ALTERNATIVE ENERGY SOURCES

General Science, Biology, Environmental Science **Grades 6–12**

OBJECTIVES

CONTENT

Students will learn how energy can be derived from the major alternative energy sources; they will learn of the availability, renewability, and environmental impact of these energy sources.

THINKING SKILL/PROCESS

Students will learn to consider options and their consequences and the importance of these consequences in making decisions. Students will also recognize the need for reliable information in making decisions.

METHODS AND MATERIALS

CONTENT

Students will use textbook material on the subject of alternative energy. This lesson includes a research option in which students gather reliable information about alternative energy from a variety of sources.

THINKING SKILL/PROCESS

Structured questioning about options and consequences and the use of a data matrix guide students through the decision-making process. Collaborative learning groups brainstorm options and consequences.

LESSON

INTRODUCTION TO CONTENT AND THINKING SKILL/PROCESS

- **We've been studying energy as it is used to meet human needs, and, in particular, different sources of energy. In this lesson, we're going to focus our attention on these different sources of energy and make some judgments about the scope and limits of their use in meeting our needs in this country as we approach the 21st Century. As we do this, we will also learn some ways to think about our decisions that can help us make good ones more frequently. Let's spend a little time on decision making first. How many of you have made decisions recently that you think are good ones?** Ask for a show of hands and a few examples.
- **How many of you have made other decisions that you weren't too happy with?** Ask for a show of hands. **Write down some details about a decision that you've made recently that didn't work out too well.** Allow a few minutes.
- **Now tell your partner about your decision. Discuss two things: Why wasn't this such a good decision? What might you have thought about before you made it that could have resulted in a decision you'd feel better about now? Write these ideas down as they come up in your discussion.** Give the groups a few minutes to work together.
- **Now that you have had a chance to discuss your decision with a partner, will someone tell the class about your decision?** Ask for three or four examples. Write the decisions on the chalkboard, along with students' suggestions about how they could have made better decisions. Responses tend to include examples in which students didn't realize some of the consequences of their decisions. They usually indicate that, if they had thought about what might happen, or had gotten information about the consequences, they would have made a different decision. Other responses tend to include examples in which students didn't think about other alterna-

tives that were better. Write the options examples in one column and the consequence examples in another. Then ask students to label what is in each column. ANSWERS INCLUDE: Alternatives, possibilities, choices, things to do, options (column 1); results, consequences, what will happen (column 2). Write these words on the board at the top of the appropriate column. Categorize students' responses using the words "Options" and "Consequences" for these two columns. Label the columns "Think about Options" and "Think about Consequences."

- **Now, you have some ideas about what to think about when you're making another decision. Let's put these ideas together with some others that have been suggested about making decisions and develop an organized plan for good decision making.** Write the thinking map of skillful decision making on the board:

SKILLFUL DECISION MAKING

1. **What makes a decision necessary?**
2. **What are my options?**
3. **What are the likely consequences of each option?**
4. **How important are the consequences?**
5. **Which option is best in light of the consequences?**

- **Good decision making is especially important when it comes to decisions our country has to make about issues that affect all of us. As you know, one issue that this country has faced is what energy source should be the one we rely on as our dominant source of energy to meet our needs. When our country makes such a decision and shapes its energy policy on it, the decision should be based on scientific facts. Suppose that you were an advisor to the government on this matter and wanted to make a careful and thorough recommendation. You would certainly want to think about this issue according to our plan for making good decisions. Let's start that process by thinking about what we already know about energy and energy sources.** Ask the students to review what they have studied about energy, in general, and about alternative sources of energy, in particular.

THINKING ACTIVELY

- **Now let's follow our plan for skillful decision making. Why are people today concerned about energy? Can you remember a time when you heard someone discussing this question? What made them concerned about it?** POSSIBLE ANSWERS: *We use a lot of energy. We rely on oil for our main energy needs, and the supply of oil may run out sometime within the next fifty years. We depend on oil from other countries, and some of those countries have closed off our oil supply in the past. We'll be needing more energy in the future. Pollution affects our health and the environment. Oil can be used in more valuable ways. The price of oil continues to go up.*

- **What are some of our options regarding energy sources? Which should be our major source? We now rely on oil. Maybe oil should still be our dominant source. However, let's think about other possibilities and try to decide which is best. Work together in groups of four and list as many energy sources as possible. Try to include some that are unusual. Think about how energy is produced from each source.** Ask the groups to report at random but to mention only one energy source from their lists. Then ask for sources that haven't been mentioned, creating a list from as many students as possible. Write the energy sources on the chalkboard or on a transparency under the heading "Options." When uncommon sources are mentioned, ask if anyone knows how energy is produced from those sources. This taps students' prior knowledge and contributes to the collaborative nature of the activity. POSSIBLE ANSWERS: *Nuclear power, wind, water power from dams, solar power, burning garbage, ethanol from grain, the tides, heat from the earth (geothermal), magnetism, lightning, animal power, human power, wood, oil, coal, methane gas, natural gas, steam, gravity, and chemical reactions (batteries).*

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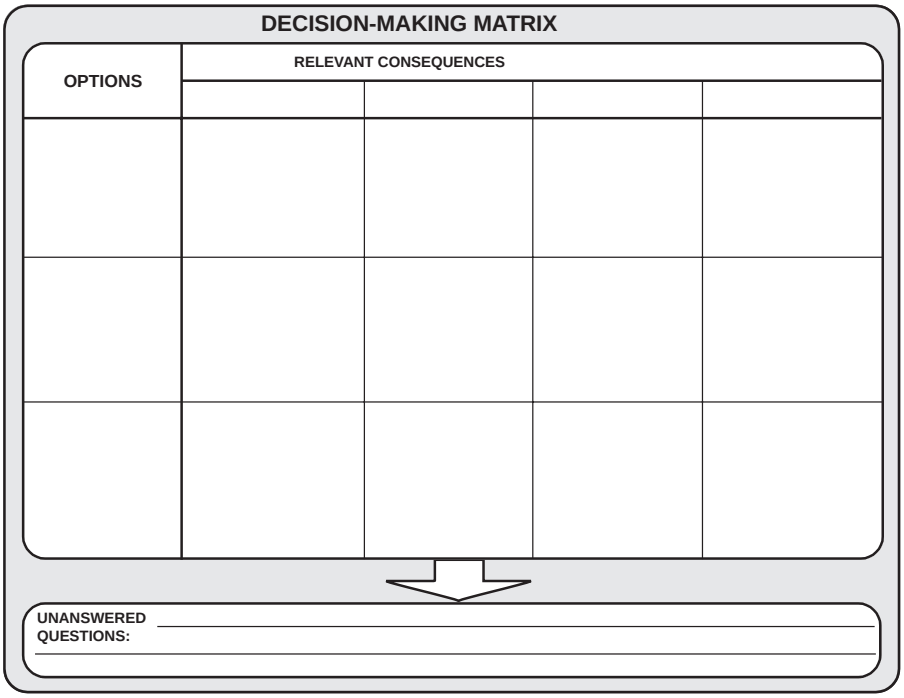
- **When you are trying to make a complicated decision like this one, it's a good idea to think about what information you might need in order to decide. What would you want to know about the consequences of relying on each of these energy sources? Make a list of the things you need to know about a type of energy in order to decide whether it is a good source for our country to rely on. Your list might include, for example, how easy it is to produce the energy. What else would you add?** The students should work in groups again and then report. Write student responses on the chalkboard or a transparency with the heading, "Factors to Take into Account." POSSIBLE ANSWERS: *Costs (production, transportation, costs to the consumer, storage, distribution, finding the source, and research), abundance, safety, environmental impact, ease and cost of converting to a new energy source, technology needed to produce and transmit the energy, whether the source is renewable, jobs lost or created, ease of use, consumer comfort, ease of production, public acceptability.*

- **Each group should now pick three sources from its list of options. Gather information about the consequences of relying on these different forms of energy with regard to the factors you have listed. You'll use a diagram called a "data matrix," which is a chart having columns and**



rows. Write the energy forms down the side under "options," and write the factors to consider across the top. Get the appropriate information from your textbooks or other sources to fill in the boxes. If you don't have information, if you have only partial information, or if you're not sure about its reliability, put a question mark in the cell. Write your unanswered questions on the lines below the diagram. For example, suppose solar was a source that you were working on. Your textbook provides you with a certain amount of information that you can put in your matrix. But it may not tell you how much a solar panel costs, and you may want to get that information in order to determine how costly converting to solar power may be for consumers. You would then write "How much does a solar panel cost?" in the "Unanswered Questions" box.

Allow sufficient time for your students to complete this activity. A good plan for this part of the lesson is to have students do it in two stages. Initially, and in class, they can use their textbooks, perhaps supplemented by some additional resource material you provide on alternative energy sources. Then you can ask them to do some outside research to get answers to their unanswered questions (e.g., using resources in the school library). Help them to develop a research plan by identifying possible sources for the information they want. Sources may include libraries, governmental agencies that deal with energy, TV documentaries, etc. Give students a few days to a week to get this information and then to report back to their groups. (If you want to conduct this lesson in less time, you can collect more information sources on alternative energy yourself and bring these into the class for students to work with there.)

- **What does this information about the consequences of using these energy sources show about the options you are considering? Put a plus next to the factors that you think count in favor of choosing the energy source and a minus next to those that count against choosing it. Put an asterisk in the boxes you think contain information that is very important. For each entry, explain why you put a plus, a minus, or an asterisk.** ANSWERS WILL VARY. Ask each group to report its findings to the rest of the class and explain why they rated the consequences as they did. Make a "class matrix" on the chalkboard or on a large piece of poster board. Fill in the matrix based on the reports of each group. Encourage students to add information from the group matrix to their individual ones. More than one copy of the matrix can be used if students need more space. (See examples at the end of this lesson.)

- **Work together in your groups and decide what you would pick as the best source of energy for this country to rely on, given the information on the chart. Discuss why it is the best energy source.**

  Ask each group to prepare an oral or written recommendation explaining the reasons for their choices. To make this lesson an ongoing research project, students should continue to gather information to answer any remaining unanswered questions and periodically report their findings. When they get additional information, students may add it to their diagrams and report it to the class. Encourage them to reconsider their recommendations in the light of new information. A diagram may also be kept on a bulletin board for students to fill in.

THINKING ABOUT THINKING

- **How did you go about thinking through your decision? Describe what you did first, next, etc. Draw a diagram that represents a flow chart of your thinking.** Ask students to display their diagrams. Student descriptions will vary, but their flow charts should contain the five key questions on the thinking map for decision making.

- **Did you find any aspects of this activity particularly difficult? Why? How might you do this more easily next time?** ANSWERS WILL VARY.

- **What do you think about this way of making a decision? Is this a good way to do it? What are some of its pros and cons?** Discuss this strategy with the class and ask students whether the pros outweigh the cons or whether they have a better way to make a decision. POSSIBLE ANSWERS:

  Pros: *Helps us think about wider energy options, reduces narrow thinking, presents an organized way to think about a complex subject, improves confidence in choices, encourages active involvement in the topic, makes us aware of the important information in determining desirability of relying on the source, makes it possible to record relevant information in an organized way so that we won't forget it and can compare different options easily.*

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Cons: *Takes longer, requires that we write on the diagram the information we find, depends on the reliability of the information we are using.*

Most students favor this approach for important decisions, though many say that it is too much trouble for decisions that are not too important. They still favor a shorter version of this strategy for even these choices—one that involves taking time to think about options and consequences before the decision.

- **What plan for careful decision making works best for you?** Allow students to map out their own plan for skillful decision making. If they omit one of the five attention points, suggest that they include something comparable. Students may include any points that they think will help them avoid difficulties they may have encountered with the energy activity.
- **How does this compare to the way you ordinarily make decisions? What's a good way to make sure that you follow this new plan instead?** Students sometimes suggest writing down their plan in their notebooks or thinking portfolios or posting it on the wall of their classroom.

APPLYING THINKING

Immediate Transfer

- **Select a decision that you are trying to make right now or that you will have to make soon. Think it through, following the plan for decision making you just developed. List any unanswered questions that you may have so that you can continue to think about your decision making and research it after you leave class. After you reach a decision, indicate how confident you feel about it, based on the questions you've been able to answer through your research.**
- **Imagine that your parents are considering whether they should use alternative energy sources in their apartment or home. Help them decide by using your decision-making strategy.**

Reinforcement Later

Later in the school year, introduce these reinforcing activities:

- **As we study the atmosphere of the earth, we will find out that it is polluted with many different particles and chemicals. Decide what to do about some types of this pollution.**
- **As we study endangered species, select one endangered animal and recommend what to do to prevent its extinction.**
- **We will be studying the way many immigrants came to this country from Europe in the early years of this century. Suppose you were a senator living at the time. What immigration policy would you support in Congress. Why? Use your decision-making strategy to decide what you think is the best thing to do. Would you support the same policy with regard to the Asians and Latin Americans who wish to immigrate to this country now? Explain why or why not.**

THINKING SKILL EXTENSION

Read an advertisement about nuclear power. What does it tell us about nuclear power? What would you want to find out about the advertisement and its source to help you determine whether the information it includes is reliable? Make a checklist of things that you might find out that would help you decide whether the information given in the advertisement is reliable. How could you get this information? Try to get this information so that you can judge whether the ad information is likely to be reliable.

Now think about whether the ad leaves unanswered any questions you have about nuclear power. If so, pick two of these questions. How could you get additional, reliable information to answer your unanswered questions? List some sources you think will be reliable and some that you are not sure about. Explain why you think they are or are not reliable.

ASSESSING STUDENT THINKING ABOUT DECISIONS

To assess this skill, ask students to write about any of the application questions. For example, ask them to think through a personal decision or to write about a controversial social issue, such as disposing of hazardous waste or environmental pollution. You may ask a similar question about a major historical decision, like Lincoln's decision to issue the Emancipation Proclamation (making sure that students have enough background knowledge to answer it). Their writing can be in the form of a standard essay, a recommendation to someone, or a letter to the editor of a local newspaper. Ask students to make their thinking explicit in their writing. Determine whether they are attending to each of the steps in the thinking map for decision making.

If you choose the extended form of this lesson, in which students gather additional information and periodically return to the question, you can use portfolio assessment techniques. Ask your students to state their learning and thinking goals in this activity and to include their comments in a special portfolio for this project. They should include products in their portfolios that indicate how well they are meeting these goals (filled-in matrices, notes on energy sources from their research, their written recommendations, etc.). They should comment on how well they believe they are meeting their goals, both with regard to gathering information about energy sources and in their decision making. The students should include these comments in their portfolios.

WRITING EXTENSION

Write a recommendation to one of your state representatives explaining why it is necessary to make a decision about which energy source this country should rely on as its dominant source, what you recommend, and why you recommend it. Make sure you explain the options you've considered, their main pros and cons, and why you choose the option you do despite its cons.

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DECISION-MAKING MATRIX

OPTIONS	RELEVANT CONSEQUENCES						
	ABUNDANCE/ RENEWABILITY	ACCESSIBILITY	COST OF PRODUCTION	COST TO CONSUMERS	SAFETY	ENVIRONMENTAL IMPACT	EASE OF CONVERSION
OIL	U.S. has less than a decade of oil reserves left. Oil is nonrenewable; worldwide resources are also being depleted. Reserves can run out. ✳ –	Oil is underground. More than 60,000 oil wells are drilled in U.S. alone. New oil reserves are very difficult to discover; locating oil will get tougher. –	In 1980, $20 billion spent on oil search. Refining, storing, transporting and delivery to consumers will continue to be expensive. –	Petroleum products (primarily oil and gasoline) are usually readily available worldwide at mostly affordable prices. ✳ +	Petrochemicals are flammable,toxic, and can pose extreme production and transport risks. Increased demand may make safety risks higher. –	Combustion of fossil fuels produce airborne pollutants; oil seepage and spills into ground and oceans can threaten life. Increased use will increase damage to the environment. ✳ –	Minimal: most vehicles have internal combustion engines; homes have furnaces easily converted to oil. Distribution of fuel oil and gasoline is already at the neighborhood level and will remain so. +
NATURAL GAS	U.S. has substantial reserves of natural gas, but much in places that are uneconomical to develop. LNG available fromArab nations; possible to gassify coal. Gas may be available for the long haul. ✳ +	Only one-fourth of all wells drilled are for gas. Unconventional sources like "tough sands" need to be fractured with high pressure liquids. These less accessible sources will have to be tapped. –	Natural gas does not have to be refined therefore not much at present but if demand increases unconventional and costly sources such as "tight sand" and shale deposits will have to be used. –	In the U.S., natural gas readily available to consumers in developed areas is generally low in cost. Technology to get to consumers in use for years. ✳ +	Gas is explosively combustible and poses extraordinary hazards to handlers; extraction, production, transport, delivery and consumer use of gas is dangerous. Increased use will increase risks. –	Natural gas burns very cleanly. Leaks into the atmosphere are relatively rare. Increased use should not harm the environment beyond the addition of more drill rigs throughout U.S. ✳ +	Expensive: furnaces might readily be converted to gas, but vehicles require new technology. It would require lots of money to build natural gas filling stations. –
COAL	Coal is the most plentiful fossil fuel;U.S. has about 25% of world's supply. The world has enough to last for at least 200 years. There is enough for the long haul. ✳ +	Forty percent of coal is dug out of deep mines; the rest comes from surface strip mines. Much is too deep for economical extraction. Increased demand could require developing new mining technology. –	Most coal not refined, delivered directly to electric utilities. Only other major expense is transportation. But increased use for other purposes might require costly processing. –	Though no longer widely used in U.S., coal is available and very low in cost. It is simple to transport and has been in use for many years. ✳ +	In typical year, 100 miners die, 1000s are injured. Coal, though combustible, is not explosively flammable or dangerous to transport or deliver. If demand rises, so will casualities. –	Smokestack emissons from coal-burning industries and increased carbon dioxide from combustion may cause acid rain and global warming. Strip mine sites need to be cleaned up. Increased demand means more pollution. ✳ –	Expensive: few homes or industries and no vehicles are equipped with coal-burning furnaces. Coal is delivered by rail. Internal combustion engines & home heating systems must be changed and the means of delivery provided. –
GEO-THERMAL	Geothermal energy is plentiful. 2,300,000 exploitable acres being explored. If new technology is developed to get it, it may be enough for the long run. ✳ +	Little geothermal energy can be utilized. In most of the U.S., a significant temperature gradient lies too deep for practical use. However, the West and the eastern seaboard are ideal areas for development. –	Cost will be high to develop new technologies to reach and use deep lying geothermal energy sources (hot rock, steam, magma). If demand increases, cost will skyrocket. –	Geothermal energy sources are scattered throughout the U.S.; though the energy is low-cost once produced, the technology to make it widely used is not yet available, hence potentially very costly. ✳ –	No substantial dangers attributed to geothermal production of energy. Steam and hot water are already safely utilized. Geothermal energy is not flammable and poses little risk. +	Geothermal energy is used to heat water. The heated water, if hot enough, generates electricity. Warm water recycled into the ground is not especially harmful to the environment. ✳ +	Easy to heat with warm water but impractical to replace the gasoline engine with portable steam. Would have to build new power plants, produce electricity from steam and replace the engine with batteries. –

KEY ✳ important + pro — con

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DECISION-MAKING MATRIX

OPTIONS	RELEVANT CONSEQUENCES						
	ABUNDANCE/ RENEWABILITY	ACCESSIBILITY	COST OF PRODUCTION	COST TO CONSUMERS	SAFETY	ENVIRONMENTAL IMPACT	EASE OF CONVERSION
NUCLEAR	Uranium in U.S. reserves will power existing reactors only thirty years; breeder reactors produce more fuel than they use and can meet increased future demands. ✳ +	One-fourth of world's uranium is in U.S. in 300 mines. If demand increases, mining would remain a practical process. +	A pound of uranium fuel has 3 million times the energy of a pound of coal; refining uranium is very expensive, but smoothly running plants produce cheap energy. Future plants likely to be more efficient. +	Energy produced from existing nuclear power plants readily available, abundant, and affordable. Nuclear power plants can be built almost anywhere. ✳ +	Radioactive material is extremely dangerous. At Three Mile Island and at Chernobyl, serios nuclear accidents have occurred. More reactors mean more risk. –	Safe and long-term disposal of used reactor fuel is a big problem. Leaked radioactivity can sicken and kill people and cause long-term damage to ecosystem. More reactors means more risk. ✳ –	Easy, although it is not feasible to power vehicles directly with nuclear energy, nuclear power plants produce electricity, which is used along the existing power distribution network. +
SOLAR	The sun potentially supplies 500 times more energy than we consume each year, more than we will likely ever need. Solar energy is renewable resource. ✳ +	Usuable radiant energy also diffuses through clouds. The sun is the most accessible of all energy sources and will remain available regardless of future demand. +	Sunlight is expensive to harness. Home solar collectors can cost $5000. Photo-voltaic cells generate electricity only in small amounts. Increased demand on solar energy would be expensive. –	Although solar panels are costly, once in place, the energy produced is virtually free. For those who live in regions that get little sun, transportation costs for the energy make it more expensive. ✳ –+	Sunlight is not ordinarily dangerous. It is not flammable, does not explode, does not leak, does not create pollutants. Harnessing more solar energy poses no unusual risks or danger. +	The sun is not only a part of nature, it is a requirement for the survival of life on Earth. Without the energy of the sun, the planet's temperature would plummet to 450°F below zero. ✳ +	Using solar energy to heat bath water is one thing; using it to power industry and vehicles is another. Would be extremely difficult covering major power utilities to solar energy. –
WIND	Areas of strong, prevailing continuous wind are not common-place in the world. Wind is seasonal; in most places the amount varies from night to day, season to season. ✳ –	Where wind blows continuously, it is often usable for producing electricity by windmills. But most areas having prevailing winds, like open oceans or mountain ranges, are impractical to exploit. –	Windmill turbines expensive to build and maintain, takes hudreds to generate a small amount of electricity. Increased supply of windmill energy would be very costly. –	In regions in which there is regular wind and windmills are in place, consumer costs are very low. Costs are determined by maintenance and transportation. In low-wind areas, costs would be higher. ✳ –+	Modern windmills are simple machines that stay anchored in the ground. Neither the wind nor the windmill poses any extraordinary danger to those maintaining them or those using them. +	Windmills little threat to environment. They don't produce toxic chemicals or endanger wildlife. Other then the property cleared for a windmill "farm," they are environment-friendly. ✳ +	Very difficult: It takes many windmills to generate a limited amount of power; it is unlikely that those areas with adequate wind would host the thousands of windmills necessary to produce significant power. –
HYDRO-ELECTRIC	Water is a renewable resource. However, availability of new construction sites for dams and hydroelectric plants are limited by environmental concerns. ✳ –	You need a fast-flowing river, a dam site, and room for a plant. Many end users of electricity are too remote from dammable rivers to benefit from them. –	Enormous initial investment to build the dam and power plant. However, the water is free. But if demand increased, new dams would be built at great expense. –	Energy from hydroelectric plants is low cost, once the dams and other technology are in place. However, because sites for dams are limited, the cost to transport the energy. ✳ –+	Modern dams only rarely breach. The power is produced cleanly, and maintenance of water turbines is routine. There is little danger to operators. +	Hydroelectric plants produce "clean" energy and emit no pollutants into the air or water. Interrupt the natural flow of rivers, which has threatened the habitat of some organisms. ✳ +	Very difficult: a substantial increase in hydroelectrict capacity would involve building hundreds of new dams, which would take years; the problem of auto and truck pollution would remain. –

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DECISION-MAKING LESSON CONTEXTS

The following examples have been suggested by classroom teachers as contexts to develop infused lessons. If a skill or process has been introduced in a previous infused lesson, these contexts may be used to reinforce it.

GRADE	SUBJECT	TOPIC	THINKING ISSUE
6–8	Science	Animal rights	What should be considered in deciding whether or not to experiment with animals?
6–8	Science	Waste management	What should be taken into account in deciding whether recycling should be a common practice, and how it should be practiced, or whether more standard methods of waste management should be retained?
6–8	Science	Global warming	Which causes of global warming would be most worthwhile spending money and resources to control?
6–8	Science	Space exploration	Should we spend large amounts of money on pushing further into outer space? Are the benefits likely to justify the expense? Or should we adopt a more limited type of space program? Explain.
6–8	Science	Endangered species	What can we do to protect old-growth forest given that the lumber industry depends on wood from these forests?
6–8	Science	Simple machines	How would you decide which simple machine is best to lift a heavy bundle in a given situation?
6–8	Science	Experiment design	Design an experiment so that you will be able to gather data that will confirm a specific hypothesis about metals, heat, and conductivity.
9–12	Biology	AIDS	What should be considered in deciding whether public health or individual privacy is most important in making mandatory AIDS testing the law? Does a better alternative exist?
9–12	Biology	Genetics	What should a couple who know they carry a defective gene consider when deciding whether to have a child?
9–12	Biology	Bioethics	What should be taken into account in forming a national policy on organ transplants?
9–12	Biology	The environment	What should be taken into account when deciding whether and where to build and locate a new nuclear power plant?
9–12	Biology	The environment	What should be taken into account when deciding which method to use to get rid of pests—pesticides, sterile organisms, natural predators, destruction of habitat, etc.?
9–12	Biology	Genetics	What characteristics should be taken into account when deciding which of a number of plants would work best in inheritance experiments?

DECISION-MAKING LESSON CONTEXTS			
GRADE	**SUBJECT**	**TOPIC**	**THINKING ISSUE**
9–12	Biology	Fossil dating	What should be taken into account when deciding which method —radiocarbon, potassium/argon/tree rings—to use in dating a fossil?
9–12	Biology	Immune system	What would you take into account in deciding the use or availability of cancer-fighting drugs that act on the immune system?
9–12	Biology	Environment	What factors should be taken into account when deciding whether or not, or to what extent, land development will be allowed in wetlands?
9–12	Biology/ Social studies	Bioethics	What should be taken into account in forming a national policy on organ transplants, genetic engineering, or financial responsibility for children with physical or mental handicaps?
9–12	Biology/ Social studies	Bioethics	What should be taken into account to decide whether DDT should be banned?
9–12	Chemistry	Chemical indicators	What characteristics—pH, functional groups, shape of molecule, etc.—should be taken into account when deciding which chemical indicator to choose?
9–12	Physics	Simple machines	What factors should be considered when deciding which simple machine would be best to perform a specific task?
9–12	Physics/ Social studies	Atomic energy	What should be taken into account in deciding how and where nuclear waste is stored?
9–12	Science	Laboratory work	How would you best arrange a science laboratory for accessibility of instruments, safety, and ease in conducting experiments?

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