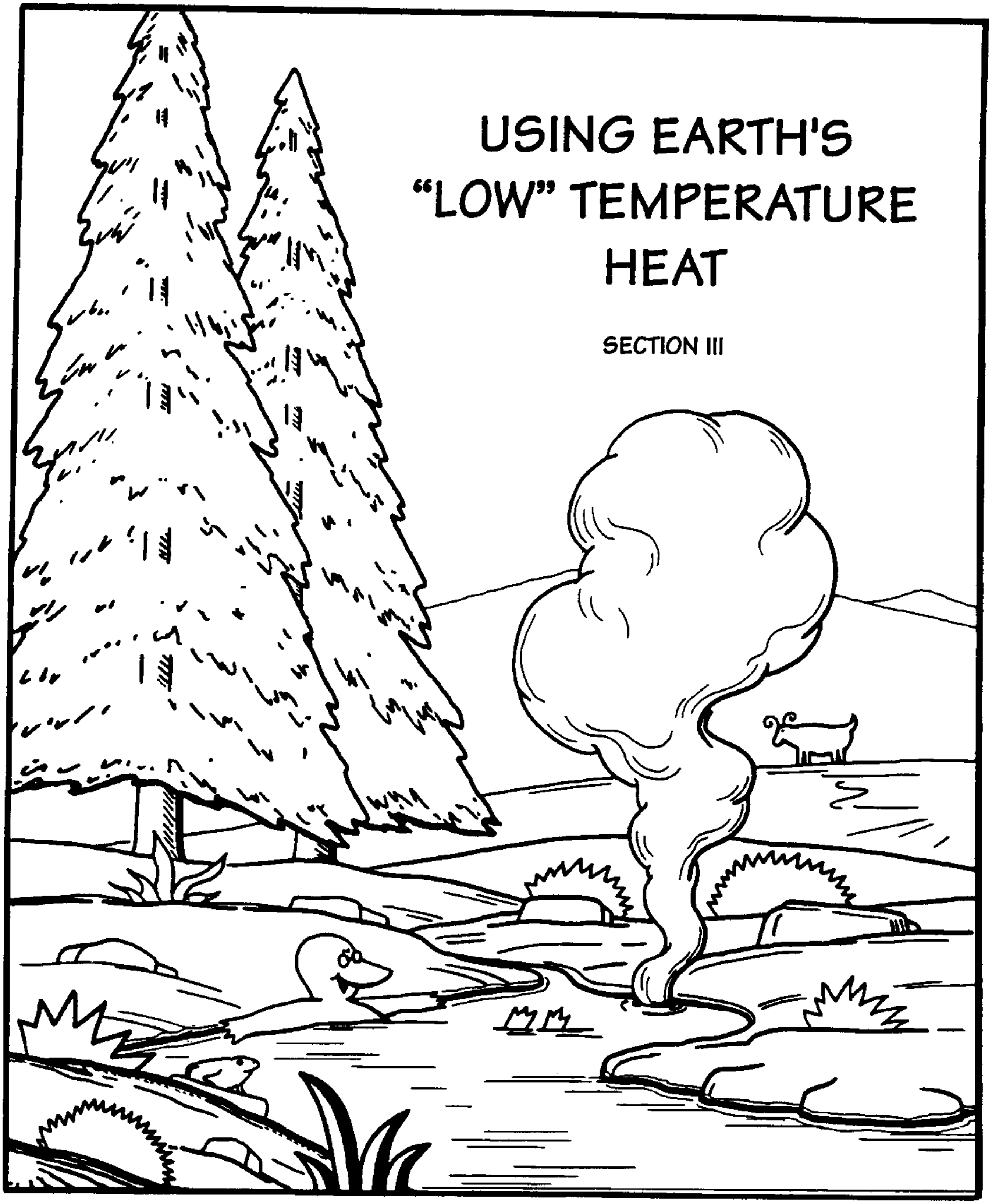
USING EARTH'S "LOW" TEMPERATURE HEAT

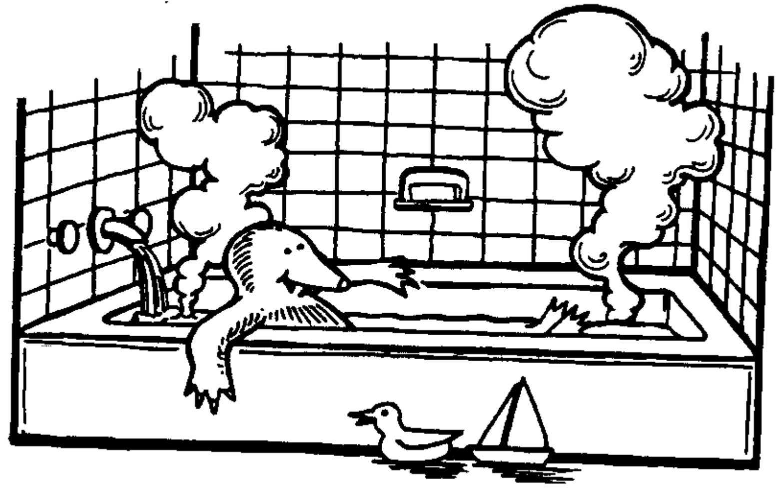
SECTION III



DIFFERENT USES FOR DIFFERENT TEMPERATURES

Once geothermal water reaches the surface, we use it in lots of different ways. Exactly how we are able to use it depends upon the temperature of the water. (Geothermal hot water can get hotter than 600° F [315° C]!). So when people talk about uses of geothermal energy, they often refer to "low temperature use" and "high temperature use." Geothermal water that is below 300° F (150° C) is called a low temperature geothermal resource. Don't let the name fool you; just because it is called "low" does not mean it isn't useful or that it isn't very hot!

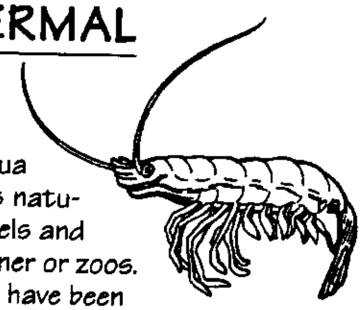
Think for a moment of all the ways hot water makes life better — baths, clean clothes and hot meals. Did you think of using hot water for growing tomatoes and cucumbers? or even fish? for heating houses or mining gold? Around the world, people living close to geothermal "hot spots" have discovered many ways to put lower temperature geothermal water from the earth to work.

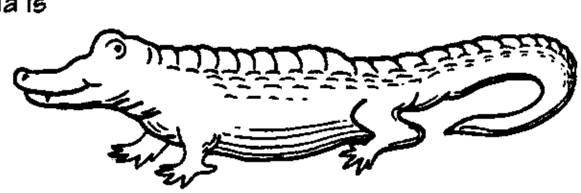


SOMETHING'S FISHY!: AQUACULTURE USING GEOTHERMAL

(70°F - 90°F) (21°C - 32°C)

Geothermal *aquaculture* (the "farming" of water-dwelling creatures) uses natural warm water to speed the growth of fish, shellfish, reptiles, and amphibians. Warm water allows *aquafarmers* to grow water-dwelling animals throughout the year, regardless of the outside temperature. Typical geothermal aquafarms mix cold and hot water for the animals to live in. This kind of low temperature use of geothermal resources in China is growing so fast that fish farms alone cover almost 500 acres (2 million square meters). In Japan aqua farms use the earth's natuwarm water to grow eels and even alligators for dinner or zoos. Fish breeders in Idaho have been using geothermal water for many years raising delicious catfish and trout. Growers using this geothermal water in Idaho, Utah and Oregon raise tropical fish for pet shops. Icelandic aquaculturists are raising abalone in tanks heated by geothermal waters. The Icelanders hope to raise as many as two and a half million abalone a year.





EVERYBODY'S GETTING INTO HOT WATER: COMMUNAL BATHING AND BALNEOLOGY

(80° F - 105° F) (27° C - 41° C)

For centuries, people have been bathing in natural hot spring water for *therapeutic* reasons. This means that they felt that their health improved by soaking in the hot, relaxing mineralized water. Using mineralized water for medical therapy is referred to as *balneology*. Hot mineral springs also became attractions which drew people together. For some groups, the occasion has even taken on a spiritual meaning. Today, as long ago, people still bathe in geothermal hot springs for a variety of reasons.

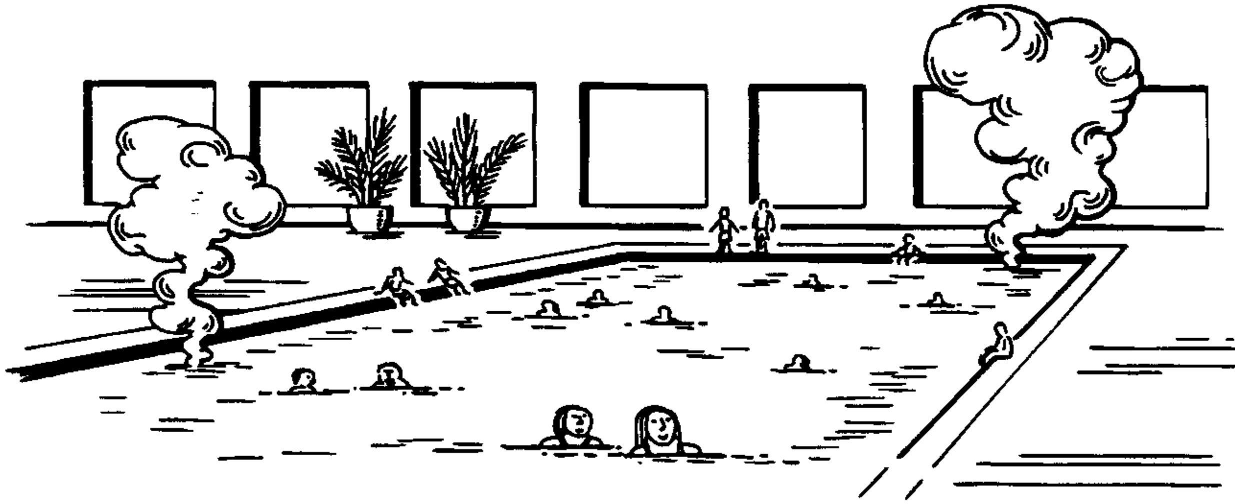
In Europe, natural hot springs have been very popular health attractions. The first known *health spa* was established in 1326 in Belgium. There, a resort sprang up named "Espa", which means "fountain." The English word "spa" came from the name of this resort and is a word still in common use. All over Eurasia today, health spas are still very popular. In Russia, for example, citizens flock to one of the 3,500 spas located throughout the country. Baths where Beethoven, Bach, Chopin and Napolean once soaked are still in use in central Europe; "curative waters" are so valued there that they are legally protected.

On the other side of the globe, the Japanese have enjoyed a long tradition of social bathing - one which dates back to ancient Buddhist rituals. Japan is considered the world's leader in balneology. One Japanese city, Beppu, has 4,000 hot springs and bathing facilities that attract 12 million tourists a year.

For the people of Mexico, geothermal mineral hot springs have been well-known attractions since the days of Montezuma, emperor of the Aztec Empire. Today, in central Mexico alone, there are more than 100 major spas — drawing more than 10 million visitors every year. Mexico has so many hot springs that one Mexican state is named Aquas Calientes, the Spanish words for "hot waters."

Native Americans used hot springs many years ago for cooking, recuperation from warfare and for the stresses of old age. Later, when European settlers arrived in the New World, they saw the potential for developing these hot springs into health spas like those back home in Europe. Soon, people were flocking to the health resorts which "sprang up" across the United States. The largest spa in this country was in what is now Olympic National Park, in the state of Washington.

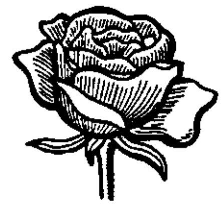
Today, there are still over 115 major geothermal health spas in the U.S. One well-known center, Calistoga, California, has been in existence since 1852 and is still a very popular attraction for tourists and health-seekers. Incidentally, Calistoga was, for a while, the home of Robert Louis Stevenson, author of Treasure Island and Kidnapped. He moved there in 1880 for, yes, ...his health!

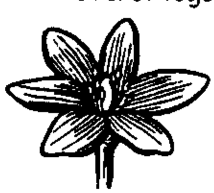


HARVEST TIME, YEAR 'ROUND: GEOTHERMAL IN AGRICULTURE AND GREENHOUSES

(80° F - 200° F) (27° C - 93° C)

Geothermal resources are used worldwide to boost *agricultural* production. For hundreds of years, Tuscany in Central Italy has produced vegetables in the winter from fields heated by natural steam. Today in Tuscany vegetables and flowers are also *cultivated* in greenhouses warmed by geothermal hot water and steam. In Hungary, thermal waters provide 80% of the energy demand of vegetable farmers, and make Hungary the world's geothermal greenhouse leader.





Dozens of geothermal greenhouses dot the western United States, where we find geothermal heat used in lots of different ways to help vegetables, flowers and other plants grow better. For example:

• In Montana, a rose grower runs 55 miles (90 km) of pipe back and forth under his roses with geothermal water flowing directly through the pipes heating the surrounding soil. This same technique is used in other places, too, as in California where one hot spring not only pipes water to a nursery, but also to local mineral hot tubs and pools.

• In Idaho, there are greenhouses that take the heat from geothermal resources and transfer it into a forced air heating system. There, no matter what the outside temperature (which can get pretty low in Idaho!), poinsettias, lilies and chrysanthemums flourish inside. A similar system helps grow 5,000 roses a day (as well as bedding plants) in greenhouses located on a twenty-three acre spread in Animas, New Mexico.

• In Oregon, one greenhouse business uses geothermal heat for a combination of radiators, soil warming pipes and a snow melt system - an ingenious solution to three tricky problems all solved at one time with geothermal heat.

HARVEST TIME YEAR 'ROUND: THE EFFECT OF HEAT ON SEED GERMINATION AND PLANT GROWTH

As you have read, low temperature geothermal heat can be used to heat greenhouses and grow crops in otherwise wintery climates. In this experiment, you will test the idea that warmth can be beneficial to plant growth.

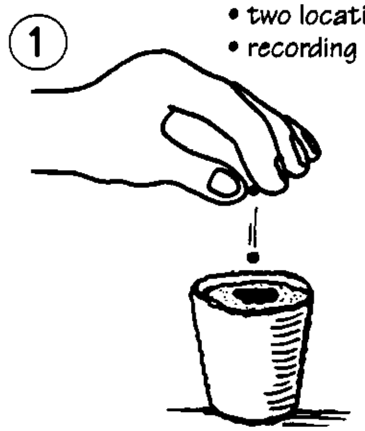
Remember that excessive heat is not helpful to plants. So, make sure the warm location you use is not too hot – for example, don't set your pot right on a radiator or other heat source.

You can add your own variations to this experiment, such as testing which location provides the ideal warmth for best growth.

Materials (per student group):
- seeds (all of the same type)
- two small flower pots (such as the "dissolvable" kind)
- soil
- measuring cup for watering
- red liquid thermometer
- ruler
- two locations: cold and warm
- recording sheet or science notebook

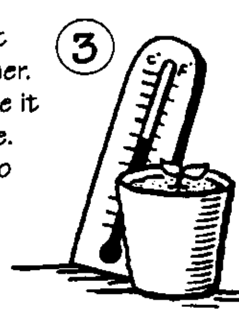
Directions:

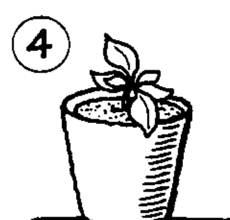
1.) Put the same amount of soil into two pots of equal size. Place the same number of identical seeds in each pot, at the same depth. Water each pot.



2.) Find or create two locations that have the same amount of light, but different temperatures: cold and warm. Check the temperature of each spot with the thermometer and make a note of each temperature. Make a note of the date you planted your seeds and the amount of water you gave them.

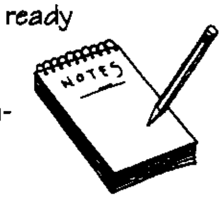
3.) Check your pots every day, or at an interval suggested by your teacher. Check the temperature to make sure it is approximately the same as before. Water if the pots are getting dry (to germinate, seeds needs to be constantly moist, but not drowning). Make notes of the date and any observations.





4.) Continue checking and making notes until you have germinated your seeds into plants. Once they've germinated, you can measure the plant growth with a ruler and make a note of that also.

5.) Be ready to share your information with the class. Each group's information could be collected, averaged, and made into a graph. Be able to discuss whether warmth had an effect on seed germination and plant growth. Be ready to discuss what this has to do with low temperature geothermal resources.



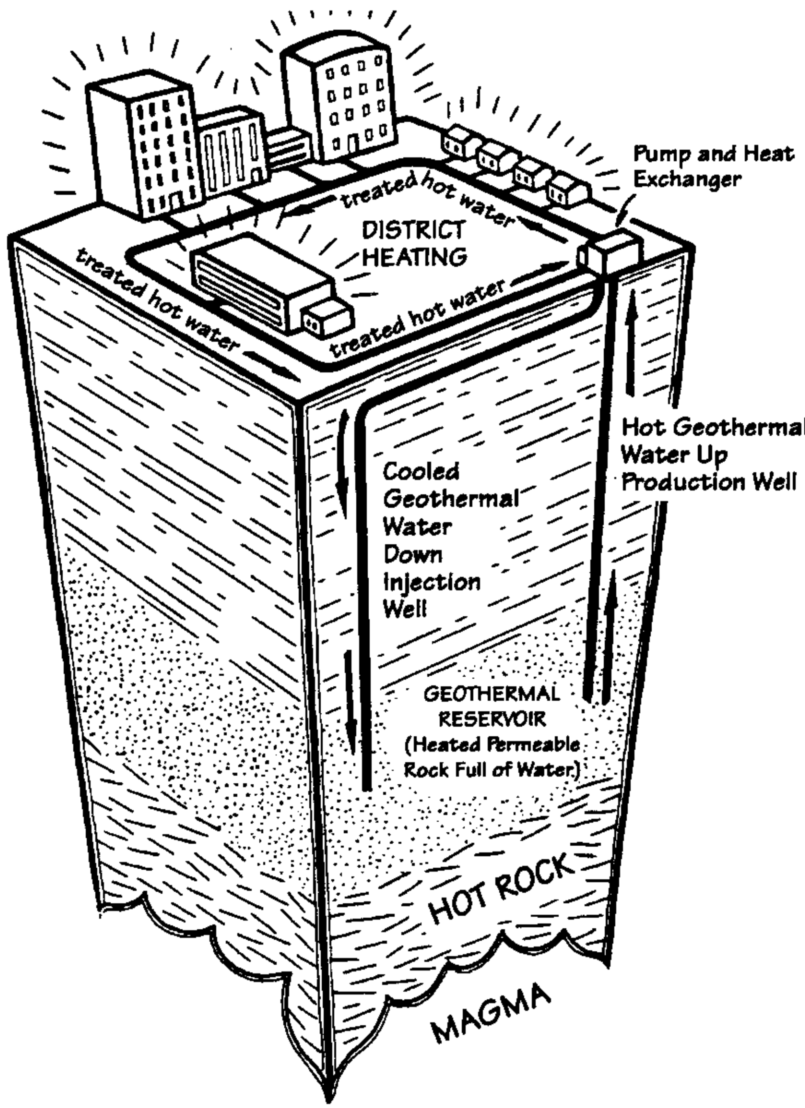
WARM ENOUGH? : USING GEOTHERMAL TO HEAT HOMES AND BUILDINGS

(80° F - 250° F) (27° C - 121° C)

Geothermally heated water can provide heat to homes, schools and offices – even to an entire business district. Individual buildings can even have their own personal geothermal heating system. (For example, over 500 residences in Klamath Falls, Oregon, have geothermal wells right in their front yards!) And, on the other hand, entire groups of buildings can be heated geothermally from one central facility. Then it is called *district heating.*

HOW GEOTHERMAL HEATS BUILDINGS

Many geothermal heating systems supply heat by pumping geothermal water – usually 140°F (60°C) or hotter – from beneath the earth's surface. The geothermal hot water is sent by pipes to a *heat exchanger,* which transfers the heat to treated city water that is then sent by pumps to the buildings. After it passes through the heat exchanger, the geothermal water is put back in the ground by means of an *injection well.* Underground, the water heats up again, so it can carry and transfer earth's heat to the surface over and over again.



WHAT IS A HEAT EXCHANGER ?

A heat exchanger is a device which allows heat to flow from a hot liquid to another cooler one without the liquids touching each other. In a geothermal heat exchanger, hot geothermal water (which might be mineralized and/or corrosive) is used to heat cooler water or other liquids. The kind of heat exchanger often used to help bring heat to homes and buildings is called a "plate" heat exchanger. In a plate heat exchanger, geothermal water and cooler water each flow separately through a series of flat hollow plates which are touching each other; so the heat from the geothermally-heated water transfers (or flows) through the metal plates and raises the temperature of the other water. This newly-warmed water then delivers its heat to a building (or buildings), while the geothermal water returns to its underground source where it is heated up again.

SOME EXAMPLES OF GEOTHERMAL DISTRICT HEATING

Because it is a clean, economical method of heating buildings, geothermal district heating is becoming more popular in many places, especially the United States, France and Iceland.

An unemployed well-driller in Boise, Idaho, invented the world's first modern geothermal district heating system in 1891. Sending hot water from a central plant, through pipes to and through residents' homes, his new company offered geothermal home heating for a flat rate of $2.00 a month, at a time when coal cost $7.00 a month. A large part of Boise is still heated with geothermal water. Other U.S. cities with geothermal district heating include: Klamath Falls, Oregon; Elko, Nevada; Reno, Nevada; Susanville, California and San Bernardino, California.

The Oregon Institute of Technology heats 11 of its buildings from 3 geothermal wells at a cost of about 6.3 cents per sq. foot of space to be heated. Compare that to the 60 cents per sq. foot that they would be spending if they were using conventional fuel such as coal or gas.

Downtown Klamath Falls uses geothermal energy to heat its central busines district.

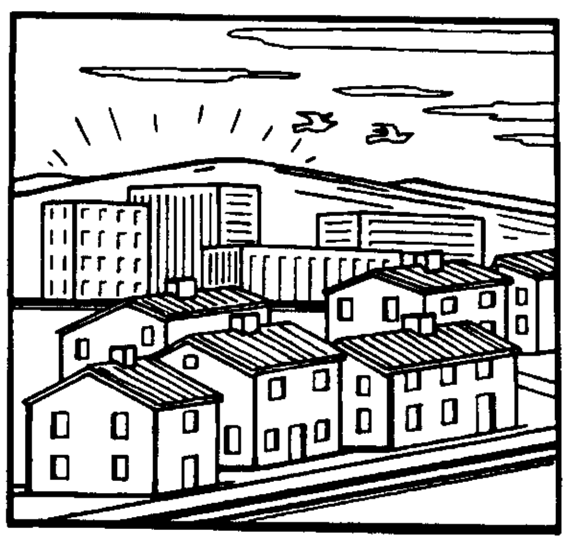
WATCH OUT FOR THOSE MINERALS!

Some geothermal water contains natural chemicals and dissolved gases (including sulfur, calcium salts, carbon dioxide, hydrogen sulfide and others). Then it is referred to as *mineralized* water. In the past, mineralized water was difficult to use because it could form scale, or corrode pipes. Geothermal engineers can now design systems using pipes and equipment that are far less likely to corrode. This means that even more low and high temperature geothermal water is available for use than ever before.

Geothermal water at 212° F (100° C) is piped almost a mile to a central heat exchanger and control room. After heating city water, the geothermal water is injected back into the ground. Geothermally-heated city water goes through almost two miles (3 km) of pipe to heat many large office buildings. The district heating system also supplies a housing addition and is being extended out to a renovated theater.

In China, between Tianjin and Beijing, many hundreds of apartments are heated by geothermal waters. The world's largest district heating system is in Iceland, home to many natural hot springs. It provides home heating to 140,000 residences in Reykjavik. Reykjavik, which means "bay of steam," used to be terribly polluted because of chimney smoke. Now it is one of the cleanest cities in the world!

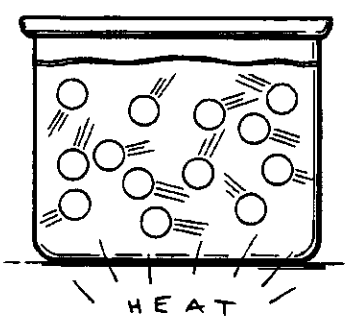
Reykjavik before geothermal.



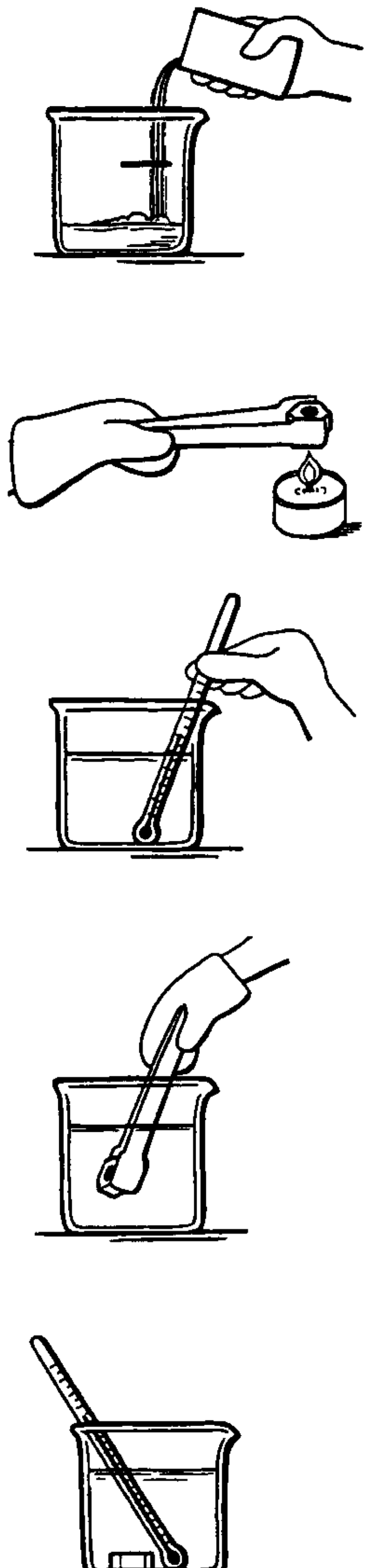
Reykjavik after geothermal !

WATCH OUT FOR MOVING MOLECULES! : HEAT EXCHANGE

In this activity you will see how heat flows from a hotter material to a cooler one. To understand how this happens, first imagine very tiny particles called molecules which move faster when they are heated. These moving molecules always spread out as they bounce around, making other molecules around them move faster also. So, if something is hot, it always passes its heat to whatever is around it that is colder. This can be called heat flow, heat transfer, or heat exchange. (This happens every day when people put pots of food or water on a stove burner to heat. The heat goes from the burner, through the pan, to the food or water.)



If ground water is near enough to hot rocks or magma, the heat is transfered to the cooler water, creating geothermal hot water. In a heat exchanger, one hot fluid passes its heat on to a cooler fluid.



Materials (per group of students):

- water
- tongs
- non-flammable mitt
- goggles, if possible
- small beaker or heatproof container
- red liquid thermometer
- large metal nut
- heat source (such as alcohol or sterno burner)

Directions:

1.) Fill the beaker with about 50 ml of water.

2.) Wearing hot mitt and goggles (if available), use tongs to hold the metal nut in the flame for several minutes (exact time depends on size of nut).

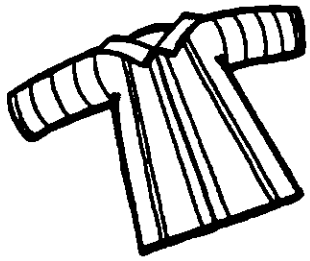
3.) Take the temperature of the water in the beaker before you place the metal nut in the water. Record this information.

4.) Place the metal nut in the water using the tongs. Record the temperature of the water every 15 seconds for several minutes (or shorter if time doesn't allow). Observe what happens to the temperature of the water and be ready to discuss why the temperature of the water changes.

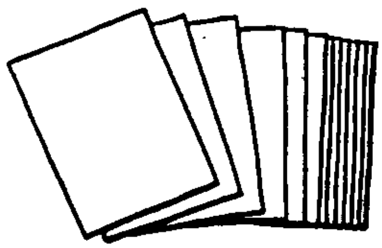
Safety Tip: To put out sterno flame, drop lid on top of sterno container using the tongs.

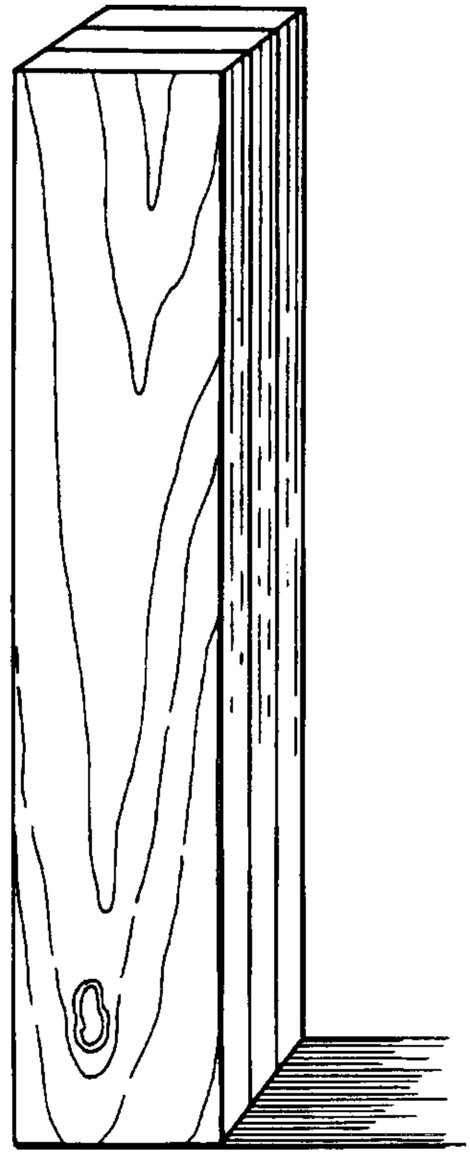
IT'S HEATING UP: USING GEOTHERMAL IN INDUSTRY

(200° F - 300° F) (93° C - 149° C)

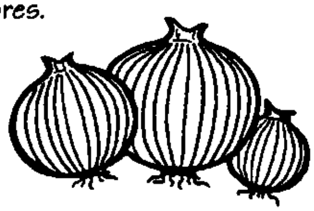


What do dried onions, bright rugs and breadboards have in common? They can all be produced with the help of geothermal resources. Here are some of the ways:



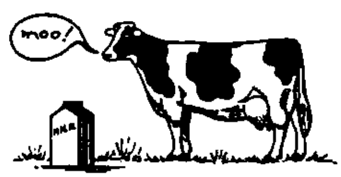


- Geothermal waters and gases have been used in Pacific rim countries for cloth dyeing and fruit drying. A company in Hawaii developed a process using a geothermal *drying chamber* to produce papaya powder for sale in health food stores.



- In Iceland, steam is used to dry diatomite, a fossil material used for filters and absorbents.

- In China, rug manufacturers use geothermal waters to wash their wool, believing more brilliant colors are produced this way.



- A business in New Zealand uses geothermal heat in manufacturing paper.

- At Brady Hot Springs and Empire, Nevada, geothermally-driven plants dehydrate heaps of onions and other vegetables. In Guatemala and the Philippines new facilities are being developed to use geothermal heat for food drying.

- Also in Nevada, thermal waters are used to extract gold and silver from ore.

- In Klamath Falls, Oregon, geothermal hot water was used to help *pasteurize* milk.

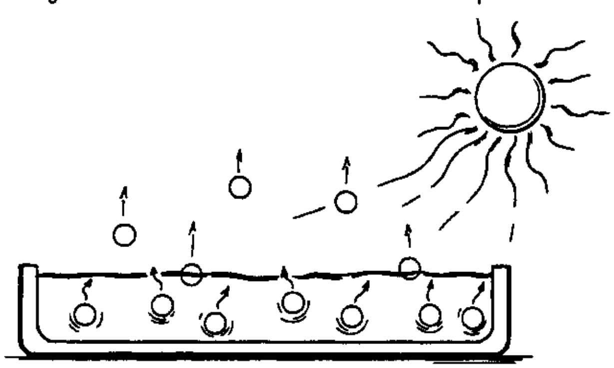
- Heat from geothermal steam is used to dry timber products in Japan and Taiwan, and in Hawaii to dry koa wood for fancy bread boards.

A GEOTHERMAL HOTLINE

When people around the world have questions about low temperature use of geothermal energy, they can call on the Geo-Heat Center, located at the Oregon Institute of Technology in Klamath Falls. For twenty years, the Geo-Heat Center has been providing geothermal information and helping people worldwide develop new ways to use geothermal resources. (See "Resources" in Appendix.)

IT'S HEATING UP: TESTING THE EFFECTS OF HEAT ON EVAPORATION

Evaporation is the changing of a liquid or a solid into a vapor state, the result of moving molecules. Evaporation can occur at room temperature or at higher temperatures. It can be speeded up by applying heat. In a liquid, molecules are in clusters that move around, bumping into each other. If the liquid is heated, the molecule clusters begin to move faster until they break away from each other and become a vapor.



The principle of evaporation is applied by companies around the world when they use low temperature geothermal heat to dry wood, cloth, food, and many other products. Geothermal heat is used, directly and indirectly, to provide the heat needed to speed up the evaporation process.

In this experiment, you will be testing the effects of heat on evaporation.

Materials:

- measuring cup
- two shallow pans
- warm location and cool place - both away from breezes
- hot plate or radiator
- two cloths of same material and size
- water

Directions

1.) Pour 1/2 cup water into each of two shallow pans (make sure the pans are identical). Put one in a warm place and the other in a cool place – away from breezes. Make a note of the time and date that you do this. Periodically check your pans and make a note of which pan of water evaporates first and when.

2.) The test can be speeded up by placing the "warm" pan over a heat source such as a hot plate or radiator. As before, make notes of times, dates, and any other observations.

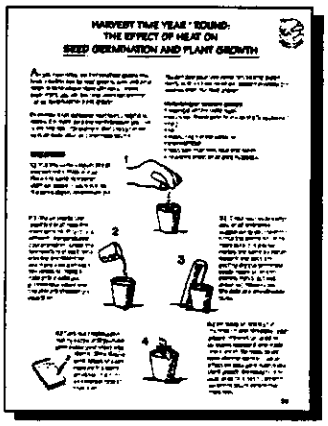
3.) Now get two cloths that are exactly the same material and size. Completley wet them with the same, measured amount of water for each. Repeat the procedure in step 1, either laying them both out or hanging them both up.

4.) Be ready to discuss your results and explain why this experiment applies to low temperature geothermal uses.

HARVEST TIME, YEAR 'ROUND

Science/ Math Activity: Testing the Effect of Heat upon Seed Germination
(Student Worksheet Provided)

Materials (per student group):
- seeds (all of the same type)
- two small flower pots (such as the "dissolvable" kind)
- packaged soil
- measuring cup for watering
- red liquid thermometer
- ruler
- two locations: cold and warm
- recording sheet or science notebook



Directions: Found on Student Worksheet

Management Suggestions:
Encourage students to be creative with this experiment. It can be turned into an investigation of the ideal warmth for the fastest seed germination, or a test of warmth's effect on plant growth once the plant has emerged.

A variation could be to make two small terrariums with identical plants and soil, putting one in a warm spot and one in a cold spot. Make sure light remains constant. Have the class observe the effects of warmth (or lack of it) on the plants.

Suggestions for integrating math into this activity include the following: Use metric and customary rulers to measure plant growth; have students record measurement results in a log. After the project is over students can calculate average plant growth and they can make graphs showing the growth rate over time.

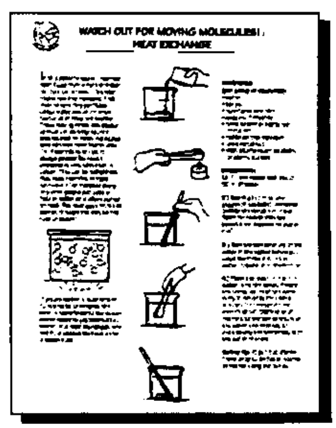
WARM ENOUGH?

Social Studies Activity (no student worksheet): After reading the section on using geothermal to heat homes and buildings, have students investigate where the heat comes from for the following: their school, their homes, their parents' offices, any place else you can think of. Before doing the investigation, brainstorm all the possible energy sources that could be providing their heat (hydro, wind, solar, nuclear, fossil fuels, geothermal, wood, butane, etc.) Brainstorm ways that they can find out what energy source their heat comes from such as asking their parents, calling the local power company, and so on. Follow-up in any way you think appropriate – verbal sharing, written reports, bulletin boards with pictures, etc.

WATCH OUT FOR MOVING MOLECULES

Science Activity: Heat Exchange
(Student worksheet included)

Materials: (per group of students):
- water
- tongs
- non-flammable mitt
- goggles, if possible
- small beaker or heat proof container
- red liquid thermometer
- large metal nut
- heat source (such as alcohol or sterno burner)



Management Suggestions: Be sure to emphasize that the metal nut is a substitute for hot rock in the earth. As a follow-up to this activity, students could construct a line graph of the water temperature over time.

FOR THE TEACHER, cont.

IT'S HEATING UP

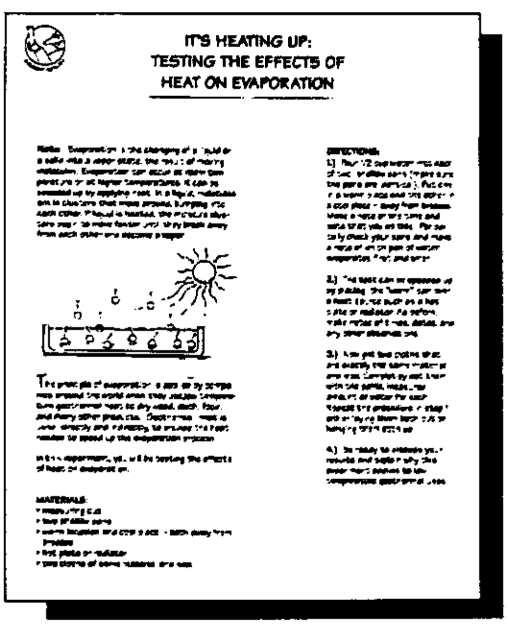
Science Demonstration:
The Effects of Temperature on Evaporation
(Student Worksheet Provided)

Materials:
- measuring cup
- two shallow pans
- warm location and cool place - both away from breezes
- hot plate or radiator
- two cloths of same material and size

Directions: Found on student worksheet.

Management Suggestions:
You might want to have different groups do different portions of this experiment. This activity can also be done as a class project.

If you have a food dehydrator that uses heat, you might want to demonstrate the use of heat to speed the drying process. Or, using a microwave to dehydrate herbs can give a new twist to dehydrating.



IT'S HEATING UP:
TESTING THE EFFECTS OF
HEAT ON EVAPORATION

Social Studies / Science Activity
(no student worksheet):

If low temperature geothermal resources are being utilized in your area, have some students research how the low temperature geothermal resources are being used. Perhaps you could visit a place where they are being used or invite someone from the industry to come and talk with your class. If you have problems arranging for a speaker in your area, contact the Geothermal Education Office for help. (See Resources, Section VII)