SCIENCE GIANTS

LIFE SCIENCE

25 Activities Exploring the World's Greatest Scientific Discoveries

ALAN TICOTSKY

Aligns to National Science Education Standards

GOOD YEAR BOOKS

Dedication

To Judy, Dave, Matthew, and Adam,
with much love and gratitude.

Science Giants: Life Science contains lessons and activities that reinforce and develop skills defined in the National Science Education Standards developed by the National Research Council as appropriate for students in grades 5 to 8. These include diversity and adaptations of organisms, structure and function in living systems, reproduction and heredity, regulation and behavior, and populations and ecosystems. In addition, the following areas of the standards are central to the approach of *Science Giants:* unifying concepts and processes, science as inquiry, and the history and nature of science. See www.goodyearbooks.com for information on how specific lessons correlate to specific standards.

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Cover Design: Sean O'Neill
Text Design: Dan Miedaner
Drawings: Sean O'Neill
Cover Images: Left to right, top: Photograph of Charles Darwin, courtesy of ©Bettman/Corbis; Photograph of Rachel Carson, courtesy of U.S. Fish and Wildlife Service; Portrait of Gregor J. Mendel, ©Bettman/Corbis; bottom: Photograph of George Washington Carver, courtesy of Library of Congress; Photograph of Louis Pasteur, courtesy of Library of Congress.

ISBN-13: 978-1-59647-106-1

Library of Congress Cataloging-in-Publication Data

Ticotsky, Alan.
Science giants : life science : 25 activities exploring the world's greatest scientific discoveries / Alan Ticotsky.
p. cm.
Includes bibliographical references (p.).
ISBN-13: 978-1-59647-106-1
ISBN-10: 1-59647-106-9
1. Life sciences--History--Study and teaching (Middle school)--Activity programs. 2. Discoveries in science--Study and teaching (Middle school)--Activities programs. I. Title.

QH305.T63 2006
570.71'2--dc22 2006043509

Contents

Introduction for Teachers

Some ideas people believed in the past appear foolish to us. Other ideas seem to be inevitable but erroneous conclusions reached using limited resources and information. One may assume with reasonable certainty that some of today's prevailing knowledge will be overturned by new discoveries in the future. Science can describe reality to the limit of our tools and our ability to conceptualize that which we cannot measure or observe. New ideas constantly challenge old assumptions. Revolutions occur when an idea is discarded in favor of a better one.

The Structure of This Book

Science Giants: Life Science arranges important scientific discoveries in major disciplines into a historical context. Activities and simulations provide hands-on experiences for students using readily available classroom supplies. Activities are followed by student reading pages summarizing the history of scientific discovery and explaining the theories.

The book is divided into chapters based on major areas of science inquiry. Each chapter contains teacher instructions for active student investigations paired with student reading pages. You can use chapters individually, or you can follow the sequence of the book to provide an overview of the history of life science.

Activities are designed for teams of students and follow a simple format—a list of materials needed per team (mostly common, inexpensive items), followed by instructions and teacher background information. Teamwork among students provides valuable rewards in the classroom. Working in teams:

- encourages dialogue among students, creating better thinking and more discovery.
- improves communication skills.
- increases motivation.
- promotes peer teaching and learning.
- builds social competency.

After doing an activity, hand out the student reading pages to enhance students' knowledge of the history behind each discovery. Student reading pages include vocabulary words, which are shown in bold type and defined at the end of each reading, and offer suggestions for further study. Each reading is self-contained and has all the necessary information for students to understand the significance of the scientific achievements. Time lines at the beginning of each chapter provide reference points and springboards for studying biography, an important and interesting aspect of the history of science. There's a bibliography for teachers at the end of the book.

The book focuses on ideas rather than personalities. Some famous legends are covered because scientific and historical literacy would be incomplete without them. The circumstances of discovery often illustrate the truth of Louis Pasteur's observation, "…chance favors the prepared mind." Using *Science Giants* should help prepare the minds of students for future discoveries.

Gender Equity

Why is there a predominance of men in the history of science? Margaret Cavendish was the first woman elected to the prestigious Royal Society in 1667; the next woman member was admitted in 1945. Examples of women scientists are necessary and important for students—and so is a discussion about why such a high percentage of great scientists mentioned in the history books are men.

As you and your students follow modern scientific developments in newspapers, magazines, and other media, note how both women and men contribute to the advances in all fields. Make it an assumption in your class: scientists come in all genders and colors and from all countries—in short, every variety of human being. Resources abound to help you if you choose to devote a section of study exclusively to women's contributions to science.

Generating Enthusiasm

Start each section with students' questions and ideas. What do they know? What do they want to know? Then go on and survey the history of each field you choose. The activities will emphasize science process skills and most will need little introduction—get the kids started and stay out of the way. Through the experimenting, students will be controlling variables, making predictions, recording and interpreting data, drawing conclusions, and *doing* science.

Connecting the main ideas in a historical and social context should enrich their overall understanding and make them eager to discover where science is heading today. Studying today's news should be a major goal for all of us who teach and especially those who teach science—helping students become scientifically literate and able to understand current issues and ideas.

A goal of writing and using this book is to excite the scientists of tomorrow about all there is to know now and all there is for them to discover in the future. There's a lot you can see from the shoulders of giants.

Introduction for Students

Science as Historical Process

What do we know and how do we know it? These two questions can lead you on a very rewarding journey. Thanks to thousands or even more years of questioning, observing, and experimenting, we know a mind-boggling amount about the world and universe around us. The average ten-year-old school child knows more science than anyone knew just a few hundred years ago. How did all that knowledge get here?

Isaac Newton (1642–1727) was born in the same year in which another famous scientist, Galileo Galilei (1564–1642), died. Responding to a question about how he could know so much, Newton is reported to have said, “If I have seen further, it is by standing on the shoulders of giants.” Galileo was a giant pair of shoulders for Newton, and Newton grew giant shoulders for others himself. Every generation starts from the current knowledge and builds further.

Look outside your classroom window. The sun comes up on one side of the building, rises and travels across the sky, then heads down to set on another side. Throughout the year, the sun’s path changes as it appears lower in the winter and higher in the summer. Doesn’t it seem reasonable to describe the sun as traveling around the Earth?

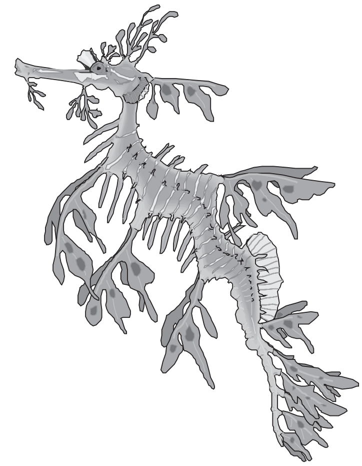
In fact, not so long ago, most people thought the Earth was the center of the universe. Other ideas that have changed include the following:

- Scientists believe the Earth was formed about five billion years ago. In 1650, Bishop Ussher set the date at 4004 BCE.
- Things burn when they combine with *oxygen*, not because they contain a substance called *phlogiston*.
- Matter consists of tiny atoms that are themselves made of smaller substances. Earlier people believed all matter was made from four elements: earth, fire, water, and air.
- Plants make their own food mostly out of the carbon in the air, not from the soil or water.

Who knows what ideas of today will be changed in the future? Enjoy these activities and ideas that teach about how science has grown and changed, and maybe you will see something new on the shoulders of giants.

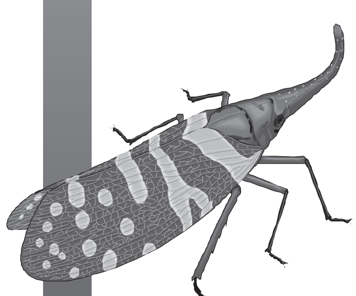
CHAPTER 1

Natural Selection



TIME LINE

Year	**Notable Event**
300s BCE	Greeks found fossils and knew they were remains of ancient animals.
1680	The dodo became extinct.
1795	Georges Cuvier discovered bones of an ancient sea reptile.
1830	Charles Lyell published the first volume of his work claiming the Earth is millions of years old.
1831	Charles Darwin began his trip as naturalist on the HMS *Beagle.*
1842	Richard Owen used the term *dinosaur.*
1859	Charles Darwin published his book *On the Origin of Species by Means of Natural Selection.*
1860	Gregor Mendel experimented with the laws of heredity.
1953	James Watson and Francis Crick built a double helix model of DNA.
1962	Rachel Carson published *Silent Spring,* warning of environmental problems from man-made chemicals.



Materials per Team

- potatoes
- toothpicks
- push pins
- pipe cleaners
- cotton balls
- other craft materials—the greater the diversity of materials, the greater the differences among the creatures

Design a Species

Potato Creatures

Ask students, "Why are specific animals successful in specific habitats?" The theory of natural selection, popularly called "the survival of the fittest," revolves around that question. If children don't suggest many survival criteria at first, guide them toward recognizing these essentials:

- ▶ ingesting and digesting food
- ▶ respiration to release the chemical energy of food
- ▶ response to stimuli
- ▶ finding a mate for reproduction to pass genes along

To begin, tell the teams that they will be designing their own creature, building it with attributes that will help it be successful. They must think about their creature: How will it survive? How will it obtain food? How will it avoid predators? What senses will it use to process information about the world? How will it attract a mate of its own species? Questions like these are central to evolution theory.

Activity

When students are ready, provide each group with a potato and let them decide what attributes their creature will have. Make available various craft materials for them to use in creating their creatures.

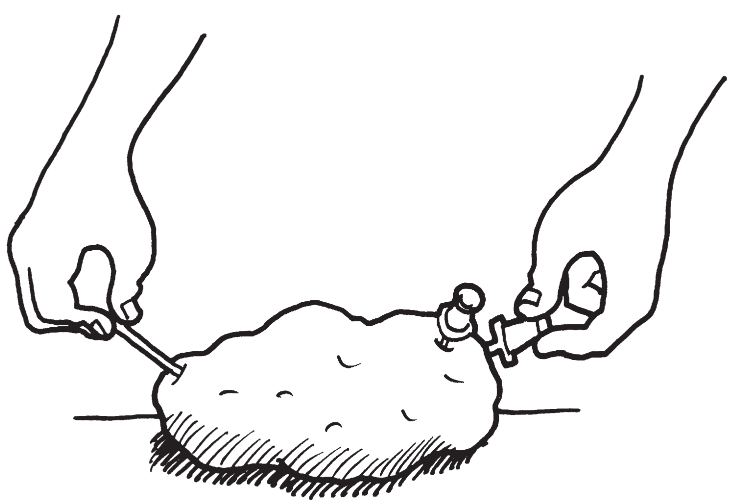
When thinking about what materials to offer students, keep these two points in mind:

1. If you make many different materials available to attach to the potatoes, student groups will probably build a wide diversity of creatures. This will simulate the widely diverse set of life-forms on Earth.
2. Conversely, if you offer only a few kinds of materials, many of the potato creatures will look alike. This simulates another attribute of life on Earth. Students will recognize that many creatures are similar in overall design.

Sometimes this is a result of species diverging from common ancestors. But even very different creatures share fundamental similarities. For example, nature has provided many animals with eyes—different structures and abilities exist but there is a standard design in many species.

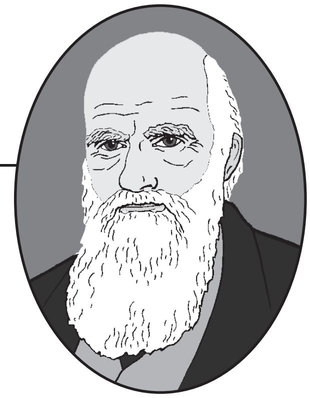
When students have finished their creatures, have them write descriptions of their characteristics and share them with other groups. The biodiversity of the "organisms" will be surprising. Afterward, have students bring the potato creatures outside and hide them in the environment to test their ability to blend into the habitat. (This may lead into the camouflage activity on page 11.)

Enjoy this rich activity with its opportunities for interdisciplinary extensions. To complete a cycle, students can remove materials that are not biodegradable and then bury the potatoes.



READING:

Darwin's Theory



Charles Darwin

When Charles Darwin was twenty-two years old, he began a journey around the world as the naturalist on a ship named the *Beagle*. The journey took nearly five years, and Darwin's experiences set into motion a most memorable career.

In the Galapagos Islands off the west coast of South America, Darwin studied tortoises, finches, and other animals that had lived apart from the mainland. Unique species of these animals lived on each island. Somehow the variety of conditions on different islands had produced a variety of creatures. The tortoises had different markings depending upon which island was their home. The beaks of the finches seemed fitted to their food. The Galapagos Islands continue to be a rich research area for life scientists.

Because of the animals he saw there and other experiences later in his career, Darwin formulated a theory called *natural selection*. He published the major part of it in 1859 after working on it for many years.

Darwin's book, *On the Origin of Species by Means of Natural Selection*, said that organisms live and die and many have offspring, or babies. Populations can increase very rapidly. The offspring are similar to their parents in some ways and different from them in other ways. Changes from one generation to another happen for a variety of reasons, sometimes through **mutations.**

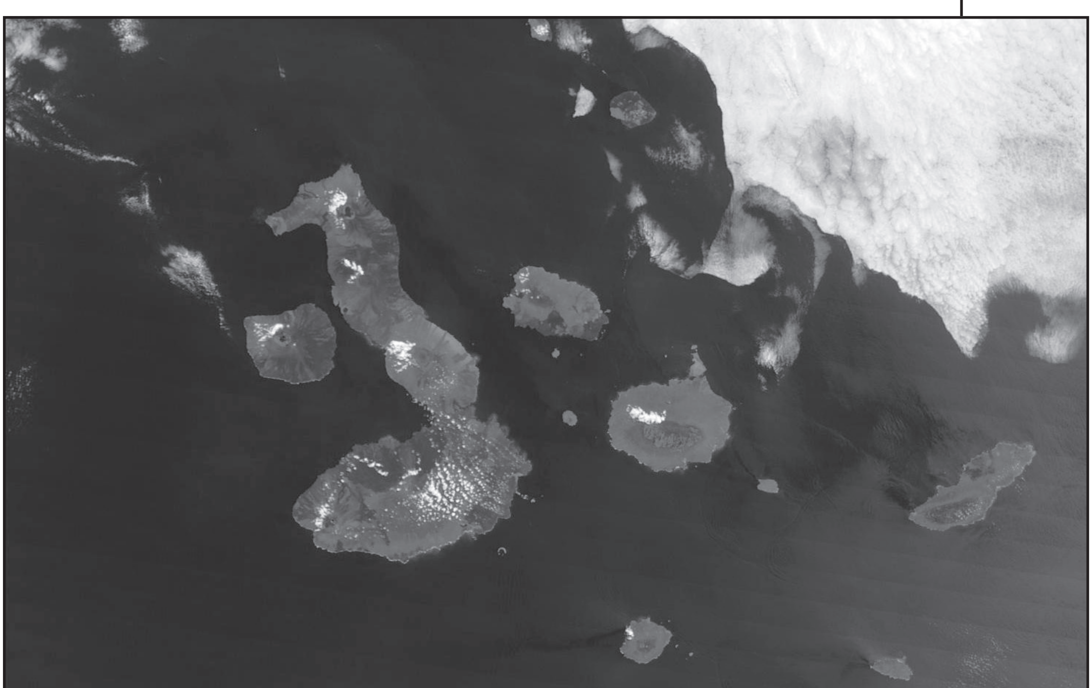
Organisms whose changes are beneficial (helpful) to survival have a better chance to grow to adulthood and produce offspring. Organisms whose mutations reduce their ability (harmful) to survive tend to produce few or even no offspring. As generations pass, organisms whose changes aid in both survival and reproduction will dominate the species.

Darwin reasoned that variations and changes are either passed along or die out. Some people refer to this process as "survival of the fittest." Natural selection theory explains how these changes become established and passed along, and the resulting process is known as **evolution.** Evolution theory was one of the most important scientific ideas of the nineteenth century and remains a central principle in life science. Not everyone accepts the theory Darwin popularized.

Many scientists have built upon Darwin's work, interpreting life science problems and issues through natural selection theory. Darwin's contemporary, **naturalist** Alfred Russel Wallace (1823–1913), explored the Amazon River area and developed a theory of evolution at about the same time as Darwin. At first, there was much resistance to the idea that species change over time. More than a century after the publication of his famous book, Charles Darwin's theories continue to be disputed by some educators and scientists.

Darwin read the work of Charles Lyell (1797–1875), a geologist of his time who argued that the Earth was very old. This idea was not easily accepted by the public, either. Evolution usually depends upon very great stretches of time to do its work. Over time, the competition in nature selects the organisms best suited to succeed. Not only individual organisms but entire species may eventually fail to produce successful offspring. When that happens, the species becomes extinct. Darwin worked with fossils of extinct creatures, and that experience also helped him see changes over time.

Let's apply the theory of evolution to an animal with a distinctive set of characteristics. Take the case of giraffes. They



Galapagos Islands (Courtesy of NASA)

are born with long necks, well adapted for eating leaves high in the trees on the African plains. A short giraffe would not compete for food successfully against its taller neighbors and could not easily raise a successful family. Its neck would not grow much by stretching up for leaves, as some of Darwin's opponents claimed. Natural selection would favor the taller giraffes. (Male giraffes also use their long necks to fight one another, so a long-necked male is favored as a fighter.)

Can you think of some animals for whom a long neck would be a disadvantage? All animals have qualities that allow them to find food, defend or protect themselves, and meet others of their species in order to pass along their genes to offspring. Start with a potato and model a creature you think is well adapted for life in a habitat you create.

Vocabulary Words

evolution .... the theory that genetic changes from generation to generation over time cause species to change gradually

mutation .... permanent change in the genes of an organism

naturalist .... scientist who studies natural objects and organisms