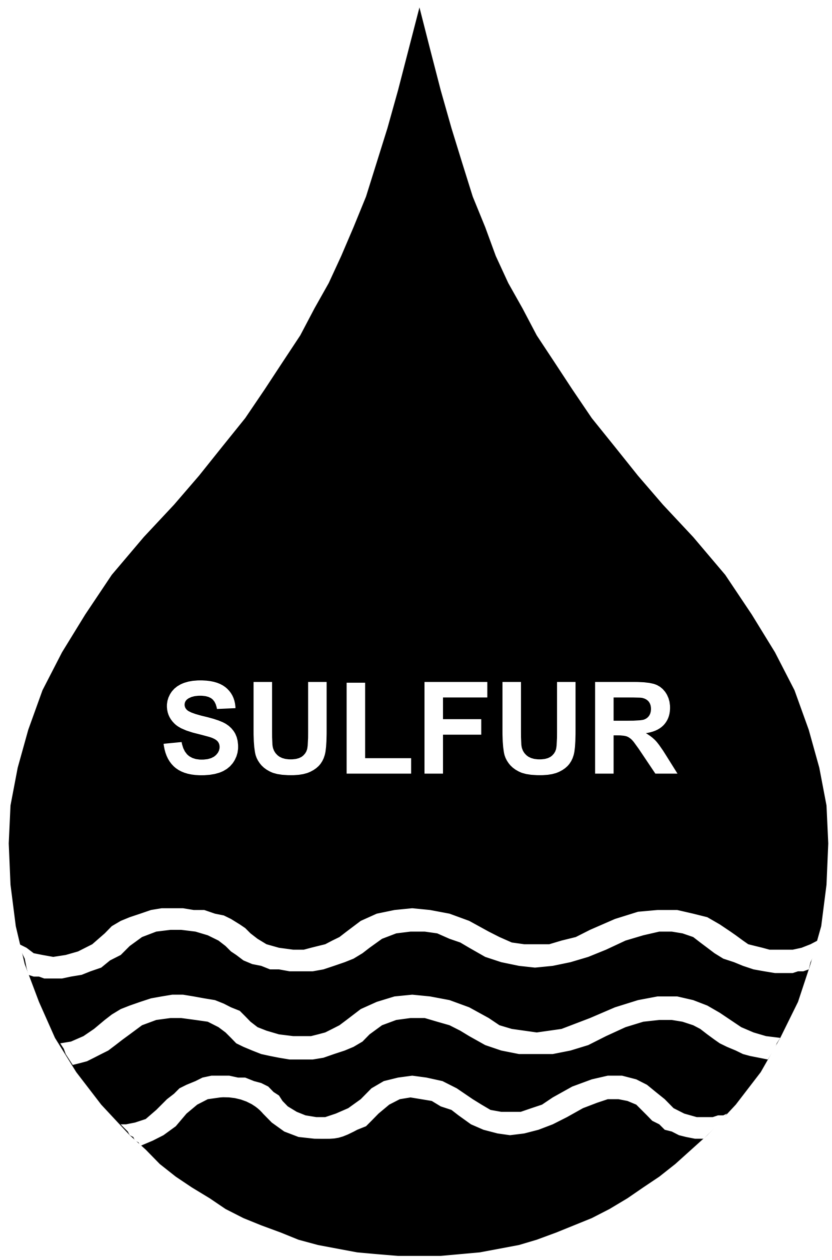

LIMESTONE

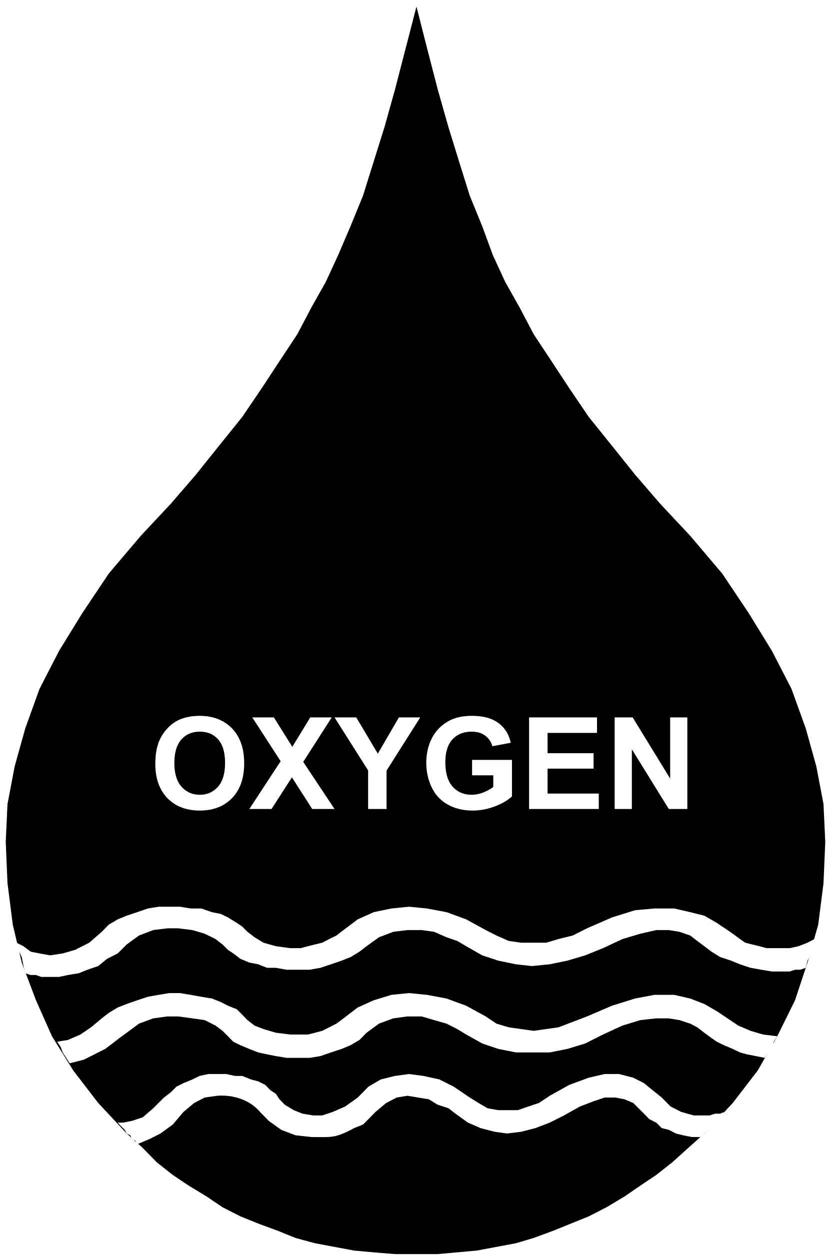

ALUMINUM

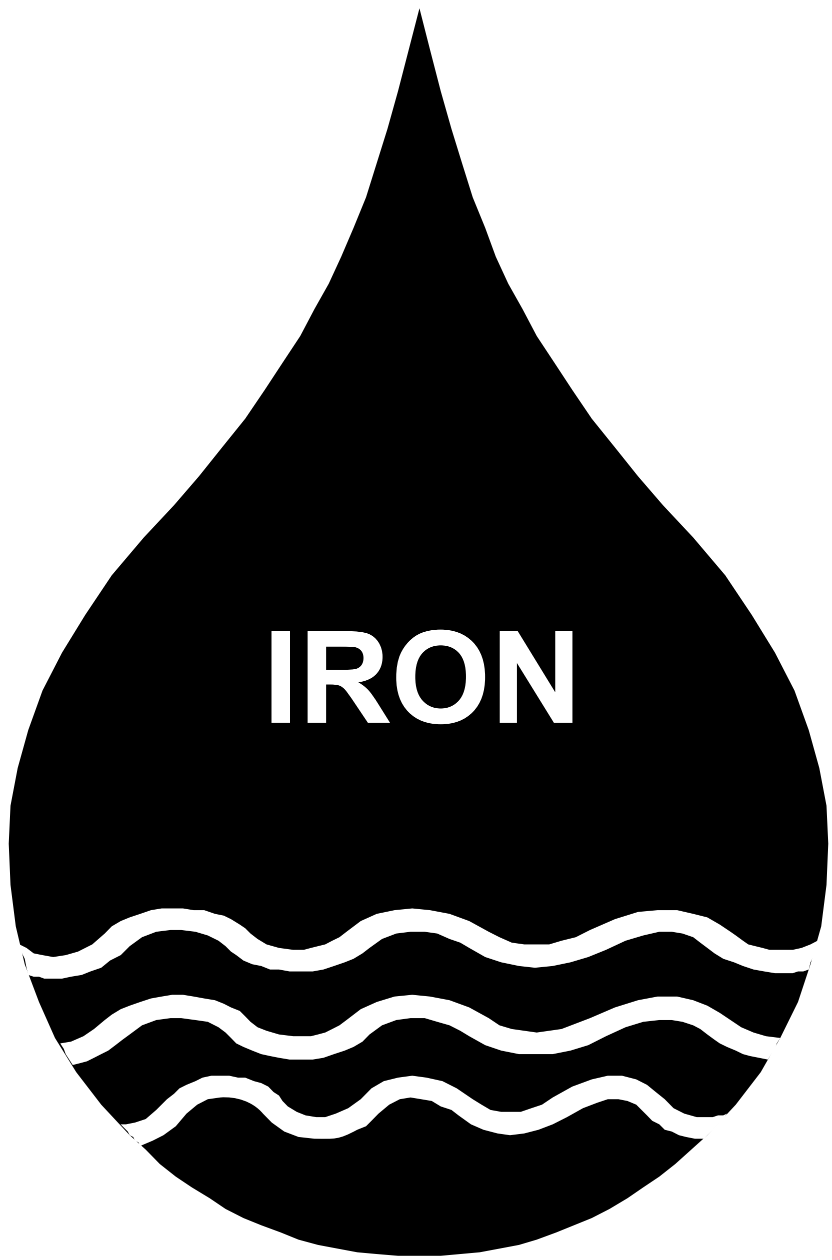

WETLAND

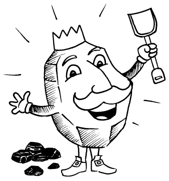

ALGAE


PYRITE


SULFUR


OXYGEN


IRON



Rock Matching

Goodbye Orange Water
Activity Booklet Lesson

Background

Geology, the study of the Earth's crust, is an interesting, but broad topic. Geology is subdivided into branches, which can become a career or course of study in itself. Physiography, one branch, looks at the surface features of the land (like mountains) and tries to understand their origins. Mineralogy is the study of minerals, or naturally occurring inorganic substances, having definite chemical and physical characteristics. Minerals come together to form rocks. Finally, petrology is the study of the origin, composition, and character of rocks. These are a few of the many branches of geology.

Geology plays an important role in environmental issues. Water, for example, travels through the ground. As it is traveling through the ground it may react with rocks and minerals that make up the rocks. If there is water seeping out of the ground and a geologist is familiar with the types of rocks in the area, an educated guess can be made about the chemical and physical characteristics of water. This type of speculation could be used when treating abandoned mine water.

If an area has an abundant source of carbonate containing rocks, like limestone and dolomite, the water passing through cracks and crevices of this rock will be net alkaline. Having net alkaline water is an advantage to treating mine water. A product of the reactions that take place as mine water reacts with air is sulfuric acid. Sulfuric acid in the water could lower the pH enough to be harmful to aquatic life and could also prevent metals in the water from precipitating out. It also costs more money to treat acidic mine water, because limestone must be incorporated into the treatment to raise the pH. Alkalinity helps neutralize the sulfuric acid so that the pH of the mine discharge remains at a safe level.

This card game helps familiarize students with common types of rocks and their characteristics found in Pennsylvania. The game also mimics the benefits of net alkaline mine water.

Warm-up

To warm-up the teacher could obtain samples of the rocks in the game. Students could guess what they think the rocks are and put away their answers until the end of the game.

Activity

Playing the game:

1. Dealer deals six cards to each player. The remaining cards are placed on the table face down and the top card is flipped over to form a discard pile.
2. In a clockwise manner the player next to the dealer must pick one card either from the card deck or the discard pile.
3. Each player must discard one card each turn.
4. Players collect matching rock and description cards, and during their turn place matches on the table along with 1 alkalinity card. Sets of alkalinity and acidity cards may also be placed on the table.
5. The game continues until a player is all out of rock and description cards.
6. Scoring
    - +2 for each rock and description match with one alkalinity card
    - +2 for each alkalinity and acidity match
    - -1 for each acidity, rock, or description card left in players hand
    - +1 for each alkalinity left in hand
7. Next in turn can deal another round. Play can continue until an agreed upon score is reached or until the end of a time limit. The player with the highest score wins.

Accompanying Page (s)
Page 11-12

Objectives
- Students will recognize common rocks, and their associated characteristics.
- Students will begin to understand the benefits of alkaline water in mine drainage formation.

Duration of Activity
One class period

Pennsylvania Standards Addressed:
4.5.1.C, 4.1.8.B

Materials
Set of cards

Setting
Classroom

Wrap-up

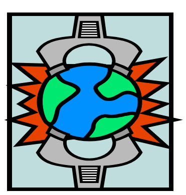
At the end of the game the students should again guess the identity of the sample rocks.

Assessment

Students should be able to correctly identify more of the rock samples after the game then before the game.

Extensions

Take students on a fossil hunt in the local area. For information on finding fossils check out resources on the US Geological Survey website, http://www.usgs.gov/

Igneous 	• Fire Born • Made when magma solidifies • Examples: granite, pumice stone
Metamorphic   	• Igneous or Sedimentary Rock that has been under heat and pressure • Often splits into thin layers • Examples: marble, serpentine, slate

<table>
<tr>
<td>Sedimentary
</td>
<td>

Formed from grains of older broken rocks
Rock are stratified or have layers
Examples: shale, sandstone, limestone

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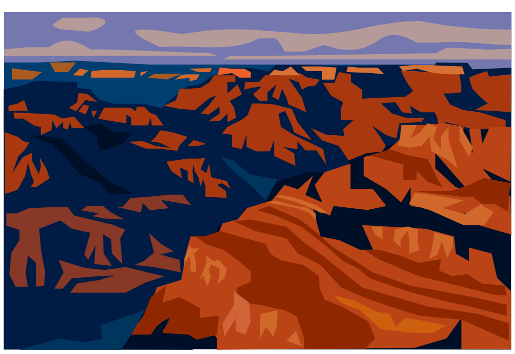
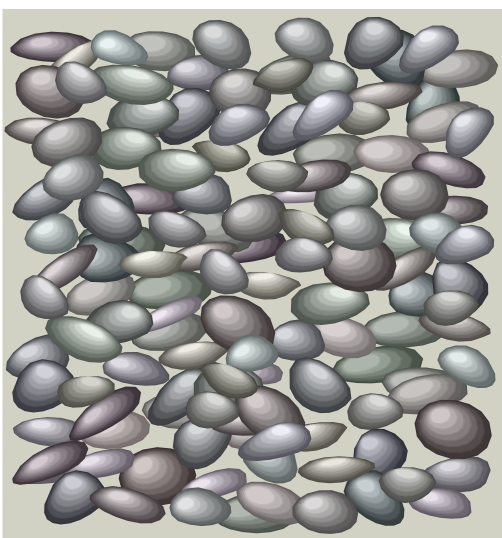
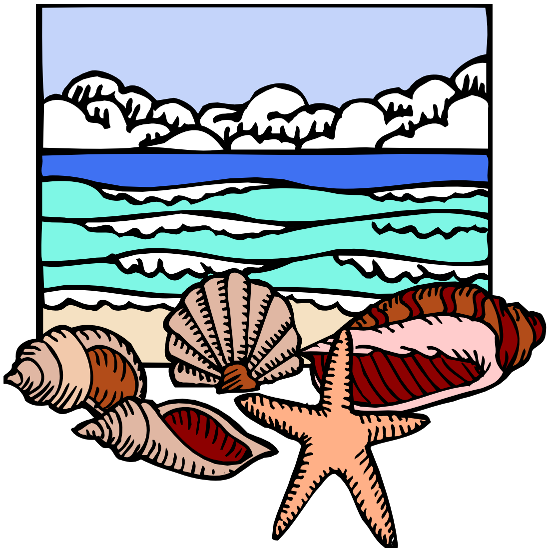
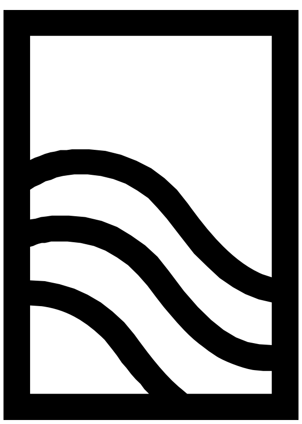
<tr>
<td>Sandstone
</td>
<td>

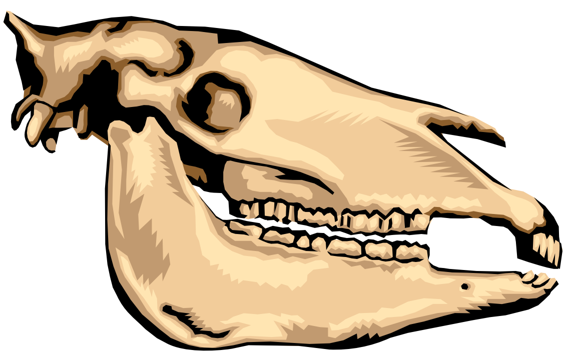
A type of sedimentary rock
Made of cemented quartz grains from 2mm to 1/1 mm diameter
Weathering resistant rock which forms cliffs and mountain caps and is used as building stone and in glass making

</td>
</tr>
</table>

Shale 	• A type of sedimentary rock • Weak, weathers quickly, ranges in color from gray to black and also comes in reds and greens, smooth to the touch • Fissile, or splits into thin plates • May contain fossils of plants
Claystone 	• Sedimentary rock made up of particles with <1/256 mm diameter, smooth to the touch • Can be red or green if iron was present when the rock was formed • General chemical composition is hydrous aluminum silicate

Siltstone 	• Made up of particle with diameter 1/16-1/256mm • Can be fissile or un-fissile, layered or un-layered • Rough to the touch
Conglomerate 	• Formed from cemented gravel with particle size >2mm • Cement is often clay • In Western Pennsylvania this type of rock is associated with sandstone

Limestone 	• Made of calcium carbonate, $CaCO_3$ • Dissolution of carbonate in these rocks results in underground caverns and passages • Will effervesce strongly when hydrochloric acid is dropped on it
Dolomite 	• Made of calcium magnesium carbonate, $CaMgCO_3$ • Weathers to yellowish grey • Breaks and weathers with a curved surface

Coal 	• A type of metamorphic rock • Formed from dead and partially decayed swamp like plants were under pressure and heat for millions of years. • Used today to produce electricity
Fossils 	• Found in limestones • Supports the theory of evolution • Used as time markers for geologists

ALKALINITY	**ALKALINITY**
ALKALINITY	**ALKALINITY**

ALKALINITY	**ALKALINITY**
ALKALINITY	**ALKALINITY**

ALKALINITY	ALKALINITY
ALKALINITY	ALKALINITY

ALKALINITY	**ACIDITY**

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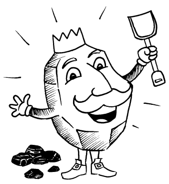


Who Does AMD Affect Activity

Goodbye Orange Water
Activity Booklet Lesson

Background

The products of AMD formation, acidity and iron, can devastate water resources by lowering the pH and coating stream bottoms with iron hydroxide, forming the familiar orange colored "yellow boy" common in areas with abandoned mine drainage. Abandoned Mine Drainage disrupts the healthy function of a stream ecosystem in a variety of ways.

Habitat Bottom:

Abandoned Mine Drainage “sludge” is both a slippery and sticky substance, somewhat the consistency of toothpaste. When mine drainage enters a stream, the iron oxide sludge mixes with the water forming a cloudy precipitate in the stream (orange color). The cloudy condition of the stream does not allow sunlight to penetrate to the bottom of the stream. This condition does not allow the macroinvertebrates to survive.

Sedimentation:

Abandoned Mine Drainage “sludge” makes the water in a stream become turbid as pieces of iron begin to form and precipitate out of solution. The “rusty” pieces of iron make the water and stream cloudy; therefore block sunlight from reaching the photosynthetic organisms and aquatic plants. This process destroys the producers in an aquatic food chain, thus destroying the healthy balance of “who eats who”.

Lowers Dissolved Oxygen:

Abandoned Mine Drainage utilizes the existing dissolved oxygen in the stream in the oxidation reaction as mine water enters a stream. It is the dissolved oxygen or DO in the water that allows macroinvertebrates or other gill-breathing organisms to survive and thrive in a stream.

Abandoned Mine Drainage affects many individuals in a community. Kayaking, swimming, and fishing in streams and creeks impacted by mine drainage becomes difficult, unenjoyable, and sometimes dangerous. Families are affected because the unpleasant odor of mine drainage and the unsightly discolor of streams near their homes may make it difficult to resale their home located along an AMD impacted stream or creek.

Warm-up

1. The teacher will introduce mine drainage by asking students if anyone has ever seen a “colored” stream. How did this make you feel?
2. The teacher will then prompt discussion of how it smells, looks, and feels. Would you like to swim in an orange-colored stream? Could you fish in an orange colored stream?
3. Students will then be directed to the classroom.

Activity

1. Each student should pick-up one of the Who Does AMD Affect Cards found scattered throughout the classroom.
2. Each student should find the student that chose the exact match to their card by walking about the classroom and asking other classmates.
3. Each “partner” should unscramble the word found on the bottom of his or her card.

Accompanying Page (s)
Page 13

Objectives
- Through a card game, students will identify who and what mine drainage affects.
- Students will begin to understand how mine drainage impacts many facets of our community.

Duration of Activity
~ 30 minutes

Pennsylvania Standards Addressed:
4.5.K.C

Materials/Equipment
- Who Does AMD Affect Game Cards

Setting
Classroom

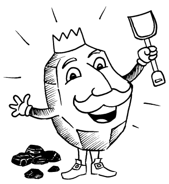
4. Each “partner” should discuss how or why his or her word is affected by abandoned mine drainage.

Wrap-up

1. The teacher will ask each student to discuss how the item on his or her card is affected by the presence of mine drainage.
2. The teacher will refer back to the discussion on “colored” streams at the beginning from the Anticipatory set. How do these items relate to the reasons why we should clean-up streams contaminated with mine drainage?

Assessment

Extensions



Mining and AMD Story

Goodbye Orange Water
Activity Booklet Lesson

Accompanying Page (s)
Page 14

Objectives
- To examine the life of a coal miner, their families and the patch towns they lived in and write a story portraying the life of a miner.
- To use the words in the AMD word search to understand the legacy coal mining has left behind.

Pennsylvania Standards Addressed:
CC.3.6.6-8.C

Duration of Activity
2-3 class periods

Materials
Research material
Paper
Computers

Setting
Classroom
Library
Computer Room

Background

Bituminous coal is mined in 21 Pennsylvania counties: Greene, Somerset, Armstrong, Indiana, Clearfield, Washington, Cambria, Jefferson, Westmoreland, Clarion, Elk, Fayette, Lycoming, Butler, Lawrence, Centre, Beaver, Blair, Allegheny, Venango and Mercer (ranked in order of production).

Beginning in the mid-1700's coal mining in Pennsylvania fueled the Industrial Revolution in the United States. It began to support the Colonial iron industry, then Andrew Carnegie's steel mills in the 1800's and finally electric power plants of more modern times. Two kinds of coal are mined in Pennsylvania- anthracite (hard coal) and bituminous (softer coal).

The environmental legacy of hundreds of years of coal mining in Pennsylvania is over 2,400 miles of Pennsylvania's 54,000 miles of streams polluted by acid mine drainage from old mining operations. Abandoned mine drainage is the single largest source of water pollution by far in the state. Modern laws and regulations require that present day mining cannot begin if it might result in harm to the environment.

Room-and-pillar Mining

Room-and-pillar mining involves driving tunnel-like openings to divide the coal seam into rectangular or square blocks. These blocks of coal, or pillars, are sized to provide support for the overlying strata. The openings are referred to as rooms or entries.

Room-and-pillar mines have been active in Pennsylvania's bituminous coalfields since the late-1700s. Bituminous coal was first mined in Pennsylvania at "Coal Hill" (Mount Washington), just across the Monongahela River from the city of Pittsburgh. The coal was extracted from drift mines in the Pittsburgh coal seam, which outcrops along the hillside, and transported by canoe to the nearby military garrison. Development of the anthracite coalfields in eastern Pennsylvania had progressed to the point where "hard coal" had captured the eastern markets. Consequently, bituminous coal production in western Pennsylvania grew principally with western population growth, expansion and development of rail and river transportation facilities to the west, and the emergence of the steel industry.

The Mining Legacy

During mining operations, the coal seam was usually located below the groundwater level, so the mine would fill up with water if the mining company did not pump the water out of the mine during the mining operation.

In the roof of the mine, was pyrite or fool's gold, FeS_2, to see information, makeup, uses, sources and other information about pyrite, check out the following web site. http://www.minerals.net/mineral/sulfides/pyrite/pyrite.htm. The two elements that make up pyrite are Iron and Sulfide. Pyrite is commonly found in the rock layers overlying coal seams.

When the mine was "played out", the company abandoned the mine and stopped pumping the water out of the mine. Eventually, the roof would probably collapse and the mine would be filled with the rocks and minerals that were in the roof, things such as pyrite, sandstone, shale and limestone. Just like when you put sugar in water, the water will begin to dissolve the minerals, and the pyrite will dissolve into iron (Fe^{+2}) particles and sulfate (SO_4^{-2}) particles.

The products of AMD formation, acidity and iron, can devastate water resources by lowering the pH and coating stream bottoms with iron hydroxide, forming the familiar orange colored "yellow boy" common in areas with abandoned mine drainage.

Many areas also contain naturally occurring limestone ($CaCO_3$) deposits, which neutralizes acidity. To determine whether or not a mine will create acidic drainage, coal companies must analyze how much pyrite and neutralizers are in the rocks, which will be disturbed by mining. Then DEP can determine whether or not a site can be mined without harming the environment. By law, DEP cannot issue a permit for new coal mining where it is determined mining will cause acid mine drainage.

When the mine is filled up with ground water, there needs to be an outlet, often times that outlet is a seep, or sometimes it is a borehole that was drilled for any of a number of reasons. When the water exits the mine, the reaction begins.

Reference: http://www.dep.state.pa.us/dep/deputate/minres/bamr/amd/science_of_AMD.htm
Reference: http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Bituminous_Coal_Mining.htm
Reference: http://www.dep.state.pa.us/dep/deputate/minres/bmr/act54/sec6.htm
Reference: http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Coal_Mining_in_Pennsylvania.htm

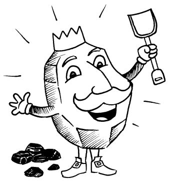
Warm-up
Come in dressed in dirty clothes and covered with coal dust and carrying the equipment associated with coal mining. Ask the students what they think you are and why you look the way you do. Discuss why you are dirty, and why you have to carry all the equipment.

Activity
Have the students research coal mining in Pennsylvania and how that has affected the current status of Pennsylvania Streams. Have the students use the information obtained to write a short story portraying the life of a coal miner, the mining heritage of Pennsylvania and the legacy it has left behind. The story should contain at least 15 words from the AMD Word Search on Page 14.

Wrap-up
Have the students read the stories to their classmates. Discuss how each student made their story different. Maybe some focused on the mine, some on the water, and some on coal.

Assessment
Grade the students on grammar, spelling and completeness of thought.

Extensions



Active vs. Passive

Goodbye Orange Water
Activity Booklet Lesson

Background

Debate Background

Debates are an important part of water quality issues. They help people to be informed about different perspectives of water quality issues, and therefore make more informed decisions about public policies and development issues.

Debates are characterized by two types of speeches: constructive and rebuttal. A constructive speech uses evidence, which is researched and written on note cards, to support a view while a rebuttal offers evidence to discredit an opposing viewpoint.

Debates also have an affirmative and negative side of the issue. For example, when debating the Endangered Species Act one side of the debate could be for the act and one against it. A negative constructive speech may say: The Endangered Species Act is unfair to private landowners; because of the amount money they must expend to accommodate endangered animals that may live on their property. One elderly couple in Kentucky had to spend all of their retirement savings to move their driveway away from an endangered animal's home. A negative rebuttal would say: The endangered Species Act does not help restore a species population. Since the installation of the act none of the species listed as endangered have been removed from the list, and ten of the species have become extinct.

Another dimension of the debate is the cross-examination. Each position is offered a chance to cross-examine the opposition after their constructive speech. Cross-examinations can be used to get more information about the opposition's arguments or to develop a greater understanding of their position. Questions asked in a cross-examination can also be used to set up one's arguments, and a cross-examination also gives the cross-examiner a chance to make a good impression on the judge. The following is a simplified debate schedule based on the Oregon style of debate, taken from "Hot Water" a lesson plan in Project Wet.

Debate Schedule For 2 Speakers	Minutes (Middle School)	Minutes (High School)
Affirmative Constructive Speech	4*	8*
Cross-examined by the Negative	2	3
Negative Constructive Speech	4	8
Cross-examined by the Affirmative	2	3
Negative Rebuttal	2	3
Affirmative Rebuttal	2	3

*Maximum Time allowed in minutes

Mine Drainage Treatment Background

Mine Drainage problems were initially treated actively. This means that the water was treated in a factory-type setting by adding chemicals, like lime, that would precipitate the iron out of the water and neutralize the pH. This method was found to be costly because as long as there is water coming out of the mine, the chemicals needed for treatment have to be purchased and there must be people to operate the facility. Cost can become a problem when the responsible parties of the mine drainage cannot be found or cannot be held responsible, as is the case with many abandoned mines.

Accompanying Page (s)
Page 15

Objectives

- Students will research about passive and active treatment of mine discharges and then construct and hold a debate on the issue.

Duration of Activity
Two 50 min. class periods and possible time outside of class.

Pennsylvania Standards Addressed:
CC.3.6.6-8.A

Materials
4 X 6 inch note cards
Copies of Debate Ballots
Video of an actual debate (optional)

Setting
Classroom and library

Adapted from Project WET – Hot Water

Over the past 20 years, passive treatment of mine drainage has become more important and more widely used. Passive treatment allows mine drainage to flow into a wetland, usually a man-made wetland, where the iron precipitates out into cells of the wetland. Little or no chemicals are used in the process, and the wetland also becomes a habitat to many wetland plants and animals. Some advantages of passive treatment are that after an initial high start-up cost, long-term cost is lower than active treatment, because of the little use of chemicals. One disadvantage of passive treatment is that the discharge is not as easily maintained, at consistent level, as it would be if treated actively. For instance winter conditions result in higher iron concentrations in the discharge of a passive treatment system.

Because of this advantage and disadvantage active treatment is usually used at active mining sites where discharge limits are important permit requirements and passive treatment is used for abandoned mines where funding is more of an issue. There are also scenarios where there is a combination of the two treatment methods. The goals of cleanup and feasibility of cost and space limitations are what determines what type of treatment a mine discharge receives.

Warm-up
Have students watch a taped debate in class or watch one scheduled to appear on TV. Have them identify the affirmative and negative positions as well as constructive and rebuttal speeches for each viewpoint. You may even have them judge the debate using the debate ballots.

Activity
1. Present one of the following scenarios to the class.

Scenario 1:

The city of Coalville was a bustling center of activity during the 1950's and 1960's. Two major industries allowed Coalville to thrive: fishing tourism and coal production. In the 70's, however, coal mining was no longer economically beneficial in this town. Shortly after the mines closed, Coalville experienced an environmental catastrophe.

All the streams in town turned orange and smelly! All the fish and aquatic life died too. Water from the abandoned mines began to find its way to the surface in streams, wetlands, and from boreholes. The mine water contained metals and sulfur and when it reached the surface produced iron oxides and acidic conditions that the aquatic life could not tolerate. Coalville became a ghost town because it had lost two major industries in less than a decade.

As the years went by and people began to pine for places to go to get away from the cities and to reconnect with the wilderness. Coalville once again became more noticed. The area surrounding Coalville was almost pristine wilderness. It was spacious and created habitat and recreational opportunities abound. Only the stream conditions kept the area from being pristine.

A committee formed of people who wanted to restore the area's streams for many reasons. Some wanted their children to be able to swim in the local creeks. Others wanted to bring back aquatic life and diversity to the streams. Others just wanted the orange color of the water to go away. The committee decided that everyone in Coalville would benefit from the cleanup of the mine water. The only problem was those companies responsible for the pollution were no longer around or were unable to pay for the problems they had caused. It was up to the committee to find a way to treat the water that would work for the committee.

A preliminary study was done by a local college and it was determined if two major discharges were cleaned, than water quality in the area would be significantly improved. One of the discharges was located within the Coalville city limits and drained into the Willow Creek, which runs through the city. The other major discharge entered Willow Creek 10 miles upstream of the city from Farmer Joe Pig's property. When the committee began planning the treatment of these two sites, it became divided into two factions: those who were supporting active treatment of the discharges and those who were supporting passive treatment of the discharges.

Scenario 2:

The city of Coalville was a bustling center of activity during the 1950's and 1960's. Two major industries allowed Coalville to thrive: fishing tourism and coal production. In the 70's, however, coal mining was no longer economically beneficial in this town. Shortly after the mines closed, Coalville experienced an environmental catastrophe.

All the streams in town turned orange and smelly! All the fish and aquatic life died too. Water from the abandoned mines began to find its way to the surface in streams, wetlands, and from boreholes. The mine water contained metals and sulfur and when it reached the surface produced iron oxides and acidic conditions that the aquatic life could not tolerate. Coalville became a ghost town because it had lost two major industries in less than a decade.

As the years went by and people began to pine for places to go to get away from the cities and to reconnect with the wilderness. Coalville once again became more noticed. The area surrounding Coalville was almost pristine wilderness. It was spacious and created habitat and recreational opportunities abound. Only the stream conditions kept the area from being pristine. A community committee was formed and attacked the problem by treating two major discharges in the area. They treated these discharges using passive treatment, because of low long-term costs and multi-purpose advantages.

A few years after the passive systems were in place a coal company came to Coalville with the desire to strip mine in the area. Coalville's people were very wary about the coal company, because of what resulted from mining in their community in the past. Some people were also interested in the proposition because it would mean good paying jobs. When applying for a permit to mine the Company was referred to the community committee. Together they were to come up with a pollution prevention plan that would work for the community and the mining operation.

The mining operation had to adhere to strict discharge standards for things like metals and pH as long as they were mining on the land. They were in favor of active mining. The community, however was concerned about the fate of the water after the mining company was gone from the area, and given their past success, favored passive treatment. Could the two groups reach an agreement that could go into the mining permit?

2. Tell the class to imagine they are on the Coalville cleanup committee (Scenario1), or the committee and mining company (Scenario 2). Have the class split up into two groups. Assign one group, which will support passive treatment of the mine drainage and be the affirmative viewpoint. The other group will support active treatment and be the negative viewpoint.
3. Further divide the groups into two groups: A and B. The following chart gives advantages of both treatment methods to be used in the debate by both affirmative and negative views.

Affirmative (for Passive Treatment)	Negative (for Active Treatment)
A. Cost-effective	A. Consistent discharge water to meet regulations
B. Provides habitat for Wildlife	B. Good for Space limitations

4. Group A from each side will research and compose a constructive argument for the advantage A of their favored treatment method. They will also research and compose a rebuttal argument for the opposing sides advantage A. Group B will do the same with the advantages labeled B. Arguments and evidence found through research can be summarized of index cards.
   Ideas for research:
   - Internet - www.dep.state.pa.us/, http://facweb.stvincent.edu/eec/
   - Local - Mining companies, Parks or environmental education places, Local colleges
   - Library reference
     Key words: Mine Drainage, active treatment, passive treatment, AMD, Coal mining, etc.

5. Two people (one from Group A and one from Group B) from each side should be elected spokespersons for the debate.
6. The chosen speakers will sit at the head of the classroom and the rest of the students will act as judges of the debate.
7. The debate schedule given in the background can be followed, but a coin is tossed to determine whether the negative or affirmative gives their constructive speech first. Either speaker may give their rebuttal first, and preparation time up to 3 minutes is allowed for the rebuttal.
8. Judges should assign values from 1-4 (1 being the most convincing argument and 4 the least convincing argument) for both constructive and rebuttal sections. Judges may take notes during the argument, and at the end of the debate the team with the least amount of points wins the debate.

9. Judges should consider the following when scoring:
    a. Analysis: getting to the heart of the question
    b. Proof: supporting contentions with sufficient and convincing evidence
    c. Argument: sound reasoning; logical conclusions
    d. Adaptation: clashing with or responding to the opposition
    e. Refutation: destroying the opponents contentions, reinforcing your own
    f. Organization: clear, logical presentation of the material
    g. Speaking: effective delivery, favorable impact on the audience

Wrap-up

Discuss judging ballots. Discuss and explain strengths and weaknesses of affirmative and negative arguments and speeches.

Discuss and make a decision about what should be done to treat the discharges in Coalville after completing the assessment.

Assessment

Have students write a short essay what should be done to clean the discharges in Coalville. Have them indicate what arguments of the debate swayed their opinions.

DEBATE BALLOT

Judges Name: ______________________

DIRECTIONS: Circle the number that best describes the debater(s) you judged, and record your comments below. 1=the most convincing argument, and 4=the least convincing argument. Take into consideration:

- Analysis: getting to the heart of the question
- Proof: supporting contentions with sufficient and convincing evidence
- Argument: sound reasoning; logical conclusions
- Adaptation: clashing with or responding to the opposition
- Refutation: destroying the opponents contentions, reinforcing your own
- Organization: clear, logical presentation of the material
- Speaking: effective delivery, favorable impact on the audience

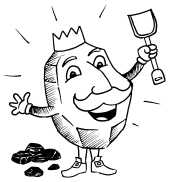
Group A

Overall Affirmative	**1**	**2**	**3**	**4**	**Overall Negative**	**1**	**2**	**3**	**4**
Constructive Speech	1	2	3	4	Constructive Speech	1	2	3	4
Cross Examination of Negative	1	2	3	4	Cross Examination of Affirmative	1	2	3	4
Rebuttal	1	2	3	4	Rebuttal	1	2	3	4
Comments:					Comments:				

Group B

Overall Affirmative	**1**	**2**	**3**	**4**	**Overall Negative**	**1**	**2**	**3**	**4**
Constructive Speech	1	2	3	4	Constructive Speech	1	2	3	4
Cross Examination of Negative	1	2	3	4	Cross Examination of Affirmative	1	2	3	4
Rebuttal	1	2	3	4	Rebuttal	1	2	3	4
Comments:					Comments:				

I determine the debate to be won by Affirmative / Negative. (circle one)



How Wetlands Clean Water

Goodbye Orange Water
Activity Booklet Lesson

Background
Wetlands have many functions, including erosion control, flood control, and can also clean polluted runoff. Wetlands clean polluted water in two ways. Wetland plants can take up pollutants that are dissolved in the water via capillary action as they "drink" with their roots. Wetland plants and their root systems act as a physical barrier that stop large particles, such as coagulated iron oxide, from remaining in the water. In Both cases the pollution is retained in the wetland and returns to open water at a safer rate, than with out the wetland.

Warm-up
Ask in what different ways a wetland functions and record answers on the board. Some possible answers: Habitat, recreation, flood and erosion control, and pollution cleanup.

Activity
Plant Uptake

Perform steps 1and 3 one day before the lesson, but repeat steps in front of class to show how the demonstration was prepared.

1. Fill a jar with water and add several drops of food coloring. Explain that the food coloring represents a pollutant like iron in mine water, and have students come up with other examples of pollutants.
2. Tell students to imagine the jar of colored water is a wetland and the celery stalk is a wetland plant such as a cattail.
3. Cut off the bottom ½ inch of the celery stalk and place it in the jar of colored water. Allow the celery to soak overnight.
4. Cut the celery stalk into 1 inch pieces and allow the students to observe. Ask them to write down their observations and then discuss them. The students will see a cross section of vertical channels that have been filled with the colored water from the jar. Discuss how wetland plants similarly take up water in their roots, and like the food coloring that traveled through the celery stalk a pollutant can travel up a wetland plant.

Wetland Model

Making the Model Wetland:

1. Spread a layer of modeling clay in half of the long pan shaping it so that it slopes down into the empty side of the pan. The modeling clay represents the land.
2. Cut a hole in the empty short edge of the pan. This hole will represent the output of the wetland into a stream or other body of water.
3. Fill the empty side of the pan with sponges, florist foam, or indoor/outdoor carpeting, making sure that the fit is snug without too much space around the edges of the pan. This part of the model represents the wetland.
4. If students are preparing the model(s), they can make and place objects into the land and wetland to make it appear more realistic. Students can use natural decorations like twigs and pine needles to represent wetland vegetation. They may also cut out pictures of wetland animals, attach the pictures to toothpicks and place them in the wetland.

Accompanying Page (s)
Page16

Objectives
- Students will understand wetlands functional role in the treatment of pollution.

Duration of Activity
60 min for demonstrations only.
2 hours, if students are making the models
Plant Uptake: Needs to sit overnight

Pennsylvania Standards Addressed:
CC.3.5.6-8.C, 4.1.2.A, 4.1.2.E, 4.2.3.B, 4.5.1.C

Materials
Plant Uptake: Celery stalks with leaves, 2 beakers or jars, red or blue food coloring, water, paring knife

Wetland Model: Modeling clay (bought or homemade); long shallow aluminum disposable pan; knife; sponges, florist foam, or indoor/outdoor carpeting; 2 jars of muddy water or mine water mixed with iron oxide sludge; stopwatch; two clean beakers that hold as much as the jars.

Setting
Classroom

Adapted from "Treatment Plants" and "Wetland in a Pan", Wow! The Wonders of Wetlands: An Educator's Guide, Environmental Concern Inc. and The Watercousre: 1995.

Demonstration:

1. Show students the wetland model and explain the different parts and what they represent.
2. Ask the students to speculate what will happen if the polluted water is poured onto the land if the wetland is removed from the model. Ask the students to speculate what will happen if the polluted water is poured onto the land while the model is fully intact.

Experiment Part 1:

1. Remove the wetland from the model.
2. Place a book or notebook under the part of the pan containing the land. Place the pan so the edge with the hole is level with the edge of a table or sink, so that a student can hold a beaker underneath the hole to catch the water.
3. Have another student shake up the jar of polluted water, and then pour it slowly over the land.
4. As the water is filling up the beaker have a student with a stop watch record how much time it takes to fill the beaker half way and then record how much time has elapsed when the water stops flowing from the hole.
5. Have the student record observations about the water in the beaker, including how much water is present and the appearance of the water. Save the beaker of water.

Experiment Part 2:

1. Rinse out the model to remove any residue from Part 1.
2. Replace the wetland.
3. Position the model as in Step 2 of Part 1.
4. Once again have the student shake the second jar of polluted water and pour it at the same rate as in Part 1 over the land.
5. Record how much time it takes for the water to fill the beaker half way and the amount of time for water to stop coming out of the hole.
6. Have the students record observations about the water in the beaker.

Demonstration:

3. Discuss the differences observed in each part of the experiment.
4. Note that in Part 1 the water filled the beaker faster and there was more water was in the beaker at the end of Part 1 than at the end of Part 2. Explain that wetlands can act as flood protection, and slow water down and even retain some water, stopping or making flash flooding less severe. Sponges can be wrung out to show that water was retained in Part 2.
5. Note that the water in the beaker from Part 2 was cloudier than the water in the beaker Part 2. Explain that the wetland absorbed some of the pollution so it could not reach the beaker. In this way a wetland traps pollutants and stops or slows them from entering the stream. The mud should appear on the material used for the wetland in the model.

Wrap-up

Plant Uptake

Some questions for consideration:
What happens to the pollutant when the plant dies?
-The plant will return to the wetland soil and decompose, so the pollutant, as long as no chemical reactions have taken place, will also return to the soil and/or the water.
Is the water still polluted in the jar?
-Yes. Plants can only uptake so much water and store so much pollution.
Where else could the pollution go in the wetland?
-It could settle out into the bottom of the wetland or stick to the outside of the wetland vegetation.

Wetland Model

Some Questions for consideration?
Was the water in the beaker from Part 2 completely clear?
-No. Again Wetlands have limitations to the amount of pollution they can remove, and do not always remove pollution in a consistent manner.
If Part 2 was repeated, without ringing out the wetland first would the outcome be the same?
-No. The water may move faster and there may be more water in the beaker than after the first run. Wetlands can become saturated with water and pollution. At wetland treatment systems that treats mine drainage, may need to be dredged after so many years, to make room for more precipitates.

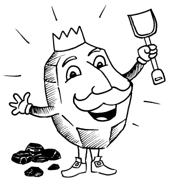
Assessment

Have students:
List two ways wetland plants clean polluted water.

1. Plant uptake
2. Filtration

Discuss wetland treatment limitations

1. Wetlands can become saturated.
2. AMD Wetland outputs are not always consistent.



Wetland Field Trip

Goodbye Orange Water
A Wetland Field Trip

Background

Wetland Zones

1. Bottom Zone or Benthic Zone
   - The soil layer at the bottom of the wetland.
   - Life found there: bacteria, dragonfly nymph, mayfly nymph, nematodes and hibernating frogs
2. Deep Water Zone or Limnetic Zone
   - Area in or on top of the deep, open water of the wetland
   - Life found there: bladderwort, coontail, predacious diving beetle, mosquito larva, water strider, northern pike
3. Shallow Water Zone or Littoral Zone
   - Shallow water where the light penetrates to the bottom
   - Life found there: sedges, whitetop grass, springtail, water spider, garter snake, mallard duck

Life Cycles

1. Metamorphosis – changes in an organism that allow it to have different forms and live in different habitats throughout its life.
   - Complete Metamorphosis – Four stages: egg, larva, pupa, and adult
   - Incomplete Metamorphosis – Three stages: egg, nymph, adult
2. Amphibians
   - Three stage metamorphosis: egg, larva, adult
3. Fish and Birds
   - Two stage cycle: egg and adult
   - Intermediate juvenile phase
4. Mammals
   - One stage – must mature from infancy to adulthood (marked by ability to reproduce

Warm-up

Ask students if they know what kind of animals live under, on, and beside the water of a wetland. Make a list on the board of the three categories and the students responses.

Activity

Classroom Background

1. Explain and/or give notes on the three-wetland zones and give examples of animals that live there. Use Wetland Ecosystems I, Student Journal pages 7-9 from Ducks Unlimited Canada, www.ducks.ca/edu/resource.html
2. Explain and/or give notes on Life Cycles as outlined in the background section, or use Wetland Ecosystems I, Student Journal pages 10-12, www.ducks.ca/edu/resource.html.

Teacher Preparations

1. Egg Carton Specimen containers
- Copy enough organism sheets so that each group has one for each wetland zone. Use pages 20-22 of the Wetland Ecosystems I, Educator's Guide from Ducks Unlimited Canada, www.ducks.ca/edu/resource.html.
- Fit the sheets into appropriate number of egg cartons with tape or glue.
2. Coat Hanger Nets
- Pull the triangular shape of the hanger until it is more circular.
- Bend the hanger hook so that it is perpendicular to the wire loop.

Accompanying Page (s)
Page 17

Objectives
- After performing this activity, students should be able to successfully sample macroinvertebrates and be able to write down the life cycle of at least one insect.

Duration of Activity
1class period for introduction to background material and preparation for field trip, ½ day for field trip, 1 class period for discussion and clean-up

Pennsylvania Standards Addressed:
4.5.1.C, 4.4.2.C

Materials
Per Group of 4 Students
- 3 foam egg cartons with organism charts (1 shallow water, 1 deep water, and 1 bottom dwellers) attached to the lids
- Magnifying glass
- 2 wire hanger nets (prepared by teacher): wire hangers, used pantyhose, duct tape
- Clip board with pencil and Field Trip Notes sheet
- Under water scope (made by teacher)

3 Plastic containers with lids (used butter or sour cream tubs)

Setting
Class Room and local wetland – could be small or large, natural or constructed wetland

Adapted from Wetland Ecosystems I: a unit plan by Ducks Unlimited Canada found online at www.ducks.ca/edu/resource.html

- Stretch one leg of the pantyhose over the circular frame and tape the opening shut around the base of the hook of the hanger. The result will be a double-layered screen that can be used to filter animals that may be in the water or sediment of the wetland. (Note: you can purchase inexpensive small aquarium nets for this exercise from most pet stores.)

3. Under Water Scope: Use page 23 of the Wetland Ecosystems I, Educator Guide, www.ducks.ca/edu/resource.html.

Wrap-up

After the field trip discuss with each group the types and numbers of insects found and possibly record data on an overall results graph. The teacher could discuss how adaptations of the different stages help the insect survive in the different areas of the wetland.

Assessment

Each group should be able to describe the life cycle of one insect.

Extensions

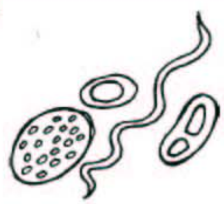
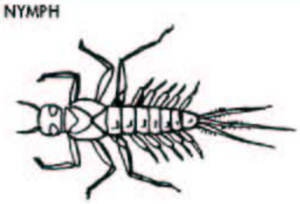
Each group can pick one insect and make a display of its life cycle. A different group could display their life cycle each week.

Lesson three

Wetland zones and the cycle of life

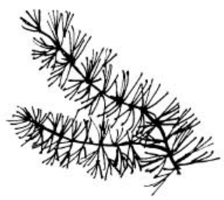
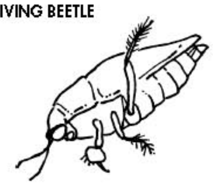
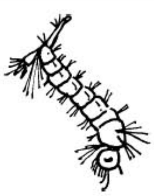
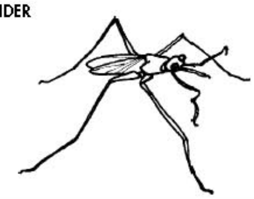
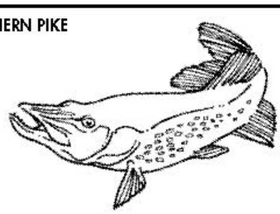
Organism identification chart

Bottom Zone
The bottom or **benthic** zone is the soil layer at the bottom of a wetland. Many plants and animals live here.

BACTERIA 	Bacteria are important wetland **decomposers** – organisms that help break down dead plants and animals for reuse. Bacteria are microscopic, among the smallest of living things, and can be found in the **mud** or **water column** of wetlands. There can be up to one million bacteria per cubic centimetre.
DRAGONFLY NYMPH 	Though most people recognize the flying adults of this wetland insect, few know that the **nymph** may spend up to two years living on the marsh bottom. They are aggressive **predators** that feed on insects and other invertebrates, tadpoles and even small fish.
MAYFLY NYMPH 	One of the most common wetland insects, **mayfly nymphs** can burrow into the **mud**. Most mayfly species are easily recognized by their three hair-like tails. The nymphs feed on plants found on the bottom of the wetland. Adult mayflies have wings and do not feed. They are eaten by fish and birds.
FROG 	Frogs are **vertebrate amphibians** which **hibernate** to get them through the cold winter months. They will burrow into the soft **mud** and remain inactive until spring. During this time they breathe through their skin and do not need any food.

Lesson three continued

Deep Water Zone
The deep water or **limnetic** zone is the area in or on top of the deep, open water in a wetland.

BLADDERWORT 	These are small **carnivorous** marsh plants. Most have bladders which are like tiny air sacs that help keep the stem afloat and trap small organisms for food.
COONTAIL 	Coontail is often the most common **submergent** plant in newly formed wetlands. It has three-forked leaves that grow in whorls around the stem. Coontail does not need to be rooted in the soil to grow well.
PREDACIOUS DIVING BEETLE 	These large beetles are brown or black in colour and one of the most common of the aquatic beetles. They **prey** upon any small animal they can catch.
MOSQUITO LARVA 	These small, wormlike animals move **through the water** with a wriggling motion. They **feed on algae** and other microscopic organisms. Their **pupal** stage can also be found in the deep water zone. Flying **adult** females **feed on the blood** of other animals using sucking mouth parts.
WATER STRIDER 	These slim **insects** live on the **surface film** of quiet waters, drifting aimlessly or running rapidly about. They **prey** on other smaller insects, catching them either on the surface or by diving below.
NORTHERN PIKE 	The pike is a **fish** that waits in ambush for unsuspecting **prey** to swim by. Found only in larger wetlands that are deep enough to allow it to live through the winter, the pike has few natural predators. It feeds on other fish, frogs, small birds, crayfish and insects. People, loons, otters and ospreys eat pike.

Lesson three continued

Shallow Water Zone

The shallow water or **littoral** zone is where light penetrates to the bottom.

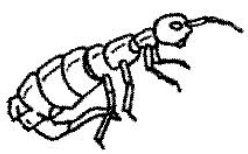
SEDGES

Sedges are **emergent** plants found in shallow water or moist soil around a wetland. They are an important plant for **nesting** and feeding waterfowl and provide valuable **cover** and **food** for many species.

WHITETOP GRASS

An **emergent** plant of shallow, temporary wetlands, whitetop can grow to nearly one metre. It provides excellent **cover** for marsh nesting birds as well as being a valuable **hay crop** for farmers after the birds' eggs hatch.

SPRINGTAIL

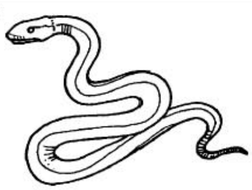


These small, wingless insects are found in vegetation along a **wetland's edge**. The name comes from their ability to spring into the air by using their tail when disturbed by **predators**.

WATER SPIDER

Water spiders live among the vegetation in shallow water. They **hunt** for other small invertebrates and can dive under water for several minutes in pursuit of **prey**. Waterbirds and large insects prey on them.

GARTER SNAKE



These nonpoisonous snakes live along the **wetland's edge**. They **feed** on frogs, minnows, toads, mice and insects. While solitary during the summer, they spend the winter hibernating **underground** with other snakes.

MALLARD DUCK

The mallard is the most common duck, easily recognized by the dark green head of the male. They **nest** in fields or along the shore of marshes, feeding on vegetation and insects. Mallards eat a variety of foods and are **omnivorous**. When the marshes freeze, mallards **migrate** south to warmer areas.

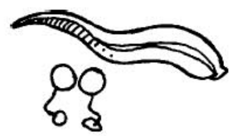
Lesson three continued

Organism life cycles

Metamorphosis is a series of changes that allows an organism to have different forms and different habits as it grows. In **insects**, those with **four** life stages are **complete**, those with three stages are **incomplete**. In complete metamorphosis the stages are **egg, larva, pupa** and **adult**. In an incomplete metamorphosis the stages are **egg, nymph** and **adult**. **Amphibians** also have a three stage metamorphosis – egg, larva and adult. **Fish** and **birds** usually have a two stage cycle – egg and adult, with an intermediate **juvenile** phase. Most **mammals** do not lay eggs (the platypus is an exception) and are born resembling the adult. They are not mature and are unable to reproduce for some time after. In fact, the offspring of mammals are often born blind and helpless.

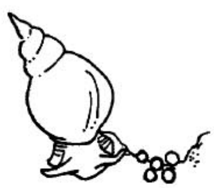
Let's look at some wetland creatures and examine their life cycles.

LEECHES



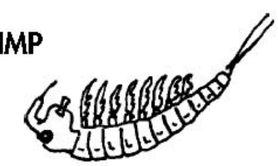
Leeches lay **eggs** in a cocoon which they fasten to a plant or bury in the mud. They hatch looking just like adults.

SNAIL



Most snails have male and female organs. Snails lay **eggs** which hatch into young resembling the adults.

FAIRY SHRIMP

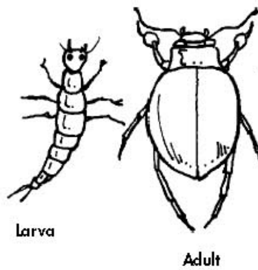


These tiny **crustaceans** lay **eggs** which are dropped to the bottom of the wetland by the adult. They hatch into an immature stage which must **moult** before becoming an adult.

DAPHNIA (water fleas)

Females carry a number of **eggs** in their body. They hatch and remain there for several days before being released. The young must **moult** before becoming adults.

Lesson three continued



PREDACEOUS DIVING BEETLE

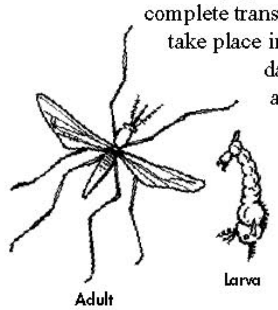
These common wetland insects have a complete **metamorphosis**, meaning they have **four stages**. The **eggs** are laid on shoreline plants, hatching into aggressive aquatic **larvae**. The larvae eventually crawl to shore where they become **pupas**, hiding under logs or stones. They emerge weeks later as full grown **adults**.

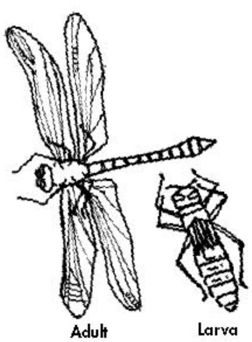
SPRINGTAIL

Eggs are laid in the vegetation along the shore. The young are different from adults only in colour.

MOSQUITO

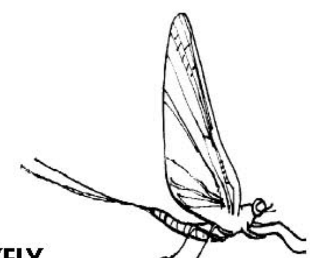
Like all true flies, mosquitoes have a **four-stage life cycle**. Their metamorphosis is complete – from **egg** to **larva** to **pupa** to **adult**. This complete transformation may take place in as little as 10 days or as long as two years.





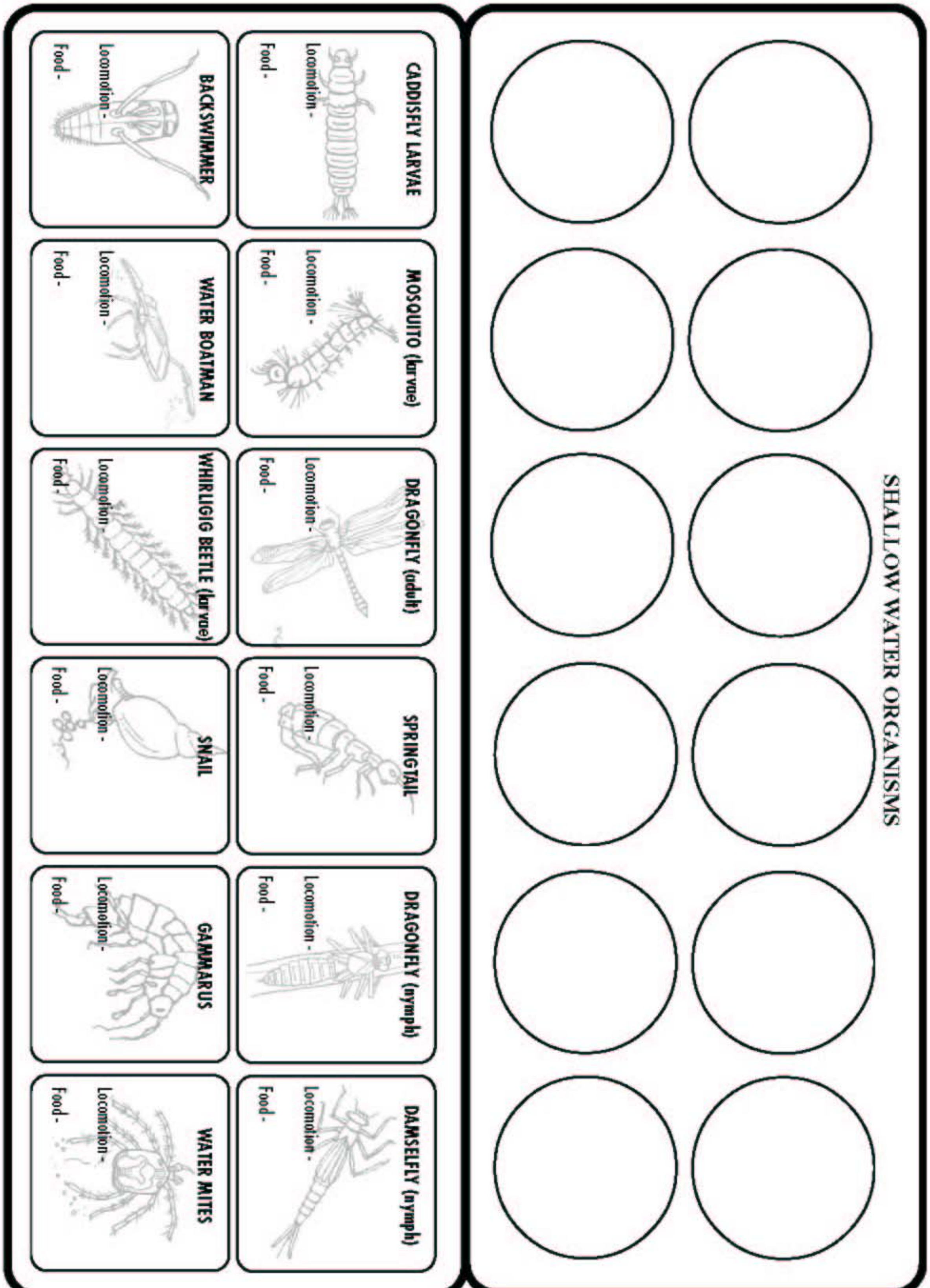
DRAGONFLY

These large insects have a **three-stage life cycle** much like that of the mayfly. The **eggs** are laid in water, where they hatch into **nymphs**. The nymphs eventually crawl up on shore where they moult into winged **adults**.

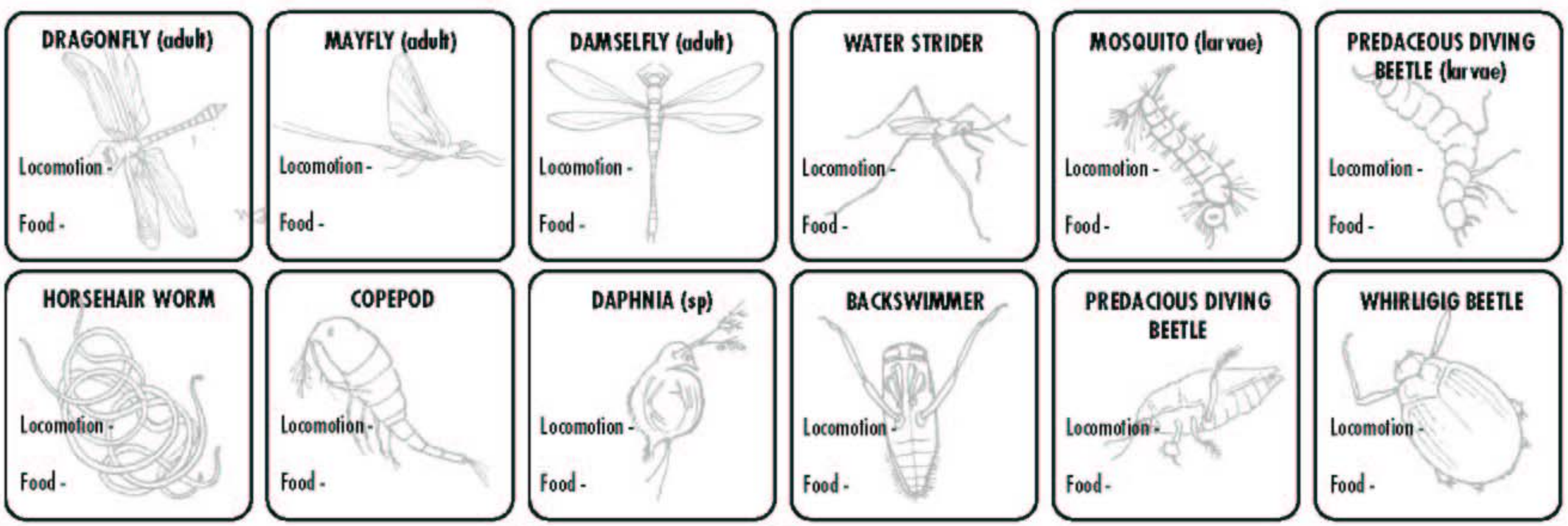


MAYFLY

Mayflies show **incomplete metamorphosis**. They lay **eggs** in the water which hatch into **nymphs**. The nymphs live and feed in the water. After some time the nymphs crawl up on shore where they moult, emerging as flying **adults**.


SHALLOW WATER ORGANISMS
CADDISFLY LARVAE
Locomotion -
Food -
MOSQUITO (larvae)
Locomotion -
Food -
DRAGONFLY (adult)
Locomotion -
Food -
SPRINGTAIL
Locomotion -
Food -
DRAGONFLY (nymph)
Locomotion -
Food -
DAMSELFLY (nymph)
Locomotion -
Food -
BACKSWIMMER
Locomotion -
Food -
WATER BOATMAN
Locomotion -
Food -
WHIRLIGIG BEETLE (larvae)
Locomotion -
Food -
SNAIL
Locomotion -
Food -
GAMMARUS
Locomotion -
Food -
WATER MITES
Locomotion -
Food -

DEEP WATER ORGANISMS



CADDISFLY LARVA

Locomotion -

Food -

PLANARIA

Locomotion -

Food -

MIDGE (larvae)

Locomotion -

Food -

GAMMARUS

Locomotion -

Food -

HORSEFLY (pupa)

Locomotion -

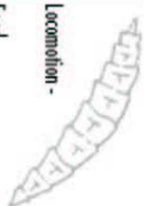
Food -

DRAGONFLY (nymph)

Locomotion -

Food -

HORSEFLY (larvae)



Locomotion -

Food -

MAYFLY (nymph)

Locomotion -

Food -

LEECH

Locomotion -

Food -

STONEFLY (nymph)

Locomotion -

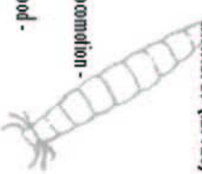
Food -

SNAIL

Locomotion -

Food -

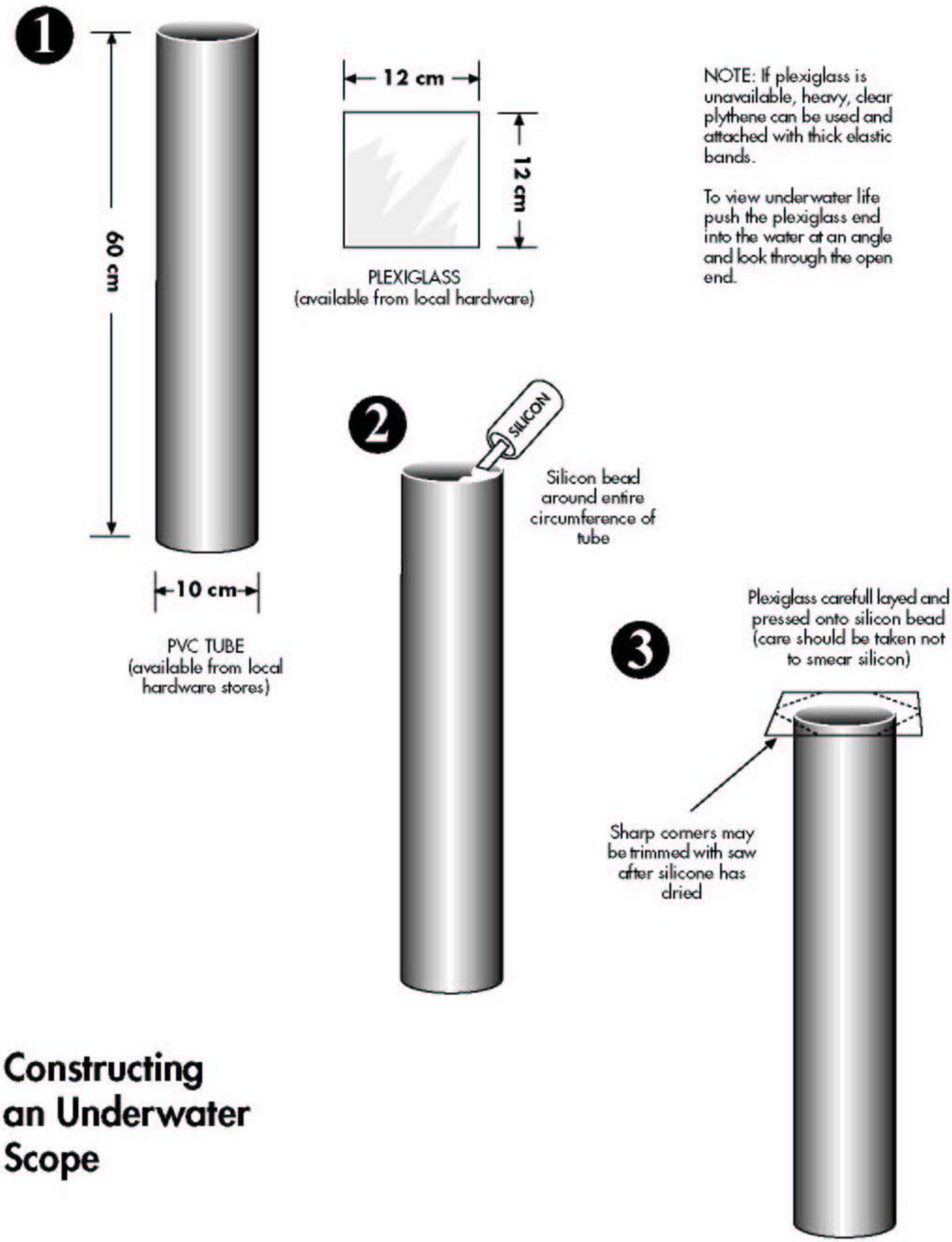
CRANEFLY (larvae)



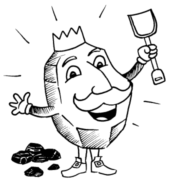
Locomotion -

Food -

BOTTOM ORGANISMS



Constructing an Underwater Scope



Wetland Riddles

Goodbye Orange Water
Activity Booklet Lesson

Accompanying Page (s)
Page 20

Objectives
- Students will be able to identify three common characteristics of a wetland ecosystem.
- Students will recognize the types of plants, animals, and insects found in a wetland ecosystem.

Duration of Activity
~50 minutes

Pennsylvania Standards Addressed:
4.2.4.A, 4.2.3.B

Materials
1 Ziploc Baggie of mud
1 plastic or toy frog
1 cattail with roots
Organism Riddle Cards
Riddle Clue Cards

Setting
Classroom

Images adapted from Mark Jackson- Jackson Graphics; and Ranger Rick's NatureScope: Wading Into Wetlands.

Background

U.S. EPA- "Wetlands" is a general term used to describe areas that are neither fully terrestrial nor fully aquatic. These areas range in character from the majestic cypress swamps of the southern United States to shallow, unimpressive depressions, which hold water at most only a few weeks out of the year.
Wetlands are important for many reasons. Some provide critical habitat for migratory waterfowl, while others check flooding and siltation on our waterways. Some act as filters - removing and sequestering contaminants that might otherwise find their way into our drinking water, while others provide us with recreational opportunities such as fishing and boating.

One of the many roles of wetlands is the role of being a home for much of America's wildlife. The variety of wetlands across the country creates habitats for many forms of fish and wildlife. Some animals spent their entire lives in wetlands, while others use wetlands primarily reproduction and raising of young. Other species visit marshes to take advantage of the abundance of food and water provided by these systems.

Warm-up

- Students will walk into the room with a baggie of mud, a plastic or toy frog, and a cattail on the table in front of the classroom.
- The teacher will list each of the items on the chalkboard in a Venn Diagram.
- The teacher will ask the students the following questions, arranging the student answers in the proper placement on the diagram.
  1. Where do you find each of these items?
  2. Are all these things living organisms?
  3. How is each of these different from one another? What do all of these things need or use?

Activity

1. After the teacher has completed the diagram. Ask the students what is similar between all three of these items?
2. Students will sit in a circle on the floor. The teacher will randomly place the images of wetland plants, animals, and insects on the floor in the center of the circle.
3. The teacher will read the wetland clues for each of the organisms displayed on the chalkboard. Students are to wait until the entire riddle is read before they chose the correct organism. The student will explain why they chose that organism, and why it is found in a wetland.
4. The teacher will work through all of the organisms in the middle of the circle until all the clue cards are read.

Wrap-up

1. The teacher will review “What makes a wetland, a wetland” with the students by referring back to the Venn Diagram prepared in the anticipatory set. (water, moist soil, and specific “water loving” organisms)
2. The teacher will then ask the students why the organisms left on the floor from the “Wetland Riddle Exercise” are not found in a wetland ecosystem.

Assessment

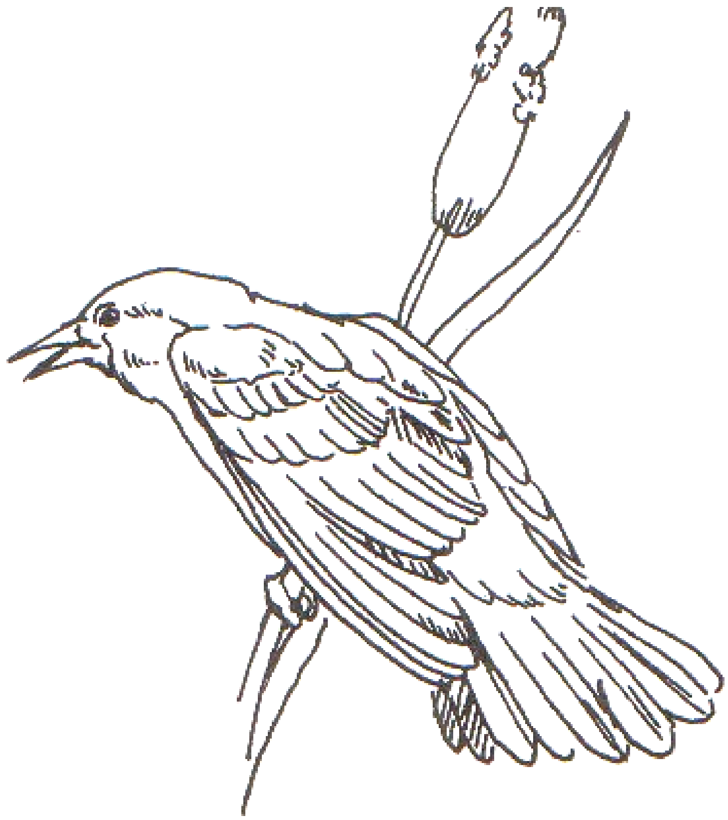
1. The teacher will verbally prompt students to explain how a scientist would know they were located in a wetland ecosystem. (Objective 1)

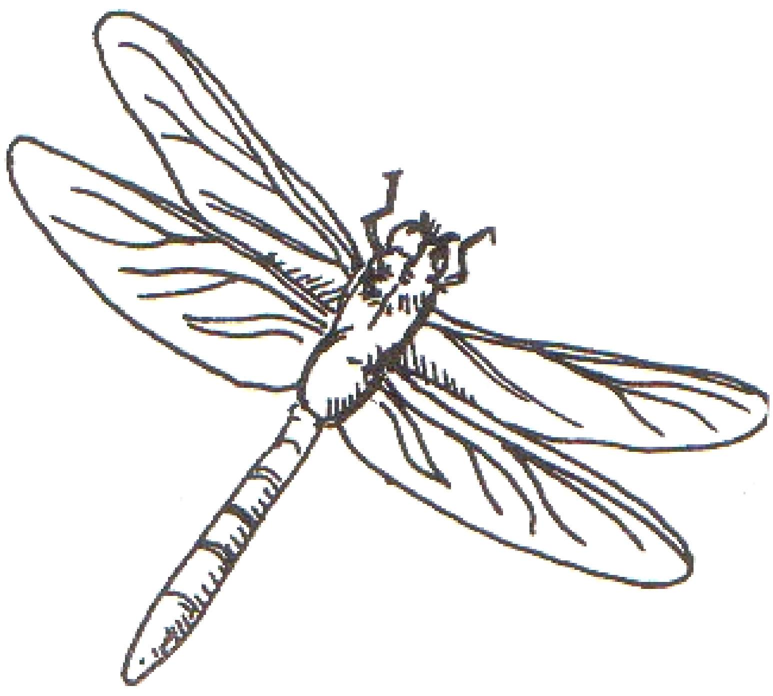
2. The teacher will use class participation- both silent and verbal – to determine if students can identify wetland plants, animals, and insects. (Objective 2)

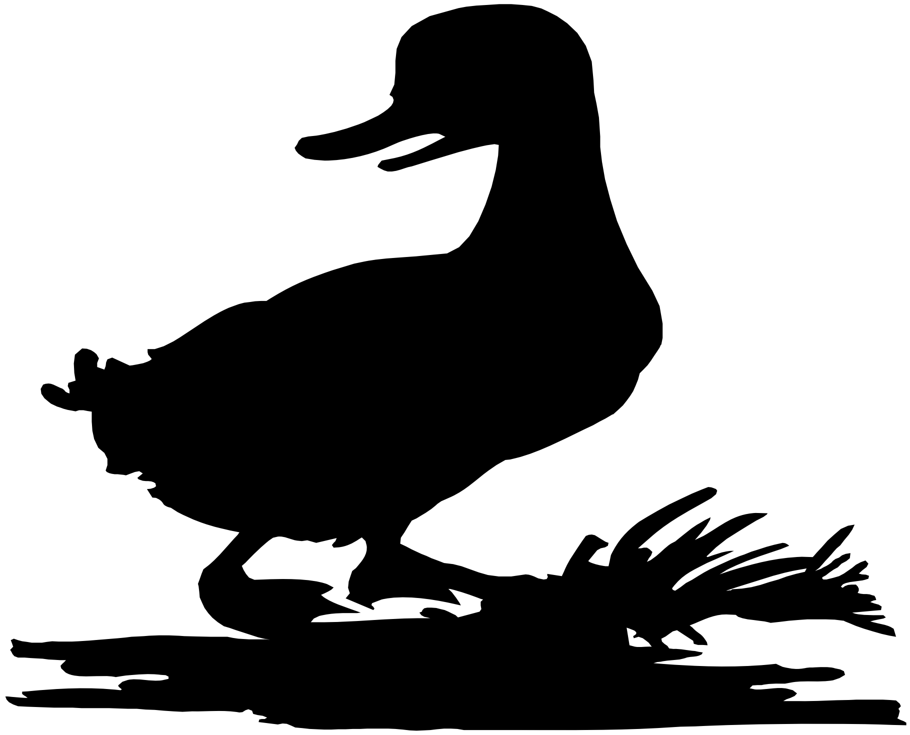
Extensions

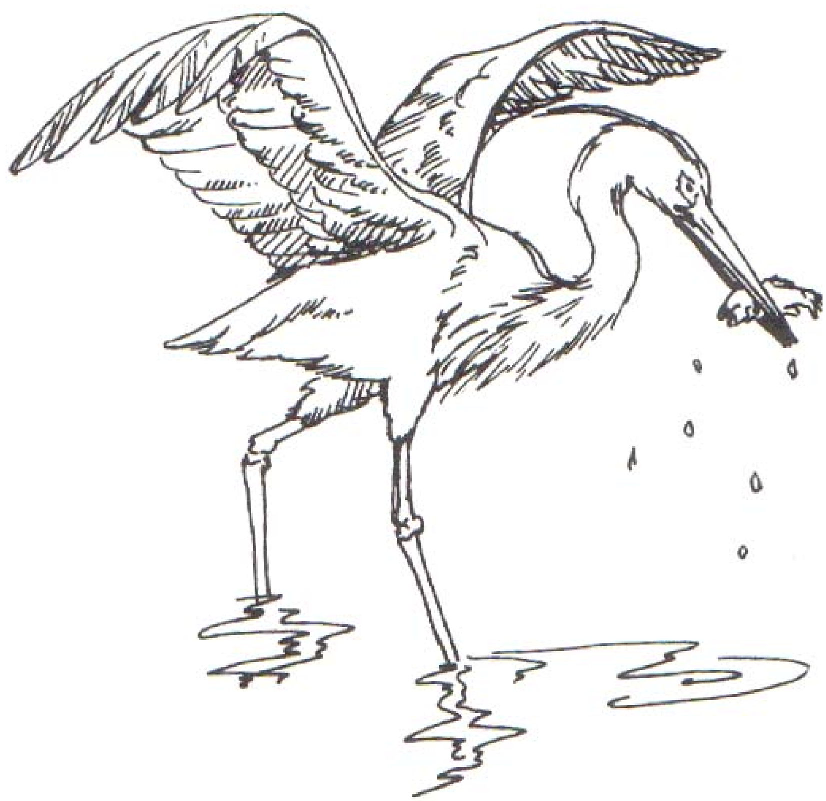
Students will design their own wetland organism based on the characteristics found in a wetland ecosystem. The organism will have to have the ability to eat, sleep, and survive in this very wet and swampy environment. Students will draw a picture of their organism and come prepared to share and discuss how their “Wetland Creature” will be able to survive in a wetland ecosystem.

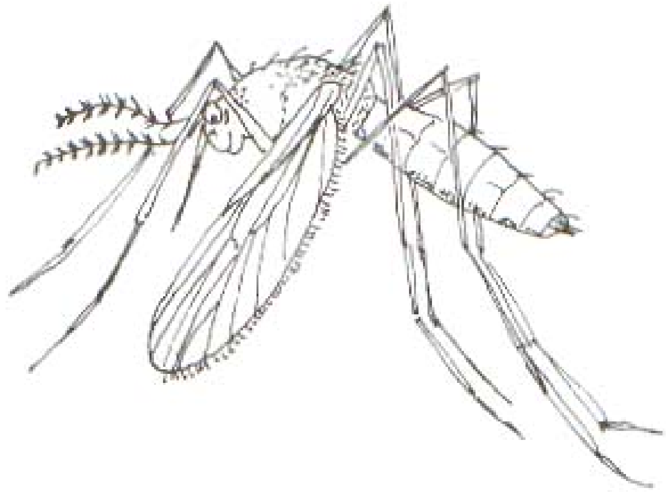
Organism Riddle Cards

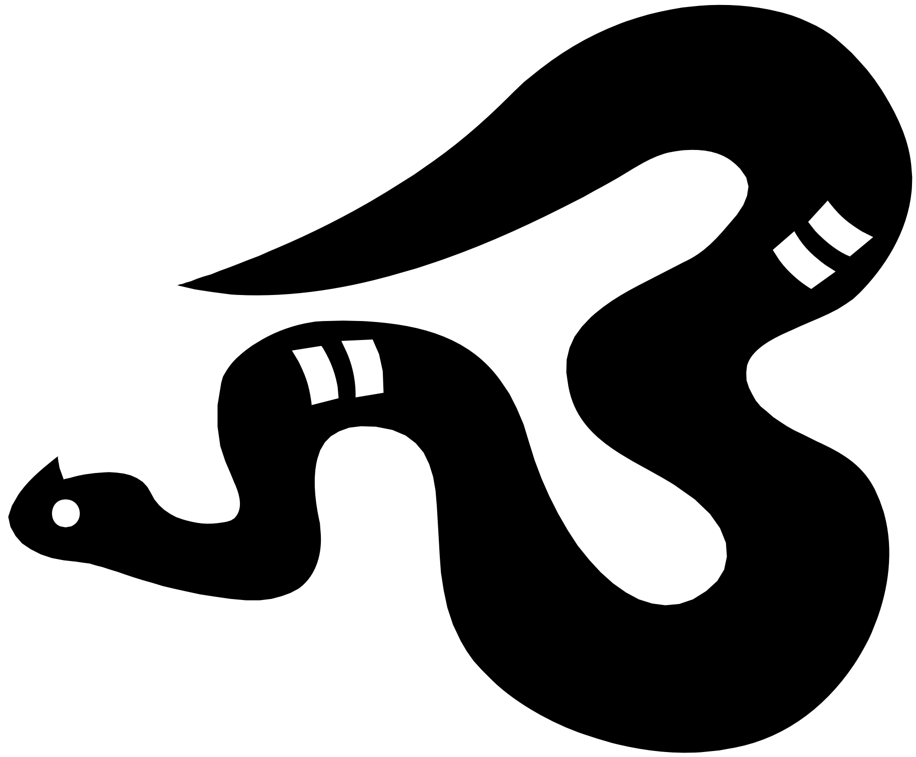


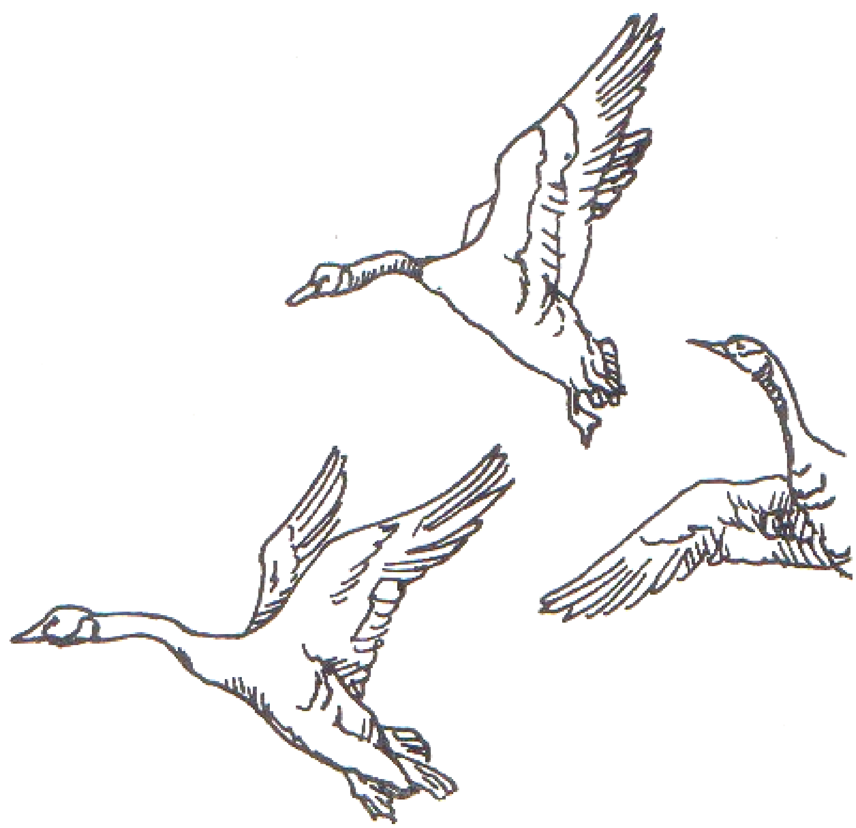


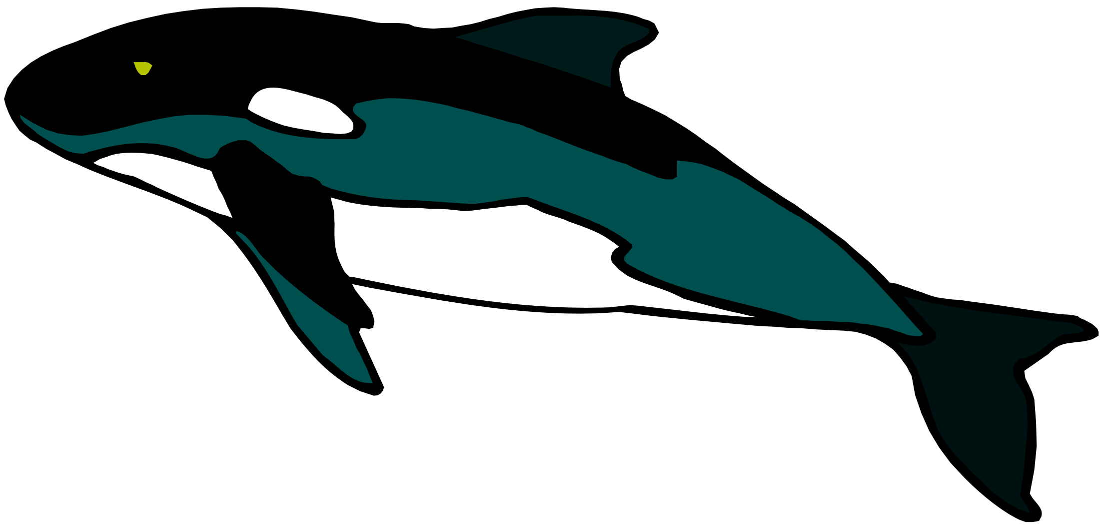


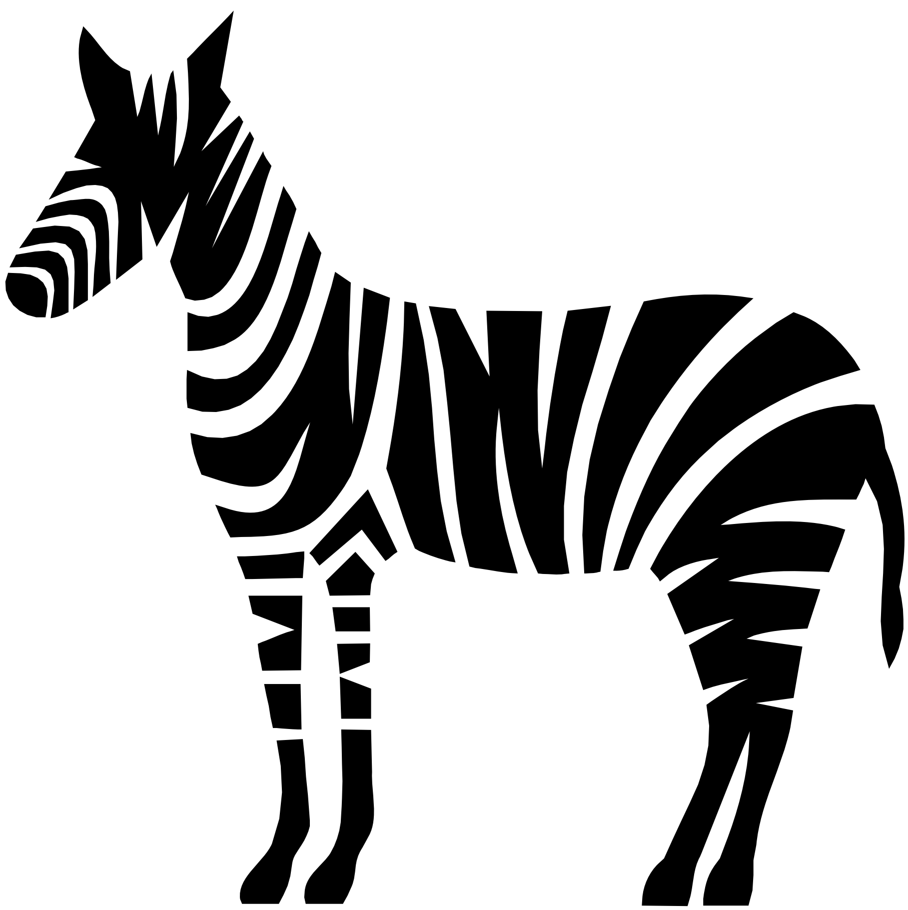












Riddle Clue Cards

Snapping Turtle
I look almost like a DINOSAUR, with my SCALY skin and HARD shell. My HOOK-LIKE nose and sharp claws make me a fast hunter deep in the pond. My TAIL acts like a propeller, as I swim fast through the water. My favorite food is tadpoles or baby ducks. I can be found BASKING in the sunshine on the top of fallen cattails.

MUSKRAT
I have a THICK, OILY, BROWN, and SHINY coat, made for swimming. My RAT-LIKE tail acts like a rudder as I swim from bank to bank in the pond. My favorite food, the cattail, I use to build my "HUT" or home that some may mistaken for a beaver lodge. I have a MUSK-LIKE smell and I am nocturnal.

WATER SNAKE
I have a very LONG, SKINNY body. I get from one place to another by crawling on my stomach. I like to swim through the wetlands, and you may even catch me swimming with my head up in an S-LIKE motion.

RED-WINGED BLACKBIRD
Some may mistake me for a CROW, but my sound of "Cur-Ree, Cur-Ree" in the wetlands keep other birds out of my nesting territory. I am seen PERCHED on the Cattail flower, eating insects and showing my beautiful RED and YELLOW patches on my wings- this is how I get my name.

MALLARD DUCK
I am usually found with my partner, "QUACKING" as I fly in and out of the water. The Male has an EMERALD GREEN head, and the female is brown and white striped. We lay close to the ground; and we are together until death with our friend. Who am I?

GREAT BLUE HERON
I am a FISHERMEN, using my LONG, POINTY, YELLOW bill to spear fish. My TALL LEGS are used for wading and walking through the water. I feel the vibrations in the water to help me locate my dinner. My LARGE GRAY-BLUE wings help me fly long distances. Some may swear I am prehistoric!

BULL FROG
Some may call me THINNED-SKINNED, this helps me breath under water. I usually spend all my time in the water waiting for my meal to fly by. My WEBBED TOES and LONG LEGS are great for swimming. I like to bask in the sunshine and call out "BURRR-ROOOM".

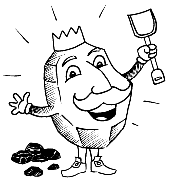
CATTAILS
I am TALL, GREEN, and LEAN. My FEET are always wet, buried deep in the mud of the wetland. My flower resembles a ballpark food, and in the Autumn it turns into a furry tail!

DRAGONFLY
Although I don't breathe fire, I am a fierce flyer. My BIG eyes and mouth make me a strong predator above the ponds. I am found landing with FOUR OUTSTRETCHED wings on a blade of grass or on the leaves of a cattail. But I am careful around the Red-Winged Blackbird, or I may become their lunch.

CANADA GOOSE
Flying in formation is our motto, and our "Car Horn" sound notifies others of our arrival. Low to the ground, we lay large eggs in the spring. We can be found in wetlands, lakes, and rivers. Our LONG neck and outstretched wings warn others as they get near. We are sometimes called "SCAVENGERS" of the land.

BULL RUSH
Shhhh….Rssssshhh is the sound we make as the wind blows through the wetlands. Standing straight, tall, and green, our slender figures are found in many. Many frogs and ducks take shelter and cover in our midst, as the edge of pond is where we like to be.

MOSQUITO
Using the wetlands on the edge, our eggs are laid in plenty. When the sun goes down we are on the prowl like vampires in the night. We try to stay out of the way of those TRUE VAMPIRES in flight or we just might breathe our last breath. We create itches and leave little lumps that put you in the slumps.



Iron Oxide and Chalk

Goodbye Orange Water
Activity Booklet Lesson

Background

Wetlands used to clean up Abandoned Mine Drainage collect a large amount of iron oxide. The collection of the iron oxide can be dried and sold to manufacturing plants for use as a pigment. It is used in paints, dogfood, cosmetics, as a dye and can even be used to color chalk. Anything that you would like to be orange or yellow tinted, you can do so with the iron oxide collected from the wetland ponds.

NOTE: It is important to know the makeup of the sludge before collecting because some treatment systems contain aluminum and other heavy metals that may be harmful. Check with the system owner prior to collecting the sludge and using it.

Warm-up

Show the students several products some that contain iron oxide and some that don't, ask them if they can categorize them and how. After the students have devised a way to categorize them, ask them to explain what their reasoning was.

Explain the proper categories and why so they can see the connection with the iron oxide.

Activity

1. Cover area or desk with newspaper.
2. Make a mold for chalk. You can use a toilet tissue roll or small paper cup, but the best is a sheet of typing paper cut in half lengthwise. Roll both pieces of paper into a tube about the diameter of a dime and tape. The paper works well because it absorbs most of the water from the chalk mixture and the drying time is significantly reduced.
3. Make a stopper out of paper towel for the end of a tube. Look through the tube to see if there is light coming through, if there is; reform the stopper until there is no light showing. Tape the stopper into place. This will ensure that the chalk mixture will not leak out the bottom of the tube.
4. Mix Plaster of Paris and water in a 1 to 1 ratio. (i.e. 1 cup water to 1 cup Plaster of Paris)
5. Add iron oxide, the more you add, the darker the chalk will be.
6. Stir very well.
7. DO NOT LET THE MIXTURE SET; IT WILL HARDEN QUICKLY.
8. Pour the chalk mixture into the tube and have the students hold upright or place in a cup to ensure that the tube doesn't fall over.
9. As the paper absorbs most of the water, the top of the chalk will sink into a funnel-like shape, the students may tap the tube gently on the table to reshape the chalk top.
10. Place the tubes of paper somewhere in the classroom where drying will occur.

After 48 Hours:

Unwrap the chalk and place somewhere in the classroom where it will continue to dry thoroughly.
NOTE: If after unwrapping, the chalk has wet paper around it, you may gently use your fingers to rub off the paper.

Accompanying Page (s)
Page 21

Objectives
- Given the dried sludge product from AMD Wetland Ponds, the students will create a piece of chalk.

Duration of Activity
30 minutes

Pennsylvania Standards Addressed:
3.3.5.A2, 9.1.V.K.B1

Materials
- Used paper (copier/printer paper)
- Tape
- Paper Towels
- Cups (preferably reusable since it is about recycling
- Newspaper
- Plastic knives or straws for stirring

Setting
Classroom/Art Room

Wrap-up
After the chalk has hardened, the students should write on the parking lot or chalkboard with their experiment. (This may stain, so ask permission first.) Included in their writings should be what the chalk is made from and that they are recycling a pollution problem found across Pennsylvania and Appalachia.

Assessment
Use probing questions to determine the students understanding about iron oxide recycling and why it is beneficial.

Extensions
Have the students research other uses of iron oxide in industry, and write a short essay on "Industrial Uses of Iron Oxide".