Introduction

This book contains **biographical** (about a person's life) sketches of famous scientists from ancient to present times. It is divided into two parts: part I includes chapters about different types of scientists, and part II includes chapters about individual scientists, which are in alphabetical order by the scientists' last names.

In each chapter, you'll find interesting facts about the scientist, as well as a discovery experiment or an activity that will help you get to know the work of the scientist being presented. You can read the chapters and perform the experiments in any order.

Each chapter explains science terms in simple language that can be easily understood. New terms are boldfaced and defined the first time they are presented. The scientific concepts are explained in basic terms with little complexity and can be applied to many similar situations. With fun facts and experiments, this book will encourage you to learn through exploration and discovery.

HOW TO USE THIS BOOK

You can start at the beginning of the book, or you can just flip through the chapters for a scientist who sounds interesting. Before you do any of the experiments, read them through completely. Once you've decided on an experiment to try, collect all the needed materials and follow all procedures carefully. The format for each chapter is as follows:

- A brief biography of the scientist and information on his or her discoveries.
- **Fun Time!** A discovery investigation related to the scientist. Each experiment includes a **Purpose,** which states the objective of the investigation; a complete list of easy-to-find **Materials;** a step-by-step **Procedure;** a section identifying the expected **Results;** and a **Why?** section that explains why the experiment works.
- **More Fun with . . . !** An additional fun activity relating to the topic.
- **Book List** A list of other books about the scientist and the experiments.

GENERAL INSTRUCTIONS FOR THE EXPERIMENTS

1. Read the experiments completely before starting.
2. Collect the supplies. You will have less frustration and more fun if all the materials necessary for the activity are ready before you start. You lose your train of thought when you have to stop and search for supplies. Ask an adult for advice before substituting any materials.
3. Do not rush. Follow each step very carefully; never skip steps, and do not add your own. Safety is of the utmost importance, and

by reading each experiment before starting, then following the instructions exactly, you can feel confident that no unexpected results will occur.

4. Observe. If your results are not the same as those described in the experiment, carefully reread the instructions and start over from step 1.

I

TYPES OF SCIENTISTS

1

Astronomers

A **scientist** is someone who observes and/or experiments to discover answers. But a scientist doesn't necessarily need special training or have to be a certain age or sex. A scientist is anyone who searches for answers to scientific questions.

Celestial bodies are the natural objects in the sky, including suns, moons, planets, and stars. **Astronomy** is the study of celestial bodies in the **universe** (Earth and all celestial bodies in space regarded as a whole). There is no record of the first **astronomers** (scientists who study celestial bodies), but they were ancient peoples who looked at the heavens and tried to explain what they saw. These ancient astronomers studied the heavens without the aid of a **telescope** (an instrument that permits distant objects to be viewed as if they were brighter and closer to the observer). Their universe was what they saw around and above them. They studied the movements of the Sun, the Moon, the planets, and the stars and often used these changes to try to explain events on Earth.

To some ancient peoples, the universe was a mountain rising out of a sea with a dome over it. The dome was lighted by the Sun during the day and by the Moon and the stars at night. Stories such as this, which answer basic questions about the nature of the world or express the beliefs of a group of people, are called **myths.** Myths generally date before the introduction of writing and were passed orally from one generation to the next. The study of the myths of a particular culture is called **mythology.**

Astrology is a study that assumes that the positions and the motions of celestial bodies, particularly the Sun, the Moon, the planets, and the stars, at the time of a person's birth affect the person's character and therefore his or her destiny. Astrology is an ancient practice that seems to have developed independently in different civilizations. As early as 3000 B.C., the Chaldeans, who lived in Babylonia (now Iraq), studied astrology. Many scholars viewed astrology and astronomy as complementary sciences until about the 1500s. At that time, the discoveries made by such astronomers as the Polish priest and scientist Nicolaus Copernicus (1473–1543) and the Italian scientist Galileo Galilei (1564–1642) disproved some of the foundations of astrology. Since that time, scientists have considered astrology a **pseudoscience** (a set of beliefs pretending to be scientific but not based on scientific principles).

The branch of astronomy dealing with the study of the universe as a whole—its distant past and its future—is called **cosmology.** Many early scientists were Greek **philosophers,** which, as defined by the ancient Greeks, meant people who search for knowledge for its own sake. **Philosophy** (the investigation of truth, wisdom, and knowledge) included all areas of instruction, such as art, science, and religion. One famous Greek philosopher, Aristotle (384–322 B.C.), is thought to have been one of the earliest **cosmologists** (scientists who specialize in cosmology). Aristotle made many observations of the natural world and developed theories to explain things he saw. He was the most influential philosopher in the history of European thought for almost two 2,000 years. Even into the 1600s, Aristotle's theories were considered the truth by the Roman Catholic Church. To disagree with his ideas was considered **heresy** (an act against the teachings of a church, especially by a person professing the beliefs of that church) and was punishable by imprisonment or death. Galileo disagreed with Aristotle's theories on astronomy and narrowly escaped being killed.

One idea that Galileo disagreed with was Aristotle's **geocentric** (Earth-centered) theory of the universe, which put a stationary Earth at the center of the universe and had all the other heavenly bodies moving around it. Aristotle wasn't the first to express this idea. In fact, it had been the accepted theory for thousands of years. But since Aristotle agreed with it, it became the accepted theory for almost 2,000 more years. Another accepted idea that Galileo disagreed with was that all heavenly bodies, including the Moon, were perfectly smooth spheres.

Aristotle was a thinker, not an experimenter. He didn't try to prove his ideas. The Greek astronomer and mathematician Claudius Ptolemy, who lived in Alexandria (in Egypt) from approximately A.D. 100 to 170, created a model to explain the motion of celestial bodies in a geocentric universe. Since his model agreed with Aristotle's theory of the universe, its accuracy was basically unchallenged until Nicolaus Copernicus proposed a **heliocentric** (Sun-centered) model. There were so many unexplained parts to Copernicus's model that the Church didn't take it seriously, but many scientists of the day became interested, including the Danish astronomer Tycho Brahe (1546–1601) and the German astronomer Johannes Kepler (1571–1630). Brahe was at

first reluctant to share his discoveries with others for fear they would take credit for his works. But in time Brahe and Kepler shared their ideas and research.

It wasn't easy for anyone to work with Brahe. Brahe once fought a duel with another man over who was the better mathematician. Brahe may have been the best mathematician, but his lack of skill at sword fighting resulted in his losing a part of his nose and having to wear a metal plate over it to hide the missing end.

Brahe and Kepler's combined efforts led to the discovery that planets must have an **elliptical** (the shape of a slightly flattened circle) **orbit** (the curved path of one object around another) around the Sun, not around Earth. Previously, it had been believed that the orbits were circular, not elliptical.

In 1609, Galileo started studying the sky with his own homemade telescopes. His observations provided proof of Copernicus's theory of a Sun-centered universe, but Galileo was forbidden by the Church to talk or write about his ideas. However, he had already published them, and other scientists were beginning to agree that the universe was heliocentric. The big missing piece to the puzzle was the force that kept celestial bodies in orbit. The English scientist Sir Isaac Newton (1642–1727) discovered this force, which is called **gravity** (the force of attraction between all objects in the universe). He worked out equations to explain how gravity affected the motion of celestial bodies. These equations were so accurate that they are still used today.

Newton thought that there were three basic parts of the universe: time, which was the same all over the universe; space, where every object had its own size and position; and **mass,** the amount of **matter** (the substance from which all objects are made) in an object, which was constant. Mass is commonly measured in metric units of grams and kilograms. In 1915, the German scientist Albert Einstein (1879–1955) made waves in the astronomical community by disagreeing with Newton's theories. In his theory of relativity, Einstein showed that time, space, and mass were different for observers moving at different velocities in relation to one another. (A **theory** is an idea or a statement, based on evidence, that explains how or why something happens, but it can be changed as new information is discovered.)

The German-born British astronomers Caroline Herschel (1750–1848) and her brother William Herschel (1738–1822) made many important contributions to astronomy. Among these were eight comets, discovered by Caroline, and the planet Uranus, discovered by William. **Comets** are small celestial bodies made up of dust, gases, and ices (mainly, water and carbon dioxide) that move in an extremely elongated orbit around the Sun. Comets and planets are **natural satellites** (celestial bodies that revolve around other celestial bodies).

Caroline Herschel was the first acknowledged woman astronomer, but her accomplishments didn't cause any great changes in the attitude of the scientific community toward women scientists. Yet Caroline's scientific work, as well as that of other women scientists, such as the American astronomer Maria Mitchell (1818–1889), was a model for women scientists who followed. Mitchell was America's first, but certainly was not the last, recognized woman astronomer. Henrietta Leavitt's (1868–1921) astronomy studies made possible the first accurate determination of distances between celestial bodies.

Another modern astronomer is the famous English cosmologist Stephen Hawking (1942–). Hawking's most famous scientific contribution is providing better arguments for the presence of black holes in space. A **black hole** is thought to be an extremely dense celestial body that has such strong gravity that not even light can escape from it. Since light can enter it but cannot get out, it would appear to be black.

FUN TIME!

Purpose

To confirm Galileo's observations that the Moon is not a perfectly smooth sphere.

Materials

sheet of white copy paper
pen
ruler
binoculars and/or telescope

Procedure

1. Use the paper, pen, and ruler to draw a Moon Data table like the one below.

Moon Data	
Date	**Diagram**

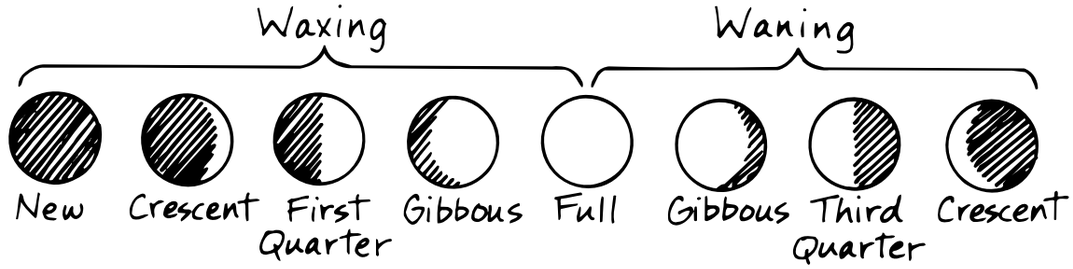
2. Observe the Moon for as many days as possible during a 29-day period. During each observation, make a diagram of the Moon, shading in the dark areas.
3. Use the binoculars and/or a telescope to study the boundary on the Moon between the dark and the light parts. Make a note on your drawings about how straight or uneven this boundary is.
4. Label your drawings with the names of the different moon phases, as shown.

Results

Your observations should show that the boundary between the light and the dark sides of the Moon is uneven.

Why?

Using a telescope that he made, Galileo studied the **Moon phases** (regularly recurring changes in the shape of the lighted part of the Moon, facing Earth) and discovered that the boundary between the light and the dark sides of the Moon, called the **terminator,** was rough and uneven. From this and many other observations made with his telescope, Galileo concluded that the Moon's surface consists of valleys, plains, and mountains, much like the surface of Earth, so it is not perfectly smooth.



MORE FUN WITH THE MOON!

The same side of the Moon always faces Earth because the Moon **rotates** (turns about an **axis**—an imaginary line through the center of an object) and **revolves** (moves in an orbit—a curved path around an object) at the same rate. While the same lunar features are always seen by an observer on Earth, in the **Northern Hemisphere** (the region north of the **equator**—an imaginary line around the center of Earth) these features appear to rotate in a clockwise direction during the day. This is because an observer on Earth sees the Moon from a different direction as Earth rotates on its axis. The "Man in the Moon" (or, as seen by some, "The Moon Rabbit") is the design on the Moon that results from shadows made by its different land features. Make note of the position of the design when the Moon is in the eastern part of the sky and then again later when the Moon is in the western part of the sky. If the Moon is in a **crescent phase** (the lighted part of the Moon that looks like a ring segment with pointed ends), instead of observing its design, note any change in the direction that the pointed ends of the crescent face.

BOOK LIST

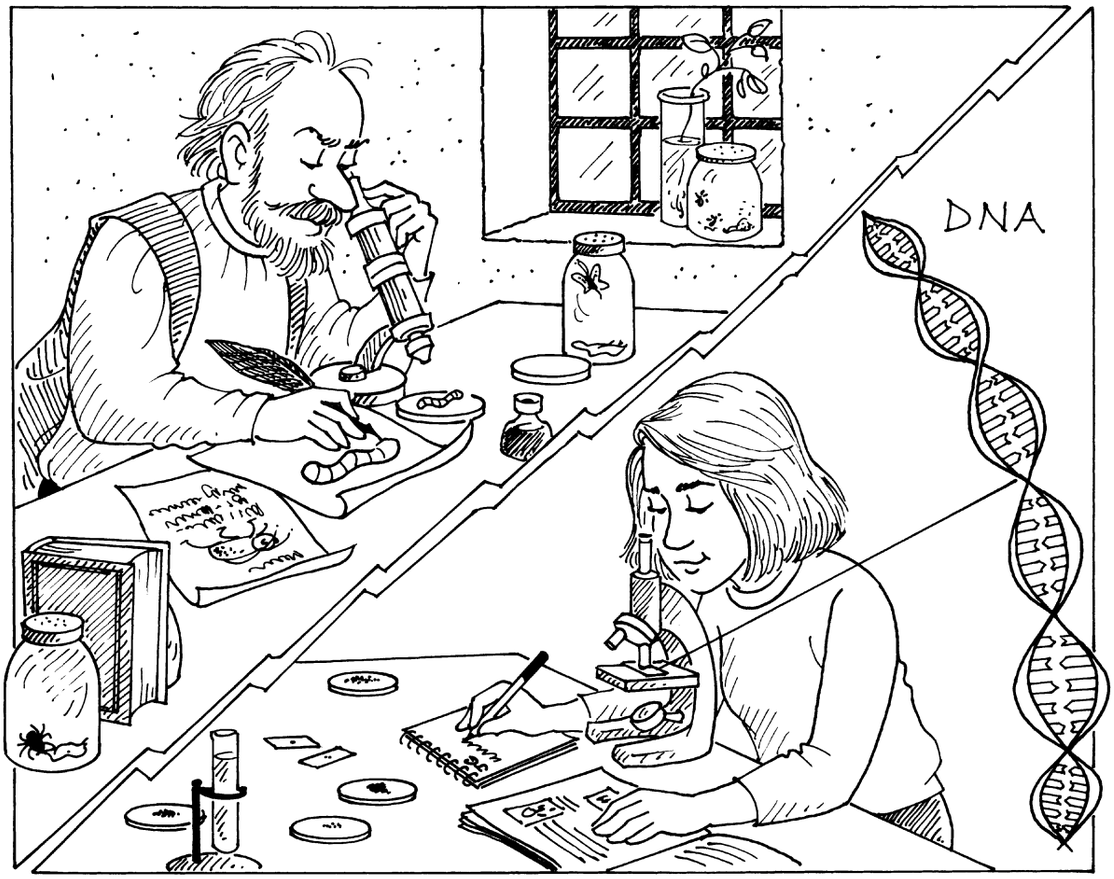
Filkin, David. *Stephen Hawking's Universe.* New York: BasicBooks, 1997. A brief history of the universe and the scientists who revealed its secrets.

Hathaway, Nancy. *The Friendly Guide to the Universe.* New York: Penguin Books, 1994. Information about the universe and the past and present scientists who have studied it.

VanCleave, Janice. *Astronomy for Every Kid.* New York: Wiley, 1991. Fun facts and investigations about celestial bodies and other astronomy topics.

2

Biologists



Biologists are scientists who specialize in **biology,** which is the study of **organisms** (living things). In 1800, the French **naturalist** (a scientist who studies plants and/or animals) Jean-Baptiste de Lamarck (1744–1829) introduced the word *biology.* Lamarck is also famous for developing a theory of inheritance, which attempted to explain how particular **traits** (characteristics) are passed down from parents to their **offspring** (the young of a particular organism). Lamarck's scientific theory of inheritance and his other theories were largely ignored or attacked during his lifetime, and he spent most of his days struggling to make a living. He was so poor that he was buried in a rented grave; after five years his body was removed, and no one knows where his remains are now.

A scientist who studies **microbes** (tiny organisms visible only under a microscope) is called a **microbiologist.** The founder of **microbiology** (the study of microbes) was

Antoni van Leeuwenhoek (1632–1723), who prepared his own microscopes and studied everything from blood to scrapings from his teeth. In 1865, the French scientist Louis Pasteur (1822–1895) published his findings that some microbes cause diseases. Pasteur called these disease-causing microbes **germs.** A later microbiologist who was able to discover a cure for diseases caused by microbes was Alexander Fleming (1881–1955).

One of the earliest detailed studies of organisms was made by the British naturalist Charles Darwin (1809–1882). His renowned studies were made aboard the HMS *Beagle,* during a British science expedition that traveled around the world from 1831 to 1836. Darwin studied plants and animals everywhere he went. From his studies, he proposed the **theory of natural selection,** sometimes called "survival of the fittest." This theory is based on the fact that all living organisms compete for things like water, food, and shelter, in order to survive Those organisms with traits best suited for survival live and produce offspring with traits similar to their own. For example, in areas where trees are tall, giraffes with longer necks would compete for food more successfully and would live to produce offspring with long necks like themselves. **Genetics** is the branch of biology that deals with the study of **heredity,** which is the transfer of traits (characteristics) from parents to offspring. **Geneticists** are scientists who study things that deal with heredity.

In the 1900s, the Austrian monk Gregor Johann Mendel (1822–1884) made the greatest single contribution to the study of heredity. Most scientists of that time supported the "blending" theory of heredity, which basically said that hereditary material from both parents blends together in the offspring. Mendel experimentally disproved the blending theory by using plants. He agreed with earlier scientists who said that separate units were passed from parents to offspring, and he guessed correctly that some of the units were **dominant** (this refers to the stronger of a pair of traits; when present, this determines the trait of the offspring). Other units were **recessive** (this refers to the weaker of a pair of traits; this doesn't determine the trait of an offspring if a dominant unit is present). The units of heredity described by Mendel were named **genes.**

It was not until the 1920s that the chemical structure of genetic material was determined to be made of proteins and a substance called deoxyribonucleic acid, or DNA. **Proteins** are chemicals in the body that are used in almost everything cells do. In 1953, the British biologist Francis Crick (1916–) and the American biologist James Watson (1928–) determined the structure of DNA. Some people report that these scientists were assisted by information collected by the American biologist Rosalind Franklin (1920–1958). Franklin died before a Nobel Prize was presented in 1962 to Watson and Crick for their DNA work. Rosalind Franklin was not mentioned as being a contributor.

While some scientists were searching for the makeup of genes, the American geneticist Barbara McClintock (1902–1992) investigated the effect of the location of genes. McClintock started her research because she became curious about the arrangements of the colored kernels in Indian corn. For years she studied the genes of corn and in 1952 concluded that the positions of genes on a **chromosome** (a rod-shaped structure in cells that is made up of genes) are not fixed; instead, the genes sometimes move or "jump" around unpredictably. It took about 25 years for the value of her work to be recognized. In 1983, she was the first woman to receive a Nobel Prize in medicine for work she did alone.

The American molecular biologist and Nobel Prize–winner Paul Berg (1926–) was the

first scientist to combine DNA molecules from two different organisms. This combination made possible a whole new industry called **genetic engineering** (the application of the knowledge obtained from genetic investigations). Genetic engineering is used to change the traits of organisms. This allows genetic engineers to produce special kinds of plants or animals that can survive in certain environments. Today, biologists are investigating **cloning** (the process of producing an organism from one cell of a single parent). A cloned organism is genetically identical to its parent.

Botany, the branch of biology dealing with the study of plants, was founded around 330 B.C. by the Greek philosopher Theophrastus (c.372–c.287 B.C.), who was a student of Aristotle's. Biologists who specialize in plants, such as the Canadian-born Alice Eastwood (1859–1953), are called **botanists.** Starting in 1892, Eastwood worked at the California Academy of Science in San Francisco. After the earthquake of 1906, which destroyed the academy's plant collection, she spent years traveling and collecting plants. She inspired other women to become botanists, including the Mexican American Ynes Mexia (1870–1938). In 1933, Eastwood, at 74, and Mexia, then 63, traveled to Mexico to collect plants. In all, Eastwood collected more than 250,000 specimens for the academy. Mexia, who did not start her career as a botanist until she was 55, was able to collect about 150,000 specimens.

Other biologists, such as the British naturalist Jane Goodall (1934–), study animals. These scientists are called **zoologists. Zoology** (the branch of biology dealing with the study of animals) was founded around 350 B.C. by Aristotle. Fascinated as a child by the stories of Tarzan, Goodall dreamed of living in the jungles of Africa with wild animals, just as Tarzan did. Her dream came true, but even more than this, she became world renowned for her studies of chimpanzees.

The study of the relationship between plants and animals and their **environment** (all external factors affecting an organism, including **abiotic** [nonliving] and **biotic** [living] factors) is called **ecology.** Scientists who study this relationship between organisms and where they live, like Rachel Carson (1907–1964), are called **ecologists** (scientists who study living things and their environments). Carson was also a writer, and her book *Silent Spring* led to the ban on the **pesticide** (chemicals used to kill unwanted organisms, such as insects) called DDT.

FUN TIME!

Purpose

To model "jumping" genes.

Materials

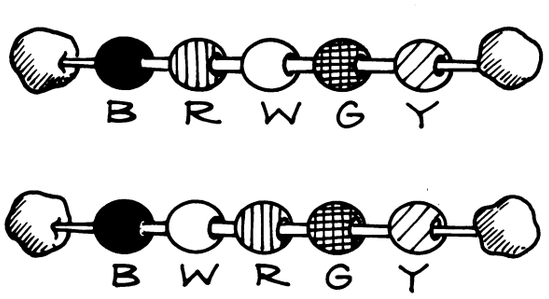
10 colored beads: 2 black, 2 red, 2 white, 2 green, 2 yellow (2 beads of other colors may be substituted)

2 round toothpicks

a grape-size piece of clay

Procedure

1. Using one of each color, thread five beads on one of the toothpicks in this order: black, red, white, green, yellow.
2. Break the clay into four pieces. Stick two pieces on either end of the toothpick with the beads.
3. String the remaining beads on the second toothpick in this order: black, white, red, green, yellow.
4. Stick the remaining clay pieces on the ends of that toothpick.
5. Lay the beaded toothpicks side by side, with the black beads to the left, and compare the arrangement of beads on each toothpick.



Results

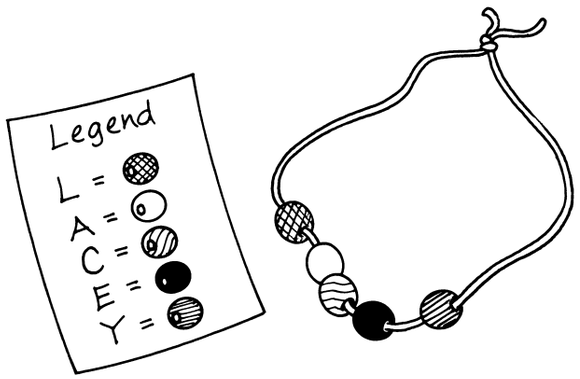
The order of the colors of the second and third beads on the toothpicks is reversed.

Why?

The beaded toothpicks represent chromosomes, and the beads are genes. New cells are made by cell division (a cell splits into two new cells). In order for the two cells formed from one cell to have the same number and kind of chromosomes, each chromosome makes a copy of itself before the cell divides. Sometimes the copy is not exactly like the original. The order of the genes is like a coded message. When the order of the genes is changed, the message is different. Barbara McClintock called genes that were not in their normal sequence "jumping genes." Her research on jumping genes helped explain how normal cells can change into cancerous cells.

MORE FUN WITH GENES!

The genes on a chromosome are like letters of the alphabet. When the genes are arranged in a specific sequence, they form the message describing a specific protein. Make a chromosome necklace that spells out a secret message. Use beads of different colors, letting the different colors represent a letter of the alphabet, as shown. Prepare a key that explains which colors equal which letters. Then string the beads in a specific order so that they spell out a name or a message. You may wish to give the necklace and the key to a friend.



BOOK LIST

Bernstein, Leonard. *Latino Women of Science.* Maywood, N. J.: People Publishing Co., 1998. Biographies about women scientists, including Ynes Mexia.

Goodall, Jane. *My Life with the Chimpanzees.* New York: Pocket Books, 1996. The fascinating story of one of the world's most celebrated naturalists, Jane Goodall.

Gribbin, John. *A Brief History of Science.* New York: Barnes & Noble, 1998. Information about different branches of science, including genetics, and how these developed.

VanCleave, Janice. *Animals.* New York: Wiley, 1992. Experiments about animals. Each chapter contains ideas that can be turned into award-winning science fair projects.

———. *The Human Body for Every Kid.* New York: Wiley, 1995. Facts and fun, simple experiments about the human body.