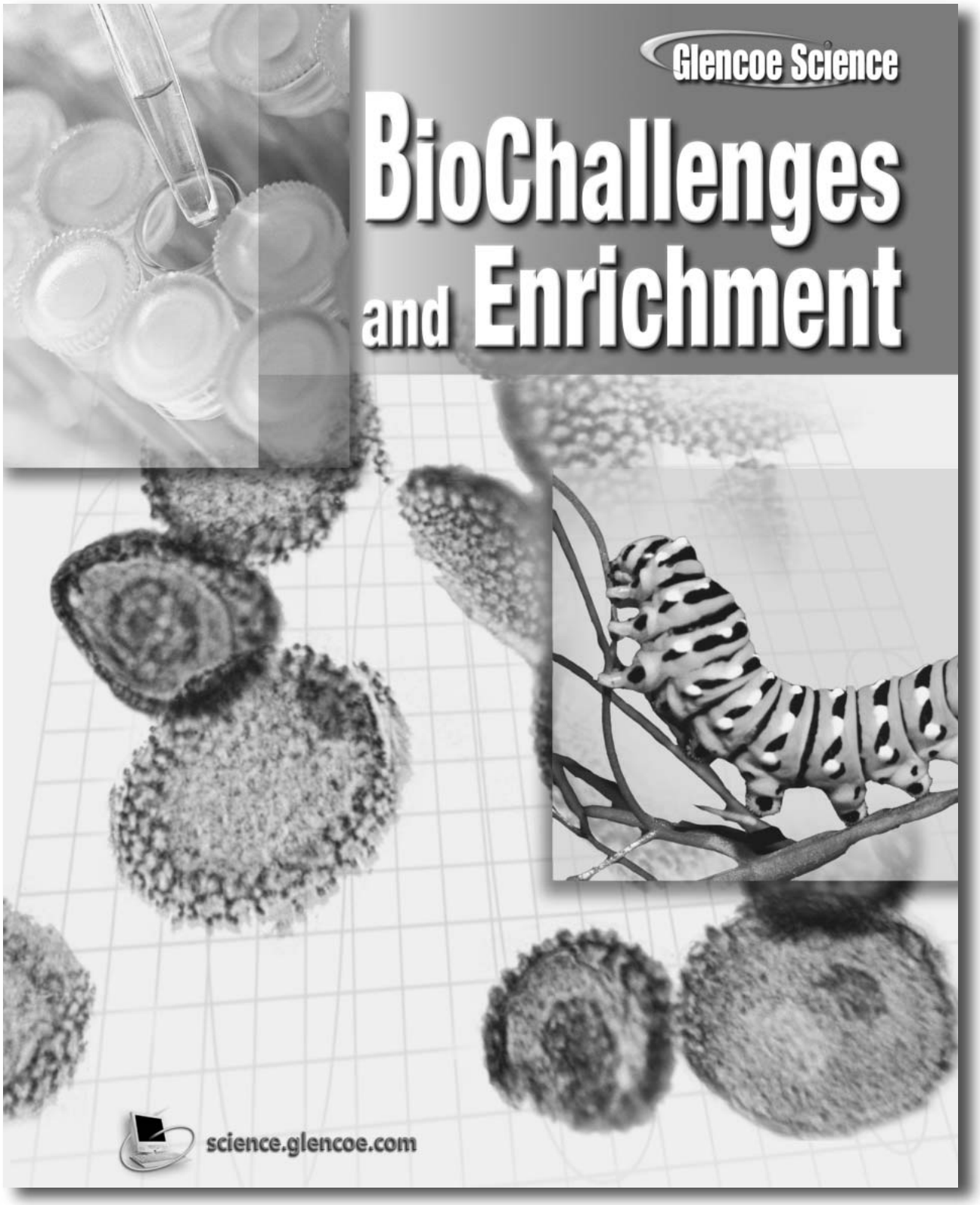

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Project 1

What is biology?

BioChallenge Goal

The purpose of this project is to compare *qualitative* and *quantitative* investigational methods, and to understand their application to the study of biology. After your preliminary research, you will design and carry out a qualitative or quantitative study using insects or other small invertebrate organisms.

BioChallenge Projects

Project 1 Qualitative Research — Use qualitative research to gather information about an organism.

Project 2 Quantitative Research — Design a quantitative experiment to answer a research question about an organism.

Project 3 Ask the Experts — Contact professionals currently engaged in research on living things.

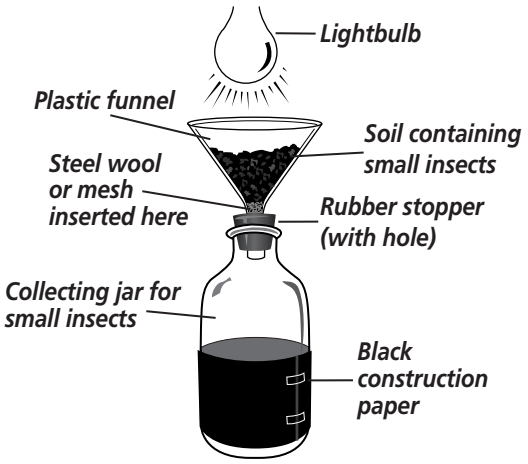
Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. **Investigate** Divide into teams to investigate qualitative and quantitative research. Prepare a list of questions about insects. Write a brief description of how you could answer the questions using either qualitative or quantitative research.
2. **Examine Published Research** Read examples of published research from various fields of science. With your research team, determine whether the researchers used qualitative or quantitative research methods in their work.
3. If you will be completing Project 3, start assembling a list of research professionals you may be able to interview.

If you choose Project 1 or 2, complete the following steps:

4. **Choose an Organism to Study** With your team, choose several possible insects or invertebrates to study. Do not list any organisms that are poisonous, endangered, or threatened. Suggestions include mealworms (larval stage of meal-eating *Tenebrio* beetles), sow bugs (isopods, a type of arthropod which are also called woodlice or pill bugs), grasshoppers, crickets, milkweed bugs, roaches, praying mantises, ants, brine shrimp (a type of saltwater crustacean sold as fish food), earthworms, and tubifex worms (aquatic worms available at many pet stores). At the library, use reliable sources to find information about the life cycles and habitats of the organisms on your list. Use the information you have gathered to choose an organism to study.
5. **Plan your strategy** for obtaining the organisms. During warm weather you might be able to catch crickets in a field or nearby lot using nets and jars. You can also buy crickets at pet stores. Make a list of everything you need to house and feed the organism you have chosen to study. One method of capturing small insects and other organisms that live in soil is by using a Berlese funnel, which is illustrated on the following page.



6. **Prepare a suitable habitat** for your organism. You may need any or all of the following items: hand lens, forceps, terrarium or cage, food, plastic containers, water, gloves, heat lamps, and thermometers.
7. **Care for your organism** for about a week to be sure that it is established in captivity. Do not begin your research during this week. Use this time to prepare the materials you will need for your study and to develop a research plan with your teacher.

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. Qualitative Research

In this project, you will use qualitative research to answer a question about the organism you have chosen to study.

- **Find examples** of qualitative research. Pay careful attention to the way qualitative research is used to answer questions in science.
- With your research team, **plan a study** that uses qualitative research to answer a question about the organism you have chosen to study. Review your research plans with your teacher. Your research plan should not include any step that will harm the organism you have chosen to study.
- **Obtain any materials** or supplies you will need to complete your research.
- **Carry out your investigation.** Keep careful written records throughout your investigation.
- When you have reached the end of your qualitative study, **analyze your data**, then prepare a report of your findings, and share your report with your class. If another group has chosen a project that uses quantitative research, compare your studies. You might want to create a movie clip or PowerPoint® presentation to share the results of your study.

Project 2. Quantitative Research

In this project, you will use quantitative research to answer a question about the insect you have chosen to study.

- **Find examples** of quantitative research. Pay careful attention to the way quantitative research is used to answer questions in science.
- With your research team, **plan a study** that uses quantitative research to answer a question about the organism you have chosen to study. Remember that quantitative research requires controls. Review your research plans with your teacher. Your research plan should not include any step that will harm the organism you have chosen to study.
- **Obtain any materials** or supplies you will need to complete your research.

- **Carry out your experiment**. Keep careful written records throughout your experiment. Use data tables, graphs, and charts to record and analyze your data.
- When you have reached the end of your quantitative study, **prepare a report** of your findings, and share your report with your class. If another group has chosen a project that uses qualitative research, compare your studies.

Project 3. Ask the Experts

In this project, you will contact several working scientists to find out about their current research.

- **Prepare Your Research** With your research group, determine where research on insects is taking place. You might want to check with the insect zoo at the Smithsonian, the insect curator at your local zoo, or an expert from a major university or research institute.
- **Prepare a questionnaire** that could be used to interview the scientists. Ask questions that will allow you to find out as much as possible about the scientists' research methods and results. Decide whether you will conduct your interviews over the phone, in person, or by some other means. Have your teacher approve your questionnaire.
- **Interview the Scientists** Contact scientists at these locations. Ask if they would be willing to share information about their research with you. After you have found three scientists who are willing to be a part of your project, you can begin your interviews.
- **Present Your Data** Prepare an oral report for your class that summarizes the interviews, or video tape the interviews.

Enrichment Activities

Short on time? Extend your knowledge about experimental design with these shorter challenges.

Research Using Models Research the use of models in scientific research, including mathematical models and computer simulations. Choose one area of research in which models are extensively used. If possible, interview a scientist in this field. Prepare an oral report about the advantages and disadvantages of using models in this field of research.

Venn Diagram of Research Methods Create a Venn diagram showing the similarities and differences between quantitative and qualitative research. Use several resources to find the information you will need for your poster. Display your Venn diagram on a poster in your classroom. Be prepared to explain your poster to your classmates and your teacher.

How Did They Do It? Choose a famous or groundbreaking scientific investigation. Research the investigation in as much detail as possible. Prepare a report that describes the research methods used by the scientist or scientists in their groundbreaking work. Some possible topics include Charles Darwin's work in the Galápagos, Watson and Crick's determination of the structure of DNA, Gregor Mendel's work with pea plants, Norman Borlaug's work with plant breeding, Barbara McClintock's research on "jumping genes," or George Washington Carver's work with agricultural crops.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. when you have chosen an organism to study, and have developed plans for the care and maintenance of the organism		
2. when you have chosen a long-term project		
3. when you have begun your study		
4. when you have results from your investigation		
5. before you prepare your report		

Project 2

Habitat Improvement

BioChallenge Goal

The purpose of this project is to improve or preserve a local habitat so that desirable plant and animal species can establish a population or increase their numbers. Habitats may be on the school grounds, in a vacant lot, meadow, or wooded area or along a stream, beach, seashore, or lake front.

BioChallenge Projects

Project 1 From the Ground Up — Make specific improvements in the habitats of various local plant and animal species.

Project 2 Meet the Press — Design and execute a publicity program that will contribute to environmental improvement.

Getting Started

Before you choose your long-term project, spend about two weeks selecting an environmental site on which to focus your project.

1. **Contact Community Resources** Contact an agricultural extension agent, wildlife biologist, fish hatchery specialist, naturalist, or greenhouse or nursery owner to discuss ideas for habitat improvement. If possible, have this person come speak to your class. Contact a representative of the United States Fish and Wildlife Service to discuss possible sites for your project. Find out if there are any nature preserves in your area and if there are any breeding programs for threatened or endangered species being conducted there. Find out if any permits are required for habitat improvement. Contact the owner of the site you are considering for habitat improvement. You must have written permission from the owner before you can proceed with a project.
2. As you begin your research on how to improve the environment, **communicate with local chapters** of environmental organizations such as the Nature Conservancy or the Audubon Society. Make telephone calls and write letters to get information and express your ideas. People from these organizations may be able to help you with the project and advise you about ongoing studies on plant and animal species and habitat improvement.
3. **Determine the dominant plant and animal species** in the site you have chosen for habitat improvement. Estimate the populations of the various species of organisms at the site using the survey methods described below.
4. **Plant Survey** To **estimate** the plant populations and determine the dominant species of plants living on your site, take a random sample of several small areas and use the information to estimate the population for the whole area. You can use the quadrat method for estimating plant populations.
   a. Divide into small teams, each team taking one quadrat. With a tape measure, stakes, mallet, and string, measure off a square that is one meter on each side.
   b. Take an inventory of the plants you observe inside the square. Use dichotomous keys to help you identify the plant species you observe.

Use caution with irritating or poisonous plants. Record the dominant species in your quadrat. Make a scale drawing of your part of the site. Then, **share information** with the rest of your class to create a complete list of plant species on the site, and the estimated size of these populations. One way of organizing your plant survey is shown below.

Plant Survey		
Plant Category	**Species**	**Population Size**
Tallest trees		
Understory trees		
Saplings (young trees 1–3 m tall)		
Shrubs (0.5–3 m tall)		
Tree seedlings (less than 30 cm)		
Herbaceous plants (weeds, flowers)		
Ground cover (mosses, lichens)		

5. **Animal Survey** Visit the site again and take an animal survey. If you live in the suburbs, many of the animals you find may be *opportunistic* species. These species have adapted to the suburban environment at the expense of less-frequently seen native species. Opportunistic species include crows, blue jays, mallard ducks, and Canada geese, all of which thrive at the expense of smaller songbirds. Other opportunistic mammals are squirrels, cottontail rabbits, skunks, and white-tailed deer. One way of organizing your animal survey is shown in the next column.
6. **Categorize** your local environment in terms of its dominant plant and animal species and classify your community into one of the major biomes of the world. Hypothesize how your quadrat might have been different if there were less human activity.

Animal Survey		
Animal Category	**Species**	**Population Size**
Small animals below ground (insects, worms)		
Small animals on ground and rocks (spiders, insects)		
Small animals living on plants		
Small flying insects		
Larger animals below ground (mammals like moles, chipmunks)		
Larger animals flying, nesting crawling, walking (birds, deer)		
Animals in water (insects, fish, amphibians)		

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. From the Ground Up

After completing your preliminary research, spend some time brainstorming the best way to preserve, protect, and improve the habitat you have chosen. Each of the suggestions below is suited to a particular habitat. If none of these suggestions seems appropriate for your habitat, create a plan that better suits your needs.

- If erosion is destroying an area of your habitat, make a plan to install fencing or plant groundcover to reduce erosion. This project is best-suited for areas by cliffs or along beaches. Hiking paths that go

directly uphill can also channel water and suffer greatly from erosion.

- **Build predator enclosures**, which are areas of protective fencing near the nests of threatened birds. You will need permission and the supervision of a local agency, such as the Nature Conservancy. These agencies usually accept student volunteers for projects such as these.
- **Cultivate** specific plants that attract species for feeding—for example, a butterfly garden. Or, plant a garden with only plants native to your area.
- **Preserve** an old, dead tree for woodpeckers and preserve the brushy understory level. The understory is usually full of bugs that birds such as flycatchers and swallowtails eat.
- **Build bird houses** or nesting platforms according to a design suggested by your local Audubon Society to attract birds suited to your area.
- You might wish to **improve the habitat for bats in your community**. There are 44 species of bats in the United States, and at least one of these species is adapted to where you live. Research the benefits of having bats in an area, and some of the misconceptions people have about bats.

Project 2. Meet the Press

If you are unable to do any hands-on improvements, here are some other suggestions.

- **Write a proposal** for the conservation of a site in your area. Research to find out which government agencies are responsible for funding and authorizing conservation projects. Send your proposal to the appropriate agency.
- **Publicize and participate** in environmentally related events for the community, such as a spring cleanup along a body of water or in a vacant lot.
- **Work with students from other grades** or other schools to devise an educational program that teaches respect for the environment. If possible, implement your educational program at a local school, park, or museum.

Enrichment Activities

Short on time? Extend your knowledge about ecology with these shorter challenges.

Literature Connection **Read *Silent Spring*** by Rachel Carson. This book, written in the late 1950s and early 1960s, describes the effects of insecticides and pesticides on songbird populations. The publication of this book greatly affected the way people think about the environment. After you have read the book, write a newspaper review of the book as it would have appeared in the paper at the time the book was published.

Ecotourism Travel Agent *Ecotourism* is tourism in natural areas that does not harm the environment or local people. **Gather information about ecotourism**. Then be an ecotourism travel agent. Plan a travel itinerary for a trip to a particular natural area and describe the steps you will take to make sure you don't damage the ecology of the area you are visiting. Prepare an ecotourism travel brochure or a virtual tour using PowerPoint® to present to your class.

Paper or Plastic **Research the environmental impact of paper and plastic grocery bags**. Consider the resources used to manufacture the bags, as well as the disposal of the bags. Prepare a one page report of your findings. Then, make a poster that encourages the use of reusable bags or containers for shopping.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. when you have chosen an environmental site		
2. when you have completed your plant and animal population surveys		
3. when you have selected a project		
4. when you have written up a strategy for your project		
5. when you are close to completion and want to schedule a day for sharing your project with the class		

Project 3

The Life of a Cell

BioChallenge Goal

The purpose of this project is to grow and examine the cells of living things over a period of several weeks and to observe cellular organelles and processes.

BioChallenge Projects

Project 1 Onion Cell Growth — Grow onion bulblets to observe growth and cell division in the shoot and root cells.

Project 2 No Couch Potato — Grow and examine the various cells found in a budding potato.

Project 3 Slide Show — Prepare permanent microscope slides that show the unity and diversity of living things.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research. For this project, you can work alone or with one or two partners.

1. With your class or small group, watch videos or films that show microscopic cell components, the differences between animal and plant cells, and the process of cell division.
2. Become familiar with the microscopes or stereoscopes available to you. Learn how to make wet mounts and depression slides. Find out what fixatives and stains are available for use in your class.
3. Learn how to use and care for prepared slides. Use both the low and the high power of a microscope to examine sets of prepared slides of plant and animal cells. Also examine cells undergoing mitosis, including those treated with colchicine to arrest mitosis in various stages.

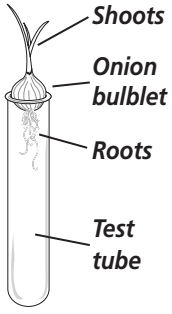
Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. Onion Cell Growth

You can marvel at the way cells divide and grow by observing the rapidly dividing cells of a growing onion.

- **Plan Your Experiment** Obtain some small onion bulblets that will fit in the tops of test tubes. Supermarket onions are sometimes treated with chemicals that prevent them from sprouting, so you may want to obtain them from a garden supply store. Balance the onion bulblets with roots inside the test tubes.



- **Set Up Your Experiment** Set up an experiment to find the best conditions for sprouts to grow from the top and for root growth to occur from the bottom of the bulblet. Accurately measure shoot and root growth and record your measurements in a data table. Draw pictures or take photographs of how the bulblets look over a period of several weeks.
- **Make Predictions** Predict which areas of the young stem and root tip have the most rapidly dividing cells. Examine and compare cells from these two regions. You may need to make very thin sections of the onion tissue and stain the cells in order to see them more clearly. Examine each kind of cell microscopically and compare its length and width. Make drawings of what you see. Compare the organelles and functions of each type of cell from the young plant. If your school has the required equipment, take pictures or videos of these cells through the microscope.
- Rapidly dividing onion root cells are often used to demonstrate mitosis. Find out how to make an onion "squash" slide and how to treat and stain the tissue to make the slide permanent. Use the slide to demonstrate mitotic division to your class.
- From what you have learned about growing onion cells in your classroom, **write a proposal** for growing onion bulblets on the space station. Your proposal should include two questions about onion cell growth that could be studied in space.

Project 2. No Couch Potato

What is a potato before it becomes an order of french fries? A humble potato can be a great teacher. Potatoes can be used to study cell processes.

- **Plan Your Experiment** Obtain a variety of white potatoes from grocery stores or farm stands. Sometimes potatoes are treated so they will not develop buds, or "eyes." **Label and record** the kinds of potatoes you have obtained and place them on a shelf at room temperature. Periodically check the potatoes for developing buds. If none develop a bud within three weeks, try some different varieties of potatoes.
- **Set Up Your Experiment** While you await the formation of buds, set up a variety of experiments to observe what happens to potato cells when immersed in different solutions. Cut up slices of potatoes. **Prepare solutions** that will demonstrate diffusion and the changes to the cell that result from diffusion. Be able to explain what is happening across the cell membrane when the potato slice is placed in hypotonic, hypertonic, and isotonic solutions. Draw pictures of the cells and use arrows to show movement of molecules for each demonstration.
- **Record Your Observations** When you can observe a sprouting potato, look at the different kinds of cells growing within the sprout. Cut a thin section and examine cells under the microscope. Compare cells in the young leaves with the growing cells in the stem. **Compare and contrast** the organelles found in these cells. What makes these cells different from one another and different from the cells in the potato itself?
- The potato itself is a form of plant stem called a tuber. **Examine cells** from the potato. What structures do these cells lack? Make drawings of the starch granules of these cells. How can you stain them to be more visible?

Project 3. Slide Show

You can teach others what you know by making a set of permanent microscope slides that demonstrate some of the important components and processes associated with cells.

- In the 1700s, Anton van Leeuwenhoek saw tiny one-celled organisms moving around in a drop of rain water. He told his daughter Maria that these "little beasties" swam and played around like eels. Do some research to find out more about van Leeuwenhoek and some of the cells he saw with the small hand-held microscope he made.
- **Create Your Own Slides** Make wet mounts of some of the ordinary things you see around you, such as leaves, insect parts, dust, and animal hair. Train your eye to know the difference between a part of a cell and pieces of fiber and debris that find their way onto your slides. Make clear drawings of what you see. Use good paper and a sharp 4H pencil. Always record the date, the name of the specimen, and the magnification on your drawings.
- As you get more adept at making wet mounts, carefully use a razor to cut thin slices of plant parts, such as a herbaceous stem or root. Make a wet mount of a cross section.
- **Collect Organisms** If you live near a pond, use a net to obtain frog eggs, algae, insect larvae, and small plants like duckweed. Do a comparative study of the organelles present in the cells of these different organisms. Go collecting in a wooded area and compare the tiny spores of mold and mushrooms.
- **Investigate staining procedures** that will allow you to see the organelles of various cells. For example, some stains make the nucleus more visible because the stain bonds to the chromosomes in the nucleus. Learn some of the methods to make slides permanent, that is, to fix the cells onto the slide so they will not come off or decay and thus can be viewed for many years to come.
- Observe and compare the surface area-to-volume ratio of the cells you have studied.
- **Find Electron Micrographs** Do some research to find electron micrographs of similar cells and make copies of the micrographs. Compare your drawings to the micrographs for details and scale.
- When you have completed your project, you should have enough permanent slides to demonstrate some of the most important cell components and a portfolio of your drawings and micrographs.

Enrichment Activities

Short on time? Extend your knowledge about cells with these shorter challenges.

History of Microscopy Prepare a time line that shows the history of the microscope. Use text and pictures to illustrate the development of the microscope.

Cell Game Use your knowledge of cells and organelles to create a board game. The theme of the game should be cell structures and processes. Construct the game and prepare detailed written instructions. Play the game with your classmates to test their knowledge of cells.

Cell Art Use classroom microscopes to view cells at various magnifications. Create a painting of a cell or organelle as viewed under a microscope.

Write a Lesson Plan Imagine that you have been asked to teach a sixth grade class some of the basic facts about cells, organelles, and cellular processes. What interesting methods could you use to effectively teach younger students about cells? Write a detailed lesson plan explaining what you would teach and what teaching methods you would use.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after you decide which project you are undertaking (Get approval before proceeding.)		
2. when you have begun gathering the materials you will need for your project (Your teacher may be able to get some materials for you and assist you with microscope technique.)		
3. for Projects 1 and 2: when you have a written plan for the experiments related to these projects		
4. when you are close to completion and want to schedule a day to share your project with the class		

Project 4

Genetics: The Secret of Life

BioChallenge Goal

The purpose of this project is to thoroughly examine one aspect of genetics.

BioChallenge Projects

Project 1 Culturing Fruit Flies — Breed fruit flies for several generations.

Project 2 Creating A Genetic Model — Create a model to simulate inheritance.

Project 3 Opinion Survey — Survey attitudes about current issues.

Project 4 Channel DNA TV — Produce an informational program about modern genetics.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. Form a cooperative group with several of your classmates who have similar interests. Brainstorm possible topics and resources for your project.
2. Check newspapers each day for at least a week, particularly if the newspaper has a science section. Cut out (or copy) and read any articles that pertain to genetics. Make a list of genetics topics that are in the news.
3. Visit the library. Use a biographical dictionary to read about leading figures in the history of genetics, such as Gregor Mendel, Hugo De Vries, Thomas H. Morgan, James Watson, and Craig Venter. Find books written by scientists for general audiences that explain chromosomes, genes, and DNA. If your library has a current magazine database, use it to conduct a search for articles on genetics.
4. If your group is considering an experiment with fruit flies, research the equipment required for culturing fruit flies. List the equipment you will need, and check with your teacher about the availability of this equipment.
5. After you have written down at least five possible topics and resources, have an informal discussion with your group about the topics that are on your lists and the projects you are considering.

Design Your BioChallenge

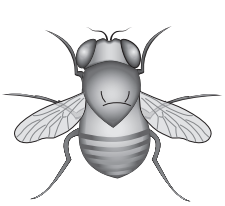
After your preliminary research, choose one of the following long-term projects to complete.

Project 1. Culturing Fruit Flies

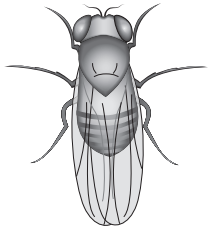
Since the early part of the twentieth century when T. H. Morgan and his students at Columbia University experimented in their lab, which was known as the "fly room," fruit flies have been used in the study of genetics. For this project, you will need to breed a population of fruit flies (*Drosophila*) over a twelve-week period.

- **Research Fruit Flies** Do research to find out why fruit flies are interesting and useful organisms for genetics research. Find out which traits and mutations are most commonly studied in fruit flies.

- **Design Your Experiment** Design an experiment to cross different varieties of fruit flies. Your goal will be to breed fruit flies that maintain particular traits after several generations.
- Once your project has been approved, your teacher can help order the varieties of fruit flies that you need. These might include red-eyed wild type, mutants with white eyes, and mutants with vestigial wings. You will also need culture bottles or vials, an anesthetizer, culture medium with mold inhibitor, a camel's hair brush for sorting, and a place to keep the fruit flies safely.



Vestigial wings



Red-eyed wild type

- **Log Your Progress** Learn to examine fruit flies to distinguish males from females and to identify the presence of each trait. Carefully label every container of fruit flies with the sex, trait, cross, date, and generation. Once your project is underway, be sure to keep careful logs of every cross.
- **Present Your Research** Continue your breeding experiment for as many generations as needed to produce offspring that are true breeding for the desired traits. Think about ways to display your procedures and conclusions graphically.

Project 2. Creating a Genetic Model

If you are interested in the outcome of genetic crosses but cannot carry out a *Drosophila* breeding experiment, you can explore population genetics in one of the following ways:

- **Become an Expert** Find and use computer software to simulate crosses in a population. Become an expert in this software and show your expertise in a concrete form that can be shared with your classmates.
- **Create Your Own Model** Make your own model of genetic crosses using different materials, such as dried beans or multicolored game pieces, as symbols. Use the symbols to represent plants and animals with particular characteristics and show how dominant and recessive traits are inherited over several generations. Display these genetic crosses in some meaningful way so you can show your classmates what you have done. Come up with your own ideas for using this technique or choose one of these ideas: simulate Mendel's experiments with pea plants, show fur color inheritance in mammals, or show inheritance of traits in a plant that has agricultural significance in your part of the country. Additional research may be required to find out the inheritance pattern for the trait.
- Make a model for human inheritance of blood type or a genetic disorder such as sickle-cell anemia or cystic fibrosis. **Use statistics, graphs, and pedigrees** in your model. If you are researching a genetic disorder, find out if the gene that causes the disorder has been mapped to a particular chromosome. Include this information in your presentation.

Project 3. Opinion Survey

For this project, you will identify some of the important social and ethical issues that surround the field of genetics and survey people's attitudes toward these issues.

- **Check Out the Issues** Use a number of sources, such as current books, magazines, and newspapers, to prepare a list of current social issues related to developments in the field of genetics. These may include issues such as cloning and genetically modified agricultural crops.

- **Create Your Questionnaire** Use these issues to write a clear and carefully structured questionnaire. Phrase your questions so that people can respond to them with *yes* or *no* answers. Include respondent profile questions such as age, occupation, education, and other variables you think are appropriate. Make sure your teacher approves your questionnaire, and then print out enough copies so that you can conduct a survey.
- **Conduct Your Survey** Survey people in your community, making sure that you include people of different ages, sexes, and professions. Interview some people for a more direct discussion of the issues.
- **Graph Your Results** Graph all of the responses according to issues and other variables, such as age and education. **Assess trends in the data**, and present your findings in the form of a report.

Project 4. Genetics Update: Channel DNA TV
For this project, you will collect information about advances in modern genetics and use it to produce an informative and entertaining news program.

- **Know the Issues** Create a file of current issues in genetics. **Use reliable sources** to obtain in-depth background material about each of the issues. If another group of students has chosen to conduct an opinion survey for their project, ask if you can incorporate some of their results into your program.
- **Prepare a Script** With your group, prepare a cohesive script that could be used for a television program in a news-magazine style. Some group members can do behind-the-scenes work such as producing graphics, models, and other visual aids, or running the video equipment. Other group members should serve as reporters.
- **Produce Your News Program** When you have enough information to fill an interesting and informative half hour, present the program to your classmates or entire school. If you have facilities available, make a videotape of your program to share with others outside your school.

Enrichment Activities

Short on time? Extend your knowledge about genetics with these shorter challenges.

Selective Breeding Selective breeding has been used for centuries to improve agricultural crops and livestock. **Research** selective breeding, and prepare a report that compares and contrasts selective breeding with the modification of crops and livestock using genetic engineering in a lab.

Letter Writing Write a letter to Gregor Mendel explaining in detail one of the advances that has occurred in the field of genetics since the time of his pioneering experiments.

For Further Study Contact several colleges and universities. Find out if they offer coursework or majors in biotechnology, genetics, human medical genetics, or plant genetics. Share your findings with your class.

A Day in the Life Contact a researcher who is involved with some aspect of genetics. Interview the researcher to find out what a typical day of research involves. **Present your findings** in the form of a report.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after you choose a long-term project (Get approval before proceeding.)		
2. when you have begun research (Your teacher may be able to provide resources.)		
3. after you have completed your research		
4. when you have written a strategy for carrying out your project		
5. when you are close to completion and want to schedule a day for presenting your group's project to the class		

Project 5

History and Classification of Life

BioChallenge Goal

The purpose of these projects is to gain a deeper understanding of the history of life on Earth, the methods used by scientists to do research in this field, and the classification of living things.

BioChallenge Projects

Project 1 A Guide to Index Fossils — Make a guide to some of the index fossils used by scientists for relative dating.

Project 2 Homologous Structures Model — Create a model of homologous structures found in organisms.

Project 3 A Great Debate — Debate the usefulness of the six-kingdom system of classification versus the three-domain system of classification.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. **Form a research team** with several classmates. Discuss areas of interest and possible research topics with your research team.
2. **Visit a Natural History Museum** Study the displays that show fossils and the history of life on Earth. Invite the museum curator to give an in-depth presentation to your class, either at the museum or in your classroom. Check to see if there are amateur fossil collectors in your area who would be willing to share their collections with your class.
3. Find books and articles about the history and classification of life. **Make a list of resources** available at your library so that when you choose a long-term project you will have a good idea of the resources available to you.
4. **Find several documentary videos** that show paleontologists at work. View the videos with your research team or as a class. Use the library to find up-to-date resources describing some of the latest findings in the field of paleontology.

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. A Guide to Index Fossils

Scientists use index fossils in the process of relative dating. In this project you will prepare a guide to index fossils commonly used by scientists.

- Thoroughly **research** the use of index fossils and relative dating in the field of paleontology. With your research team, gather information about as many index fossils as possible.
- **Review the Findings** Make sure you have information about at least one index fossil from each period in the Paleozoic, Mesozoic, and Cenozoic Eras. Fill in a table like the one on the next page as you work.
- **Prepare the Guide** For each type of fossil, provide a written description of the time period and location with which it is associated. You should also provide a picture of the fossil.

History and Classification of Life, *continued*

- Your guide should **provide a thorough explanation of the use of index fossils**. Include written material and diagrams.
- If you can obtain actual fossil examples of any of the index fossils in your guide, **set them up as a display in your classroom**. Make sure the fossils are labeled with the organism name and the time period with which they are associated.

Era	Period	Index Fossils
Cenozoic	Quaternary	
	Testiary	
Mesozoic	Cretaceous	
	Jurassic	
	Triassic	
Paleozoic	Permian	
	Carboniferous	
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	

Project 2. Homologous Structures Model

In this project, you will learn about homologous, analogous, and vestigial structures and make a model of homologous structures. These structures often give scientists information about change through time and the evolutionary relationship between species.

- **Plan Your Research** Thoroughly research homologous, analogous, and vestigial structures. Develop an understanding of what can be learned about evolution and change through time by studying and comparing the structures found in different organisms.
- **Study the Structure of Organisms** Find an example of structures from two different organisms that are considered homologous. Thoroughly research the structures.
- **Present Your Research** **Create a model** of these two structures. Possible materials for making the models include plaster of Paris or papier-mâché.
- Accurately **label** your models.
- **Prepare a short written explanation** of homologous structures that can be posted where your model is displayed.
- **Write and present** to your class a complete discussion of homologous, analogous, and vestigial structures. Use examples throughout your presentation. Use your models as a visual aid in your presentation.
- Create a multimedia presentation to present your project.

Project 3. A Great Debate

Plan Your Research

This is a team project. Learn debate skills, and then apply the skills you learn to a debate about classification methods.

- **Get Ready to Debate** Study the skills used in debate. If your school or a local college has a debate team, invite the debate coach to speak with your research team. View videos that demonstrate debating skills. Visit the library to find books and other resources that teach debate skills.
- Divide your research team into two groups—one that will **debate** in favor of the six-kingdom system of classification, and the other to debate in favor of the three-domain system of classification.
- **Research both classification methods**. Become familiar with the advantages and disadvantages of each method. Be prepared to quote different scientists' opinions during the debate.
- **Present Your Research** When you have finished your research and prepared your debate, set a time to debate in front of the class.
- Hold your debate. Follow up with class discussion of methods used to classify living things. Answer questions your classmates may have about classification systems.

Enrichment Activities

Short on time? Extend your knowledge about the history and classification of life with these shorter challenges.

Relative Dating Model **Construct a model** of rock layers using any available materials. Label some of the layers in your model with ages. Then, challenge other students to use the principles of relative dating to assign possible ages to the unlabeled layers.

PowerPoint® Presentation Design a PowerPoint® presentation that gives information about the six kingdoms used to classify living organisms. The presentation should give information about the characteristics of organisms in each kingdom, and should list several representative organisms in each kingdom.

Who Owns the Fossils? Use current resources to research the sale of rare and important fossils. Should fossils be made available to scientists free of charge? Should universities and museums have to compete with wealthy collectors for specimens? In what parts of the world is illegal trade in fossils a problem? Thoroughly research this issue, using resources that express different viewpoints. Prepare a position paper that clearly states your opinion on this issue.

Fossil Photos Use creative photography methods to create a set of photos of fossils. If the equipment is available, use lighting, various lenses, or computer manipulation to create interesting and diverse images. If possible, enlarge, mat, and frame your photos. Set up a gallery in your classroom. Consider the arrangement of photos in your display.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after you have decided which project you are undertaking (Get approval before proceeding.)		
2. when you begin research (Your teacher may be able to provide resources or guide you in the right direction.)		
3. after you have completed your research		
4. when you have a written strategy for carrying out your long-term project		
5. when you are close to completion and want to schedule a day for presenting your group's project to the class		

Project 6

Viruses, Bacteria, Protists, and Fungi

BioChallenge Goal

The purpose of this project is to learn more about protists and fungi by preparing a display, planning and carrying out an experiment, or learning about the role of fungus in the foods we eat.

BioChallenge Projects

Project 1 Protist Zoo — organize a protist zoo.

Project 2 Yeast Metabolism and Population Growth — study yeast metabolism and population growth.

Project 3 Good Enough to Eat — prepare a cookbook of foods prepared using fungi.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. **Form a research team** with several classmates. Find reference materials suitable for general research; you can use many of these materials throughout your project.
2. **Invite a guest speaker** who is knowledgeable about protists or fungi to speak to your class. You may find an expert at a local college or university, medical facility, or research institute. Do background research on the speaker's topic, and prepare questions for the speaker in advance.
3. Study the project options with your team. **Choose a project** and begin your in-depth research.

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. Protist Zoo

In this activity you will **prepare a protist zoo**—an exhibit that will contain as many protists (either actual organisms or pictures) as possible. As the zookeeper you must become knowledgeable about the foods and environments needed by the organisms in your zoo.

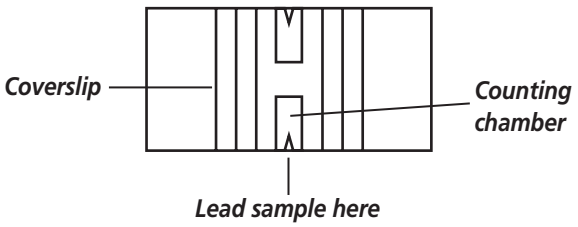
- **Locate References** With your research group, **find reference materials** about protists. The protist kingdom is the most diverse of the kingdoms. Find out which organisms are classified as protists, and why.
- **Determine** which living organisms you will have in your zoo. There are some protists that can be collected from freshwater or marine environments. Others, such as *Euglena* and *Paramecium*, are available as cultures from biological supply companies. Make a list of protists that are harmful to humans. Plan to use pictures or models of these protists in your zoo.
- **Collect Protists for Your Zoo** Begin the process of obtaining living protists for your zoo. For each living organism you plan to maintain, prepare a list of needed supplies. Review the list with your teacher. If you will be collecting protists from a marine or freshwater environment, review your plans with your teacher.

- **Design Your Zoo** With your teacher, determine the space and supplies you will have to work with. Think about the best way to organize the organisms in your zoo. Remember that you will need microscopes to view and display many of the organisms.
- **Prepare** any pictures and models you will use in place of living organisms in your zoo.
- At each display in your zoo, **provide the species name**, the common name, and as much information as possible about the organism.
- **Invite other classes** to the zoo. Be prepared to give a guided tour and to answer questions about the protists in your zoo.

Project 2. Yeast Metabolism and Population Growth

Yeast is a unicellular fungus that is relatively easy to maintain in the lab. In this activity, you will grow a yeast population, graph the population growth, and design your own experiment using yeast.

- **References** With your research group, find reference materials you can use in your study of yeast. **Review the procedure** for maintaining a yeast culture in the lab. Make a list of supplies you will need, and review the list with your teacher. Be certain you understand yeast metabolism and reproduction. Prepare a written plan of the steps needed to maintain a yeast culture for a period of at least two weeks.
- **Prepare a Yeast Culture** When you are ready to begin, prepare a yeast culture in a flask. Use distilled water, sugar or molasses, and dry yeast. Keep the yeast culture warm (about 25°C), but out of direct sunlight.
- **Calculate Cell Density** One hour after you start your culture you should make an initial **calculation of cell density**. Swirl the flask containing the culture, remove 0.1 mL, and count the number of cells by using a cell-counting chamber like the one shown. Multiply to find the total number of yeast in the flask. Check the population every day for two weeks. Before removing your sample, add distilled water to replace any water that has evaporated, and swirl the flask to distribute the yeast. You may need to use dilutions of your culture in order to count the density.



- **Graph Your Results** Graph the yeast population. Using the information you gathered during background research, compile a list of factors that might affect yeast population growth.
- **Design Your Own Experiment** Design an experiment using yeast. Remember that an experiment begins with a hypothesis. Make sure that your experiment includes controls. Review your plans with your teacher before you begin. Make a list of the supplies you will need to carry out your experiment, and review this list with your teacher.
- **Complete Your Experiment** Carry out your experiment. Prepare a written report that includes your procedure and results. Use graphs or charts to display your data. Present your findings to the class.

Project 3. Good Enough to Eat

Fungi are used in the preparation of many of the foods we eat. In this project, you will collect recipes of foods that contain fungi, and use the recipes to create a cookbook. You can also prepare several of the foods for your class to sample.

- **Research Recipes** With your research group, find background information on foods that are prepared using fungi. Remember that edible mushrooms and yeast are both fungi. Research recipes from cultures other than your own to expand your list of foods.
- Begin to collect recipes for foods that contain fungi in any form. Use cookbooks and other reference books to find the recipes.
- **Create Your Own Cookbook** Ask your family and the families of other students to provide recipes for your collection.
- **Assemble the recipes** into a collection. Remember that published recipes may be protected by copyright laws.
- **Prepare a Fungus Buffet** With your teacher's permission, **prepare a fungus buffet** using some of the recipes from your collection. Have a tasting party with your class. SAFETY NOTE: Food preparation and consumption should take place in the school kitchen or other approved site. Never cook or eat anything in the science classroom or laboratory. If you prepare foods using mushrooms for your buffet use only mushrooms purchased at a grocery store. DO NOT collect mushrooms from the wild for food use.

Enrichment Activities

Short on time? Extend your knowledge about viruses, bacteria, protists, and fungi with these shorter challenges.

Make a Model Research the structure of one type of unicellular protist or bacterium. Make a detailed, labeled, three-dimensional model of the organism. Prepare a short written report that can be posted near your model. Your report should include the scientific and common names of the organism, the actual size of the organism, and an explanation of the function of each of the structures labeled on the model.

Interview a Medical Professional Interview the school nurse or another local medical professional who works with school-age patients. **Gather information** on the most common bacterial and viral illnesses occurring in the students in your school or community. After you have identified three common illnesses, do background research on the treatment and prevention of the diseases, and the organisms that cause these diseases. Write a report to share with your class. Prepare a poster that shows one way to prevent the spread of common illnesses (for example, hand washing).

Bacteria on Mars? Use up-to-date, reliable reference materials to investigate reports of bacteria on Mars. After you have gathered your information, **prepare a multimedia presentation** to present to your class.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. when you choose or are assigned to a research team		
2. when you have begun your research (Your teacher may be able to provide resource materials.)		
3. after you have completed your research and decided on a long-term project		
4. when you have begun working on your long-term project		
5. when you are close to completion and want to schedule a day for sharing your project with the class		

Project 7 Plants

BioChallenge Goal

The purpose of this project is to research, plan, and grow a specific type of garden.

BioChallenge Projects

Project 1 Wildlife Garden — Design and plant a variety garden (wildlife, edible, art) for an outdoor site.

Project 2 Grow Your Own Lunch — Design and plant a mini-garden suitable for a rooftop or windowsill.

Project 3 Experimental Corn Garden — Design and plant for an outdoor site.

Project 4 Art Garden — Design and plant for an outdoor site.

Project 5 Grow A Mini-Garden — Design and plant a mini-garden suitable for a rooftop or windowsill.

Project 6 Dish Garden — Design and plant a dish garden.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. Send for seed catalogs or seedlings. Ask your teacher for the addresses of seed suppliers.
2. Visit your library to research garden plants. After you have chosen a long-term project, return to the library to find references specific to your project.
3. If you are considering planting a garden on school property, contact school officials to obtain permission.
4. Read and discuss the options for long-term projects. Divide into research teams based on your area of interest.

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. Wildlife Garden

In this activity, you will plan and plant a garden designed to attract a specific type of wildlife.

- **Research Your Area** Research types of plants that are suited to your area and attract certain types of wildlife, for example butterflies, birds, or bats.
- **Design Your Wildlife Garden** Examine wildflower seed mixtures that are marketed as butterfly or bird gardens. Determine what kinds of seeds are in the mixtures and if these plants are suited to your area of the country.
- Draw a design that shows how the garden might look after the plants bloom.
- **Record Your Data** Fill out a data table, like the one shown on the next page, for all of the seeds you plant.
- **Plant Your Garden** Create a maintenance schedule for the garden. Observe the garden to see if it attracts the intended wildlife. If so, keep records of the wildlife seen in the garden.

Plant Requirements	
Plant name	
Type of propagation: seeds, bulb, cutting	
Source of seeds: bulbs or cutting	
Number of days needed for germination, cuttings to be transplanted, or bulbs to show growth	
Number of days until desired bloom of fruit	
Light requirements	
Type of soil	
Watering schedule	
Type of fertilizer needed (if any)	

Project 2. Grow Your Own Lunch

In this activity, you will plan and grow a garden that you can eat.

- **Plan Your Garden** Choose a menu for your garden, or create your own.

  Possible menus:
  Salad garden: Choose salad vegetable plants that are suited for your climate. For your final presentation, make a salad.

  Pizza garden: Plant vegetables and herbs used on pizza, such as tomatoes, onions, garlic, basil, and oregano. Make a pizza for your final presentation.
- For the garden option that you have chosen, order more than one variety of each seed and compare the growth of each variety.
- Complete a table similar to the table shown for Project 1.
- On a large sheet of paper, draw a plan for your garden. On the plan, write down the date that you will plant each variety of plant. To harvest all your ingredients at the same time, you may need to plant the seeds at different times.
- **Plant Your Garden** Plant your garden and maintain it through harvest time.

Project 3. Experimental Corn Garden

In this project, you will compare several varieties of corn, including new, hybrid strains and traditional native corn.

- **Collect Information on Corn Varieties** Do research on the availability of different kinds of seed corn used by growers.
- **Survey Growers** Survey local corn growers to hear their opinion on the advantages and disadvantages of new corn varieties.
- **Design Your Garden** Order several varieties of seed corn. Design an experiment to grow and compare corn varieties. Plant the garden.
- **Compare the Varieties** Compare the varieties for vigor, size, growth rate, and so on. Keep data on your results.

Project 4. Art Garden

In this activity you will plan and design a garden that will form a mosaic design or other design.

- **Design and Plan Your Garden** Make a plan for a garden that will be a work of art when finished. You might design a garden that will mimic a piece of modern art or make a mosaic or stained glass design.

- Plan your garden using plants that will grow in your climate and produce the colors you desire.
- **Plant Your Garden** Plant and maintain your garden to create your desired image.
- **Photograph Your Garden** Take a series of photographs that will document your art garden as it grows and blooms.

Project 5. Grow a Mini-Garden

If space for a full-sized garden is not available at your school, you may choose to grow a mini-garden.

- **Do Your Research** Find plant varieties that will thrive in a small space. You can grow a mini-salad garden using dwarf varieties of plants such as tomatoes.
- **Plant Your Garden** Evaluate the space you have chosen for your mini-garden. You might need to supply additional light for the plants to flower.
- **Create a Strategy for Observation** Write a strategy for observing the ratio of stem height to fruit size in dwarf plants. Compare these observations to full-size varieties of the same plants.

Project 6. Dish Garden

In this project, you will grow a garden in a dish. Two suggestions for dish gardens are described below.

Forcing Bulbs

- *Forced Bulbs* You can force bulbs to grow in a dish before the time they would normally send out shoots in the spring. Use bulbs such as daffodils, narcissus, hyacinth, and tulips. Order the bulbs or purchase them at a local garden center. **Research the procedures** for forcing early growth in such plants. Usually bulbs are forced in a dish that is watered on a schedule. Design an experiment to determine the optimal amount of water and light for forcing bulbs.

Design a Cactus Garden

- *Cactus Garden* Miniature cacti that are the correct size for dish gardens can be found at nurseries. Include species such as barrel cactus, prickly pear, and yucca. Design a strategy for **observing the adaptations** that cacti have developed to conserve water.

Enrichment Activities

Short on time? Extend your knowledge about plants with these shorter challenges.

Invading Plants Plants that have been introduced to a new environment can sometimes crowd out native species and threaten entire ecosystems. Research *invasive* plant species, particularly those that are causing problems in the area in which you live. Prepare a field guide to invasive plant species in your area.

Literature Connection Ask your teacher or librarian to help you find poems written about trees or flowers. After you have read these poems, write a poem about plants. Share your poem with your class.

Heirloom Plants Research the growing popularity of gardening with heirloom flowers, fruits, and vegetables—plants that were grown one hundred or more years ago. Many of the plants grown today are hybrids, or plants that have been genetically altered to withstand disease or produce bigger fruit. In a report, discuss available heirloom plants and what makes them attractive to gardeners.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after you decide on a project (Get approval before proceeding.)		
2. after you have drawn up a detailed list of the site requirements and all the materials and supplies that you will need		
3. when you have completed the table including each of the plants you plan to grow		
4. when you obtain the materials and supplies you need		
5. when you begin planting		
6. when you have planned a method and schedule for monitoring the progress of your garden		
7. when you are almost ready to harvest or display your garden and want to schedule a day for presenting your project to the class		

Project 8 Invertebrates

BioChallenge Goal

The purpose of this project is to set up a saltwater aquarium to study various invertebrates, the environmental conditions to which they are adapted, and their interactions.

BioChallenge Projects

Project 1 Make a Key to Invertebrates — Make a dichotomous key for the organisms in a saltwater aquarium.

Project 2 Study Interactions — Design an investigation to show the relationship between two animals in a saltwater aquarium.

Project 3 Design a Coral Reef — Research and design a small coral reef.

Project 4 Set Up a Temperate Tank — Set up a saltwater tank to exhibit local saltwater species.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. **Gather Equipment** The initial phase of this long-term project will be to acquire the equipment and supplies necessary to set up and maintain a saltwater aquarium. Your teacher may be able to provide some basic equipment, but you will probably need additional aquarium supplies, as well as specimens to set up a tank for marine invertebrates.

   It may take several weeks to get a marine tank up and running. There are many jobs to do beforehand. Your class can **divide into research teams** to accomplish the preliminary work and the long-term projects.

2. Visit a large saltwater aquarium to gather information and report back to your class. A marine aquarium may be as faraway as a coastal city or as close as your local aquarium supply store. Pick up any available literature about setting up your own saltwater tank.

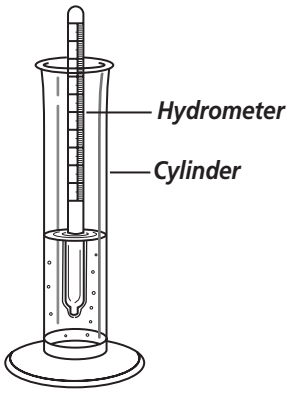
3. **Talk to an Expert** Invite a speaker to visit your school—either a professional marine biologist or a local hobbyist with experience maintaining a saltwater aquarium. To find a guest speaker, contact a local zoo or aquarium supply store. It is also possible that a teacher in your building has experience with saltwater tanks and would speak to your class. You might also watch a video on setting up a marine aquarium.

4. Make a list of supplies that are available, and a list of the supplies you will need. Use catalogs to determine the cost of needed supplies. Use the following list as a guide:

   Supplies for a saltwater tank

   - glass or other nonmetallic tank with at least 80-L capacity
   - sturdy stand for the tank
   - filtration system
   - air pump and tubing with plastic valves (metal corrodes in salt water)
   - marine gravel with a 2 to 5 mm particle size (dolomite is recommended because it not only acts as a filter, but is a chemical buffer that helps maintain the desired alkaline pH)
   - heater and thermometer
   - sea salt

- hydrometer for monitoring salinity (floating-bulb type or one with a pointer indicator)
- specimens: possible specimens include sea anemones, coral, mollusks, shrimp, crabs, and other marine invertebrates; fish such as a clown fish or damsel fish
- optional items such as lighting, protein skimmers, test kits, additional trace elements to add to water



5. **Get Community Support** Write letters to enlist community or parent support for your project. Businesses, such as aquarium supply stores, may donate equipment for your project.
6. Find or build a stand for the tank. Make sure it will withstand the weight of the tank. Choose the proper location for the tank. It should not be in direct sunlight.
7. **Maintain Water Quality** Prepare a duty roster for the maintenance of your saltwater tank. Monitoring and maintaining the water quality of a saltwater tank can be a big job.

   Some team members will need to become experts on the amount of salt needed for the tank. Usually synthetic salts are used because they are more predictable and do not introduce contamination into the tank. The salinity level must be periodically monitored **using a hydrometer**. Find out what that means, and how to use a hydrometer. Other students on the team can monitor the temperature of the water. This involves periodically checking the thermometer and making sure the heater is set correctly. Tropical specimens usually need the temperature to be between 22°C and 26°C. Some team members will need to maintain the pump and filtration system. Be aware of corrosion and other problems with the pump.
8. Add one or two inexpensive specimens, such as crabs or damsel fish, after the tank has been set up for several days. Once the water is stabilized, other living things may be added gradually. Be sure to **consult reliable resources** to ascertain the rate at which specimens may be safely added. Rock containing coral and other microscopic life brings its own chemistry. The fish help balance the chemistry of the aquarium by providing ammonia from their waste products. The ammonia is broken down by bacteria. These bacteria can be purchased from the store, or they can be added by using gravel or rock from a well-established aquarium. The invertebrates, such as shrimp and clams, are usually scavengers that eat the detritus from the tank.
9. **Be Menu Planners** Some students should monitor the food chains that exist in the tank. They should find out what each of the organisms needs to eat. Then a menu and feeding schedule for the tank can be developed. Invertebrates usually need to be fed only once a week.

Design Your BioChallenge

After your preliminary research is complete and your tank is up and running, choose one of the following long-term projects to complete.

Project 1. Make a Key to Invertebrates

- **Classify Organisms** Make a dichotomous key of all the invertebrate organisms in the tank so that everyone who looks at the tank can identify each organism. Include a description of the classification and characteristics of each organism. Make copies of the key for distribution. Invite students from other grades to observe the tank and learn about the organisms in it.

Project 2. Study Interactions

- **Observe Relationships in Your Tank** Find relationships among the organisms in your tank. For example, sabae clown fish interact with long-tentacle sea anemones.

The anemones' stinging tentacles release a toxin when a fish approaches. A young clown fish heading for the anemones for the first time is stung and quickly swims away. Then the clown fish produces an antitoxin in the form of a protective slime. The next time, the clown fish can weave through the tentacles of the anemones without being harmed. In some cases the fish actually help to feed the anemones.

Design a way to observe this interaction. Do research on the specific organisms you have chosen to observe. Write a report describing the organisms and their interactions, and present your findings to your class.

Project 3. Design a Coral Reef

- **Research Coral Reefs** Set up another tank as a mini-reef. Research corals that form coral reefs in natural habitats, then find out which corals are available to you for your mini-reef. Determine the requirements for keeping coral in a saltwater tank.
- **Set Up Your Coral Reef** After you have successfully established and maintained a mini-reef in your tank, write an instructional pamphlet that could be used by other classes interested in establishing a reef tank.

Project 4. Set Up a Temperate Tank

- **Collect Local Species** If you live along the Atlantic or Pacific coasts, set up a separate saltwater tank to exhibit some the invertebrate species that are native to your area. Research the proper conditions for your tank. After your tank is set up, contact your local or state Fish and Wildlife Department to determine where you can collect local species. You will be informed if there are threatened or endangered species in your area that must not be collected or disturbed.
- **Establish Your Tank** Once you have collected species and your tank is established, make a display that includes the tank and information about each local species. Allow students from other classes to view your tank, and be prepared to answer their questions.

Enrichment Activities

Short on time? Extend your knowledge about invertebrates with these shorter challenges.

Artificial Reefs Research reefs that are intentionally created using a fabricated object such as a ship. Prepare a report for your class that describes the purposes of artificial reefs and the processes by which they are made. A large portion of your report should describe the marine invertebrates found on artificial reefs, and the effect artificial reefs have on the marine ecosystems in which they are found.

Introduced Invertebrates An introduced species is a species moved by humans (either intentionally or accidentally) into a new ecosystem. Examples of invertebrates that have been introduced into ecosystems in the United States are the boll weevil, the Eurasian zebra mussel, and the Formosan termite. Research one of these species or another invertebrate that has been introduced to a new ecosystem. Give an oral report that thoroughly describes the invertebrate and its impact on the ecosystem to which it was introduced.

What's For Dinner? Create dinner menus for one week. Each menu must include at least one invertebrate or a food produced by an invertebrate. Prepare copies of your menus for your classmates.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after the list of required equipment is made		
2. after the duty roster for tank maintenance is made		
3. when you have written up a plan for your individual or team project		
4. when you have completed the required background research for your individual or team project		
5. when you are close to completion and want to schedule a day for sharing your project with your class		

Project 9 Vertebrates

BioChallenge Goal

The goal of these projects is to gain an in-depth understanding of amphibians.

BioChallenge Projects

Project 1 Have a Heart — Compare 2-, 3-, and 4-chambered hearts and build models of each.

Project 2 Declining Amphibian Populations — Research the declining populations of amphibians.

Project 3 Amphibians as Pets —Research amphibians that can be kept as pets and prepare a pamphlet for pet owners.

Project 4 Amphibian Habitats — Explore habitats of amphibians, track populations, and prepare a field guide to local amphibians.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. **Visit your library** to find background information about amphibians. Prepare a list of available references that you can use when you choose a long-term project.
2. Look at the BioChallenge project ideas. **Divide into research groups** according to your area of interest.
3. Invite a guest speaker who is knowledgeable about amphibians to come to your class. This could be a veterinarian, park ranger, zoologist, or pet store owner.
4. Help your teacher arrange a field trip to a zoo or museum where there are amphibians or exhibits relating to amphibians. Arrange a talk with the zookeeper or museum curator. Ask about the care and keeping of the amphibians as well as any ongoing research involving amphibians.

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. Have a Heart

In this activity, you will research and build models of 2-, 3-, and 4-chambered hearts.

- **Compare and Contrast** Adult frogs have three-chambered hearts. Tadpoles, like fishes, have two-chambered hearts. Humans, like most mammals and birds, have four-chambered hearts. **Find background information** on each type of heart. Be certain that you find diagrams of each type of heart and information about the circulation patterns in each. Fill in the table on the next page as you do your research.
- **Create a Detailed Diagram** After you have obtained your reference materials, **draw** a detailed diagram of each type of heart. Review your drawings with your teacher. Be certain that you can explain the path of blood in each type of heart.

Number of Heart Chambers	Number of Atria	Number of Ventricles	Found in what organisms?

- After your teacher has reviewed your drawings, begin planning your three-dimensional model of each heart. Consider the materials you have available while planning your model.
- **Construct Your Models** **Label** your models and use arrows, colors, or some other indicator to show the path of blood through the heart.
- **Present Your Research** Present a report to your class. **Use your models** as visual aids during your presentation.

Project 2. Declining Amphibian Populations

The population size of many species of amphibians is rapidly shrinking. In this project, you will explore threats to amphibian populations around the world.

- **Reference Current Information** Use up-to-date reference materials to find out about amphibian populations. Gather as much information as possible for your background research.
- **Evaluate Your Information** Examine the possible causes of the decreases in amphibian populations. Many causes for the declines have been proposed by scientists. **Evaluate the scientific research** that has been done to study the causes of the population declines.
- **Graph Your Research** Find charts or graphs that show the decline in amphibian populations. **Make charts and graphs** using numeric data on population declines from your background research.
- **Organize and Report Your Findings** Organize your research into a detailed report. Share your report with your class. Offer your own opinion about the cause of the decrease in the amphibian population.

Project 3. Amphibians as Pets

In this activity, you will learn more about amphibians that can be kept as pets. You will prepare a pamphlet describing the care of a pet amphibian.

- **Visit a Pet Store** Visit your local pet store to see what kinds of amphibians are sold as pets. Obtain the name of other pet dealers who might also sell amphibians as pets. There are a variety of species of frogs, toads, newts, and salamanders that are usually available at pet stores.
- **Plan a Habitat** After your trip to the pet store, **research** the requirements for keeping one specific amphibian pet. What types of equipment are required? What food does this species eat? After you have a complete list of the requirements for

keeping one species of amphibian, discuss with your teacher the possibility of obtaining an amphibian as a classroom pet. Be sure that any animal cared for as a classroom is not endangered or a threatened species.

- If you are able to actually care for one species of amphibian, take detailed notes about the care and feeding of this species.
- **Create a Guide** If you have been able to obtain and care for a pet amphibian, prepare an informational guide about that particular species. Include as much information as possible about the equipment, care, and feeding of the amphibian. The guide should include enough information to lead a beginner through the process of caring for a pet amphibian.
- **Create a Pamphlet** If you have not been able to care for one specific amphibian, you can prepare a more general pamphlet. Your pamphlet should include information about where to buy pet amphibians; a list of threatened, endangered, and poisonous species that should not be kept as pets; and the equipment that is needed to maintain a pet amphibian.

Project 4. Amphibian Habitats

In this project, you will visit a natural area where amphibians can be found and prepare a field guide to the amphibians in your area.

- Contact your local representative of the U.S. Fish and Wildlife Service, a naturalist at a local park, or another expert on local species. Ask about locations in which amphibians can be observed in their natural habitat.
- **Plan a Field Trip** With the help of your teacher, plan a field trip to the suggested site. As a part of your planning, do extensive background research on the amphibians that are native to your area.
- **Record Your Sightings** At the natural site, keep track of the species of amphibians you are able to see. Take notes about the habitat in which each amphibian is found.
- Use a camera to take pictures of the amphibians you are able to observe at the natural site.
- **Prepare a Field Guide** Using the information from your trip and your background research, prepare a field guide to local amphibians. Share your field guide with your class.

Enrichment Activities

Short on time? Extend your knowledge about amphibians with these shorter challenges.

Frog Malformations Use up-to-date research on malformations that have been found in frog populations. Find out if a cause for the malformations has been found. Write a one-page report, and share your findings with your class.

Frog-Call Counting Find out how frog-call counts can be used to monitor the populations of frogs and toads. See if there is a frog call-counting program in your state and if you can participate in such a program. Make a recording of the frog calls that can be heard in your area, and share your recording with your class.

Metamorphosis Mural Research the process of metamorphosis that frogs and toads undergo. Create a mural or poster using detailed drawings to show the stages of metamorphosis. Provide a short, written explanation with each illustration.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after you decide which project you are undertaking (Get approval before proceeding.)		
2. after you have done your background research and have a written plan for the completion of your project		
3. before you do any field work required for your project		
4. when your project is nearing completion and you want to schedule a day to share your results with your class		

Project 10 The Human Body

BioChallenge Goal

The purpose of this project is to gain an in-depth understanding of several body systems and the effect of diet and nutrition on these systems.

BioChallenge Projects

Project 1 How Sweet It Is — Design an investigation to determine if sugar in the diet is related to mood.

Project 2 Heal-A-Meal — Develop a nutrition plan suitable for people with special nutritional needs.

Project 3 Take A Break —Conduct research related to bone injuries, bone growth, and the relationship between nutrition and bone development.

Project 4 Healthful Lunch Pamphlet — Develop a guide to healthful lunches for the students in your school.

Getting Started

Before you choose your long-term project from the options described, spend about a week carrying out preliminary research.

1. **Form a research team** with several classmates. Read through the project options and choose a topic on which to focus. Discuss the resources that will be required for the project.
2. Have your teacher invite a dietitian or medical professional to speak with your class. **Share your research topics** with the guest speaker, and ask for their input.
3. **Visit the library** to perform background research related to your topic.

Design Your BioChallenge

After your preliminary research, choose one of the following long-term projects to complete.

Project 1. How Sweet It Is

The purpose of this project is to monitor your sugar intake to see if there is a relationship between sugar in your diet and your mood.

- **Develop a Hypothesis** Research studies that have examined links between sugar intake and mood. Develop a testable hypothesis about the relationship between sugar in the diet and mood. **Write a proposal for an experiment**, using yourself as the test subject, which could be done to test your hypothesis. Be sure your proposal answers these questions: How would you control your sugar intake? How can your mood be measured?
- **Check with Your Doctor** Always check with your doctor before modifying your diet. Here are some hints for designing your experiment:
  a. **Design Your Experiment** Include a four-day period in which you eat no refined sugar. Refined sugar is an ingredient in most dessert foods and many other processed foods. Read the labels of food products—you may be surprised to find refined sugars in foods like ketchup and crackers. Refined sugars include dextrose and corn syrup. During this test period, record in a journal the times that you eat a meal or have a snack. Also, write down your activity level for each hour of the day. Try to assess and record your own mood. Perhaps you can use a scale of 1 to 10. One-word descriptions such as *good* or *bad* will not allow you to properly analyze the results of the experiment.

b. During the next four-day period, eat foods that do contain refined sugar, in amounts that are typical for you. Try to keep the timing of meals and snacks consistent with the previous four days. **Record the quantities** of foods with refined sugar that you consume, and the times at which the foods were consumed. Also, write down your activity level for each hour of the day. Assess and record your moods during the four-day period.

c. **Compare** your journals for the two time periods. See what connections there are between your diet and your mood. You may wish to refine your experiment and repeat it several times.

- **Report Your Findings** At the conclusion of your experiments, prepare a report that summarizes your data. Use a table or graph as one way to present your findings. Compare your results with those of other research groups.

Project 2. Heal-A-Meal

The purpose of this project is to propose and plan a dietary menu for people with special nutritional needs, such as diabetics, athletes in training, senior citizens, or people in a homeless shelter who have suffered nutritional deprivation.

- **Research Specific Nutritional Needs** Select a group from those mentioned above or another group of interest to you. Research the specific nutritional needs of that group. Use library resources and interviews with medical professionals to gather information.
- **Plan-A-Menu** Plan a very specific menu for a three-week period. The menu plan should include three meals a day plus snacks. Include a written summary that outlines the specific nutritional needs of this group of people and the ways in which your menu plan meets these needs.
- **Prepare a Meal** If it is possible, prepare a meal from your menu plan. For athletes, it could be dinner the night before a marathon race. For people in the community who are in need, donate a meal to a shelter or senior citizen's center.

Project 3. Take a Break

The purpose of this project is to learn how to interpret X rays, compile data about sports injuries, and learn more about the body's support system and how it is affected by diet.

- **Plan A Visit** Set up an appointment to visit a hospital X-ray unit, an orthopedist's office, a sports medicine clinic, or any other place where broken bones are likely to be diagnosed.
- **Research** how X-ray equipment works, including the limitations and safety precautions needed to use X rays. Find out who takes the X rays and who reads them. Examine some X rays of broken bones. Compare X rays to other non-invasive techniques used to study the body.
- **Collect Your Data** Collect data about the most common injuries to bones, tendons, ligaments, and joints. Correlate information about age and activity to such conditions as broken bones, osteoporosis, arthritis, and knee and hip replacement surgery. Organize your data in a graph or a table.

Food	Recommended Daily Allowance of Calcium	Serving Size	Calcium per Serving

- Research nutrition and bone development. Find out the recommended daily allowance of calcium for different age groups. **Use a table** like the one on page 38 to list some foods rich in calcium, along with the amount of calcium in one serving.
- **Present Your Data** Present the information you have compiled along with sample X rays and your data tables. Answer any questions your classmates may have.

Project 4. Healthful Lunch Pamphlet

The purpose of this project is to use a survey to assess the lunches eaten by the students in your school. You will then use the results of the survey to prepare a pamphlet describing recommendations for healthful lunch choices.

- **Plan Possible Lunch Locations** With your research group, prepare a complete list of locations at which the students in your school can have lunch. Some schools require students to eat in the cafeteria; others have an open campus so students can eat at local restaurants.
- **Survey Lunch Locations** Prepare a survey that will assess the locations chosen by most students for lunch. Your survey should also determine how many students bring lunch from home. Give the survey to as many students as possible. Make sure to survey students from each grade level.
- **Use Your Results** Using the results of your survey, determine which lunch locations are most popular with the students in your school.
- **Research Healthy Lunches** Research the characteristics of a healthful lunch. What nutrients does a healthful lunch contain? What amounts of fat, calories, and sodium can be in a healthful meal? You can use reference materials or interview a dietitian to find the answers to these questions.
- **Develop Healthful Menus** Find items on the menu at each lunch location that can be combined to form a healthful meal. Nutrition information is sometimes posted in restaurants; other times you will need to ask the manager for this information. Also develop a healthful menu for students who bring their lunches.
- **Design a Pamphlet** Design a pamphlet to serve as a guide to healthful lunch choices. For each popular lunch option (restaurants, cafeteria, or from home) describe two or three healthful menus. Distribute the pamphlets to students in your school.

Enrichment Activities

Short on time? Extend your knowledge about nutrition and body systems with these shorter challenges.

As Seen on TV Analyze food products advertised during children's programming over a two-week period. Prepare data tables showing your results. **Summarize your findings** in a written report. Include your opinions on the following issues: What types of food products should be featured in advertisements directed at children? Should junk food ads be shown during children's programming?

Bioengineered Rice Vitamin A deficiency is the leading cause of preventable blindness in children. It is estimated that more than 100 million children suffer from vitamin A deficiency. Scientists have developed a bioengineered strain of rice, called golden rice, that contains vitamin A. Research golden rice and prepare a report describing its development and the controversy surrounding its use. Present your findings.

Board Game Develop a children's board game based on facts about nutrition. Make sure the game is both fun and educational. Assemble the game and prepare the instructions. Get permission to share your game with elementary students.

Strategy Worksheet

Project name: _____

Team members: _____

Benchmarks: Provide written or oral progress reports to your teacher on a weekly basis or to coincide with the following events.	DATE	COMMENTS
1. after your research team has chosen a project (Get approval before proceeding.)		
2. after you have made a list of people and places you will be contacting, such as a dietitian, a doctor, or a restaurant manager		
3. after you have made your contacts and are doing your research		
4. when you are close to completion and want to schedule a day for sharing your project with your class		