Investigation 3.1 – Geoscience Careers

Objectives

Upon completion of this activity, students will:

- Understand that women and men of various social and ethnic backgrounds--and with diverse interests, talents, qualities, and motivations--engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Know that scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.
- Be able to identify possible career options in geosciences and other fields related to climate change. Be able to identify education/training, opportunities other details about the career they've chosen.
- Be able to use technology to locate/research relevant information.

Method(s)

- Students choose a career to research using provided websites. They will develop a "character" which they will represent during the next lesson, "Policy Debate".
- They will read provided articles and/or other sources.
- They will draw conclusions based on research and reading and write in their journal.

Background

- What are some possible consequences of climate change?

Materials

- Computers, ideally, one per student and internet access
- Student Journal Page – Career Exploration
- Identity Cards
- Provided readings on climate change (Please note, some articles are more difficult than others. Please assign readings as appropriate or read and discuss articles as a group.)
  - The Potential Impacts of Global Warming on Alaska (AKPotentialImpacts.pdf)
  - What can be done about climate change? (see article following this lesson)
  - The Greenhouse Diet – Chart (greendiet.jpg)

Assessment

- Performance/Observation/Constructed Response Assessments – Teacher should assess student's effort to complete the Career Exploration Worksheet. It is possible that many students may not complete the entire worksheet. The goal is to familiarize them with various professions and resources, skills and choices for continuing their education.

Procedures

1. We have learned that geoscientists are men and women from many cultures, and perhaps some of you someday, who study the chemistry, physics, geology, biogeochemistry, etc. of the land, waters, atmosphere and biosphere of the earth. These scientists and many other individuals work in careers that focus on or are affected by climate change.

2. Today, you will choose one of the following professions (see the provided identity cards) and learn more about that career.
3. You will identify education and/or training needed for the career option you choose. You will identify resources available to support education or training i.e. scholarships, financial aid, awards, etc.
4. Review the Career Exploration worksheet with students and discuss your expectations. It may be necessary to clarify vocabulary on the worksheet (What is a Resume? Differences between education/training options; etc.
5. As they complete their internet research or as homework, they will need to read the provided articles and respond in their journal. "How would the professional, you researched, feel about climate change? Would they recommend action to prevent greenhouse emissions and/or global warming, do the feel action is unnecessary, or would they have other ideas? Why? What evidence would that person use to support their position/ideas?" If necessary, talk about quality sources. Are they getting their information from a paper/website written by an expert in the field or are they looking at a gossip newspaper? Students should use the provided readings and/or others to support their point of view.
6. As a little incentive, tell them this information will be very useful tomorrow so they should use their time wisely and do thorough work today.
7. Assist students while they research their career on the internet.

Extensions

- Students complete "The Greenhouse Diet" worksheet provided as an article. To identify specific ways that they could lessen their impacts on the environment.
- Students spend more time in "character" development. This might include more in depth research about a variety of topics i.e. What classes did you take in school for your degree? Where else have you worked?
- Similarly, students could spend time, before the "Policy Debate" lesson, researching and identifying quality evidence to support their character's position on climate change.
- Invite a guest speaker, ideally someone working on climate change issues, to the classroom to discuss their job and training.

Resources

SOME EDUCATION, TRAINING, AND EMPLOYMENT RESOURCES:

Alaska Job Center Network http://www.jobs.state.ak.us/
Alaska Pacific University http://www.alaska.net/apu
Alaska Vocational Technical Center http://www.educ.state.ak.us/AVTEC/Home.htm
Careers in engineering, physical science & mathematics http://www.agi.org/career
College Board (Testing information) http://wwwcollegeboard.org
Directory of Distance Learning http://www.worldwidelearn.com
Directory to Colleges http://home.rmci.net/michael/index6.htm
Financial Aid http://www.finaid.org
Geoscience Employment http://guideagiweb.org
Occupational Outlook Handbook (Describes what workers do on the job, working conditions, the training and education needed, earnings, and expected job prospects.) http://www.bls.gov/oco/
Self-Employment http://www.uaf.edu/rural/tvc.html
University of Alaska (Links to UAF, UAA, UAS) http://www.alaska.edu
U.S. Government Jobs http://www.usajobs.opm.gov/a9.htm

Identity Cards

Community Leader/Policy Maker i.e. Mayor, Council-member, Assembly-person	Water Quality Chemist Tests community water supplies.
Community Leader/Policy Maker i.e. Mayor, Council-member, Assembly-person	Engineer Design/Development of roads and buildings
Small Business Owner In Commercial Fishing	Geologist Studying Earthquakes/Volcanoes
Oil Industry Employee	Reindeer Herder / Subsistence Fisher
Pilot Small Commercial Business	Health Professional – Doctor, Nurse, etc.
Miner Self-Employed	Computer Programmer
Biologist	Police or Firefighter
Wildlife Refuge Manager	Self-Employed – Mechanic
Forest Manager	Director of a non-profit business to protect the environment and wildlife
Ship Captain	Teacher
Owner of a Logging Company	Small business owner Selling solar energy panels
Lodge Owner / Small Tourism Business	President of Local Native Corporation
Oceanographer / Marine Researcher	Architect

Reading Section: What can be done about climate change?

The following reading has been adapted from two reports found in their entirety at: http://www.gcrio.org/gwcc/part3.html and http://www.gcrio.org/gwcc/booklet3.htm

If carbon dioxide and other gases released by human activities cause climate change, what can people do about it? Three basic strategies are available, abatement, adaptation, and geo-engineering.

Abatement: To *abate* means to slow or stop. Abatement strategies aim to reduce the emissions of carbon dioxide and other gases that can cause climate change. They include improving energy efficiency, so that we burn less fuel, and using sources of energy that emit no greenhouse gases, such as solar or nuclear power.

Adaptation: Under this strategy people find ways to live successfully with the changed climate. For example, land use may change. Aqueducts can be built to bring water into newly dry areas. Coastal populations can be protected from rising sea level by building dikes and sea walls, by relocating populations inland, and by protecting fresh-water supplies from salt-water intrusion.

Geo-Engineering: *Geo* means earth, so geo-engineering means to engineer the earth's atmosphere and oceans to reduce the amount of climate change. For example, the amount of sunlight that strikes the earth might be reduced by putting more small particles into the high atmosphere. The idea is to off-set the warming effect of more greenhouse gas by reflecting more sunlight back into space. Many people oppose geo-engineering because they think there might be unintended side effects. However, if rapid and severe climate change occurs, some are likely to press for geo-engineering because it may be relatively inexpensive.

Choosing the appropriate combination of strategies is difficult. Each will cost money, pose problems, and offer benefits. It is unlikely that any single strategy can do the job. Uncertainty is added because scientists do not yet know enough about the costs, risks, and benefits. It is important for researchers to study the options quickly and carefully so that people can make informed choices.

Abatement options are strategies that reduce emissions.

- *Improving energy efficiency* will reduce emissions of carbon dioxide, the most significant greenhouse gas. If it is pursued wisely, it should also improve economic performance. Here are examples of three strategies that the U.S. might pursue to improve its energy efficiency:
- *Reduce energy use in buildings.* About 1/3 of all the energy used in the U.S., and 2/3 of all the electricity, goes into buildings. Most goes to heating, cooling and lighting. Researchers estimate that with improved insulation, glazing, weather-stripping, furnaces and air conditioners, and lighting in residential and commercial buildings, U.S. carbon dioxide emissions could be reduced by about 360 million tons per year, about 5% of total U.S. emissions. They also estimate that such changes would lead to reduced energy use, and actually save money, between $25 and $75 per ton of carbon dioxide saved.

- *Improve fuel efficiency of new cars.* Currently the average mileage obtained by new cars in the U.S. is 27.5 mpg. If this were raised to 32.5 mpg, and held there, over time, U.S. emissions would decline by about 250 million tons per year, about 4% of U.S. emissions. Estimates of the costs of such a program range from a savings of $76 per ton of carbon dioxide removed to a cost of $16 per ton of carbon dioxide. The savings result if the reduced fuel cost outweighs other cost increases.
- *Make appliances more efficient.* Currently available technology allows refrigerators, dishwashers, water heaters and other home appliances to be substantially more efficient than they are. If this technology were used in place of older, less efficient technology, the U.S. could reduce carbon dioxide emissions by about 75 million tons per year (1.3% of U.S. emissions) while at the same time saving $35 to $44 per ton.
- *Replacing coal, oil and gasoline with cleaner energy sources and technologies* would reduce carbon dioxide emissions and improve efficiency. The main issue for this strategy is whether there are enough abundant, low cost alternatives to coal, oil, and gasoline.
- *Instead of gasoline, use ethanol, hydrogen or electricity in cars and trucks.* Technology currently exists to allow cars to run on these and other alternative fuels. Ethanol is a kind of alcohol made from corn. If ethanol were made from sustainable agriculture, or if hydrogen or electricity were generated by renewable means, converting all vehicles would eventually reduce carbon dioxide emissions by over 1000 million tons per year (17% of U.S. emissions). However, the technology for some alternative fuel options (i.e., electric and hydrogen powered cars) is presently too expensive to be widely adopted by consumers, and researchers do not know whether farmers can produce enough corn for ethanol to replace gasoline. Such changes would cost between $50 and $177 per ton of carbon dioxide saved.
- *Switch 10% of building electricity use from electric resistance heat to natural gas heating.* Natural gas, whether it is used to warm rooms or heat water, is more efficient than electric heat. As a result, it is also cheaper and releases far less carbon dioxide than the coal burned to make electricity. By switching only 10% of commercial and residential electricity use to natural gas heating systems, U.S. carbon dioxide emissions could be reduced by about 75 million tons per year (1.3% of U.S. emissions) at an estimated savings of $90 per ton.
- *Replace all existing coal and oil fired electric power plants with new high efficiency plants that use natural gas.* The combustion of natural gas emits less carbon dioxide than the combustion of coal. If all existing coal and oil power plants were replaced by modern high efficiency natural gas systems, the U.S. would reduce its greenhouse gas emissions about 1000 million tons per year (17% of U.S. emissions). Some scientists doubt that there is enough natural gas to make this possible. The cost of such a plan, though uncertain, is estimated between $0 and $177 per ton of carbon dioxide.
- *Replace half of the existing oil and coal fired power plants with solar power plants.* The amount of solar energy reaching the earth's surface each year is enormous, thousands of times greater than worldwide annual fossil fuel use. While costs are still high, technology currently exists to use this solar energy to provide elec- tricity, light, heat, and steam for buildings and industry. If it were used wherever possible, it could reduce greenhouse gas emissions by about 1000 million tons per year (17% of U.S. emissions). However, substantial progress is necessary before solar technology is affordable as a basic source of electricity. The cost of reducing emissions through this program is estimated to be between $76 to $177 per ton of carbon dioxide.
- *Where possible, replace all fossil fuel plants with nuclear power plants.* Nuclear power currently provides about 7% of electricity in the U.S., but concerns over the safety, cost,

and environmental impacts of nuclear energy have halted development. Improvements in nuclear power might allow it to be considered as an option for reducing carbon dioxide emissions. If nuclear power were widely adopted in the U.S., the reduction in carbon dioxide emissions could reach as high as 1500 million tons per year (25% of U.S. emissions). Estimates of the cost of this policy range from $0 to $51 per ton of carbon dioxide saved.

- *Agriculture, deforestation and other human activities* are also responsible for significant quantities of greenhouse gas emissions. Reductions can be achieved through improved waste management, altered use and formulation of fertilizers, and changes in land use.
- *Establish an international "forestry fund" to prevent deforestation.* Deforestation in the developing world accounts for over 20% of the man-made greenhouse effect. The U.S. can play a role in policies to limit deforestation. Because deforestation is due largely to population and economic pressures, tropical rain forests will be preserved only if they have more value standing than cut down. One idea is an international "forestry fund," an endowment, funded by the developed world, which places $80 per acre ($200 per hectare) of protected forest into an investment account. The interest from the account is given to people living near or in the protected forests, to help them develop sustainable forestry practices, and to support them during the transition away from "slash and burn" agriculture. Residents would receive the interest as long as they practiced sustainable forestry. Fully implemented, the program could reduce global carbon dioxide emissions by 7000 million tons annually, at a cost of about $0.40 per ton of carbon dioxide saved.
- *Reduce methane emissions by improving waste management practices and changing agricultural techniques.* Though it accounts for only a small share of the man-made greenhouse effect, methane is a powerful greenhouse gas. Emissions come from rice paddies, cows and other "ruminant" animals, and from decomposing waste. Emissions can be reduced by cultivating fast-growing rice or high-density paddies, by placing ruminant animals on diets that reduce the amount of methane they emit as a byproduct of digestion, and by handling plant and animal wastes in a manner that reduces the amount of methane produced as they decompose. Such actions could reduce greenhouse gas emissions by over 200 million tons of carbon dioxide equivalent per year, at a cost of $0 to $5 per ton.

Adaptation options are actions taken to minimize the global environment's impact on humans.

- *Relocation of people, agriculture and industry* is one way to adapt to the changes in temperature, sea level and water distribution that might result from climate change. For example, state and federal governments often subsidize the rebuilding of homes and replenishment of beaches in areas that have experienced severe storms or floods. If sea level rise makes devastating storms and floods more common in certain regions, government could use these subsidies to help people relocate to less vulnerable areas, instead of rebuilding in the same spot. Banks and insurance companies may begin to influence building choices if they believe climate change may affect the properties they finance or insure. In the U.S. people migrate all the time for a variety of reasons. For this reason, it is difficult to say which portion of the costs of relocation should be assigned to climate change.

- *Improving irrigation and developing new crop strains* would allow agriculture to adapt to moderate climate change. The efficiency of irrigation systems improved 35% between 1950 and 1980, and some researchers believe efficiency can be improved

substantially more by making some relatively cheap changes to existing technology. As for crops, state, federal, and private labs today cultivate and test thousands of strains of agricultural plants. There are, for example, about 450 different strains of corn in commercial use. The costs of adapting to modest climate change would probably be a few percent or less of the overall costs of agriculture. Maintaining funding for research on crop varieties is a good way to prepare for the possible impacts of global warming on agriculture.

- *Migration corridors for plants and animals in the natural environment* might help the re-establishment of ecosystems in new locations as a response to climate change. As discussed in Details Booklet Part 2, gradual change would allow many natural ecosystems to migrate with the climate. However, natural migration of ecosystems can be blocked by human development, such as cities, highways, and farms. One way to help these ecosystems adapt to global warming might be to provide them with "corridors" of undeveloped land through which ecosystems can migrate as necessary. The costs are uncertain partly because such corridors might have other "open space" benefits and partly because it is unclear how many would be needed to be effective.

Geo-engineering options are potentially powerful, but as yet untested, ways either to stop the accumulation of carbon dioxide in the atmosphere, or to counteract its effects on our climate.

- *Global reforestation programs* could be designed to plant large numbers of trees to extract carbon dioxide and store it. A global reforestation program could remove 250 million tons of carbon dioxide per year (4% of U.S. emissions) at a cost of $3 to $10 per ton.

  Almost everyone thinks planting trees is a good idea. However, because there may be unintended side effects, many people are strongly opposed to other forms of geo-engineering. At the same time, because they may be cheap, and can be done "once we're in trouble," there will probably be some strong supporters of other geo- engineering strategies if serious warming occurs.

- *Adding iron to fertilize the ocean* may cause phytoplankton in the top layers of the ocean to absorb more carbon dioxide. While not all scientists agree that this strategy is safe, and recent tests in the ocean suggest it might not work, the absorption potential is very large, from 600 million to as high as 3000 million tons of carbon dioxide per year (10% to 50% of U.S. emissions). If it turns out to be a safe, viable option, it would probably cost somewhere between 10¢ and $15 dollars per ton of carbon dioxide removed.

- *Screen out sunlight to counteract the effects of increased concentrations of greenhouse gases.* Either large thin screens in low orbit or small particles of dust placed very high in the atmosphere could be used to reduce the amount of sunlight striking the earth. Thus, as the earth's atmosphere trapped more heat, less heat energy would be put into the earth's system by the sun, maintaining basically the same temperature. While untested, this strategy has the potential to counteract the warming effect of large amounts of carbon dioxide, at a cost of between 3¢ and $2.5 dollars per ton of carbon dioxide.

Things that an individual can do to reduce the chance of climate change:

Most effective actions.
Since most of our energy comes from oil, coal and gas, actions that reduce energy use will reduce the emissions of carbon dioxide. For example:

- When you buy a car, choose one that gets good mileage.
- Insulate and weatherize your home or apartment.
- Carpool or drive less.
- Replace old, worn-out appliances (e.g., refrigerators, heat pumps) with the most efficient new models. If the average U.S. citizen undertakes all of these actions, they can reduce their carbon dioxide emissions by about 25%, which equals about 5 tons of carbon dioxide per year.

Less effective, but helpful, actions.

- Turn off lights and appliances when not needed.
- Plant trees.
- Set the thermostat lower in winter and higher in summer.
- Recycle.

If the average citizen undertakes all of these actions, they can reduce their carbon dioxide emissions by about 3%, which equals just over half a ton of carbon dioxide per year.

***Ineffective*actions.**
Using aerosol spray cans does not cause climate change. In the U.S., they no longer contain CFCs.

Individual actions that influence others. Become informed and help your family and friends to learn about climate change. Actively support the government policies you decide are most appropriate.

What might nations do?

Improve energy efficiency: More efficient cars, appliances, and industrial systems use less energy, which means that less fuel is burned and less carbon dioxide is emitted. Substantial energy efficiency improvements can be obtained by replacing individual devices. In the longer run, even larger savings may be possible through structural changes, such as being able to work closer to home or redesigning the way houses and cities are built.

Develop and use energy sources that emit little or no carbon dioxide: Hydro power, solar power and windmills, as well as other "renewable energy" sources, emit no carbon dioxide. Neither does nuclear power. Burning natural gas emits less carbon dioxide than burning coal or oil. In the future, hydrogen, which emits no carbon dioxide when it is burned, may become a practical fuel. Ways of capturing and storing carbon dioxide might also be developed.

Improve forest and agricultural management practices: Trees remove carbon dioxide from the atmosphere and store it in wood. Methane produced by some agricultural activities, such as raising cattle and rice farming, can be reduced.

Reduce the impacts of climate change: New varieties of crops can be developed to grow in changed climates. Aqueducts can carry water to regions affected by drought. Coastal settlements and water supplies can be protected from rising sea level with dikes and sea walls. Coastal ecosystems, especially wetlands, are harder to protect.

How might government help do these things?

Government regulation: Government can require desired behaviors (e.g., force auto companies to build more efficient cars). An advantage of regulation is that it specifies the desired outcomes and can force action. However, regulation can be inflexible and discourage innovation.

Prices and markets: Higher prices for fossil fuels encourage people to save energy by promoting energy efficient devices and behavior (e.g., expensive gas prompts companies to make and people to

buy more fuel efficient cars). Government subsidies and taxes can also influence behavior. An advantage of using prices is that they present a constant incentive to innovate. However, using prices can have undesirable side effects, such as imposing a relatively larger burden on the poor.
Information and education: People often do not know how to improve efficiency or reduce emissions. Government can provide them with the information they need to make better choices.
Research and development: Government and industry can support research to demonstrate and improve existing technology, and to develop new technologies that use less energy or emit no carbon dioxide (e.g., refrigerators that use less electricity, cheap practical solar water heaters, and inexpensive solar/hydrogen technology).

What about other countries?
The atmosphere covers the entire globe and climate affects everyone. If abatement strategies are to be effective they will require international cooperation. Until now, developed countries have been the major sources of emissions. In the future, large developing countries, such as China, will be an increasingly important source of emissions. These countries argue that if the world must reduce emissions of carbon dioxide and other greenhouse gases, the U.S., Europe, and Japan should reduce the most. For years, they argue, these developed countries have been the largest emitters and they have already enjoyed the associated benefits of economic development. While this is true, developing countries could also help by doing more to control population growth.

How can people decide for themselves what should be done about climate change?
The climate problem affects everyone, and everyone has a stake in deciding what should be done. It is for you to decide what actions you should take as an individual (in your home, your car, and so forth). Equally important, as a citizen you must decide which policies to support or oppose. It may be tempting to decide that the climate problem is just too complicated to deal with. Without telling you what to choose, we can offer some advice on how to organize the choices and make decisions.
Your decision should depend on at least two considerations:

1. *What do you think the impacts of climate change are likely to be?* That is, how much do you think climate will change, and what impact do you believe that change will have on the things you care about? To make things simple, assume that there are only three possible beliefs about the impacts of climate change: it can be *not bad, moderately bad*, or *very bad*. Of course your judgment not only depends on what you believe about climate change, but also on what you value. For example, two people might agree that climate change will destroy many of the world's most sensitive ecosystems, but disagree about how much they value those ecosystems. These people would rate the impact of climate change differently. The person who values them highly will probably rate the impacts of climate change as *moderately bad* or *very bad*. The other person, who is perhaps mainly concerned with the economic impacts of climate change and doesn't think sensitive ecosystems are of great importance, might rate the impact of climate change as not bad. In short, how you rate the impacts of climate change depends on what you value.
2. *How much do you think abatement will cost?* Unlike the case above, where we were dealing with values which are very difficult, if not impossible, to measure in dollars, here we are dealing with costs that can be quantified. What are costs and benefits of prevention?