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TAKING OFF WITH PHYSICAL SCIENCE!

Have you ever thought about how pilots get all the experience they need to safely fly in all conditions? Pilots obviously need actual flight time for training, but there are many things, such as aircraft malfunctions and severe weather, for which a real airplane is not the ideal classroom! That is where *flight simulators* come in. For a simulator to be realistic, the modeling of aircraft movement has to be accurate. Programmers have to model the behavior of the aircraft as well as the aircraft's response to weather conditions and other inputs. By using the computer models in flight simulators, we can prepare pilots to handle both routine and extreme conditions. There's a lot of science and technology that goes into making these simulators realistic enough to prepare pilots for anything they might encounter.

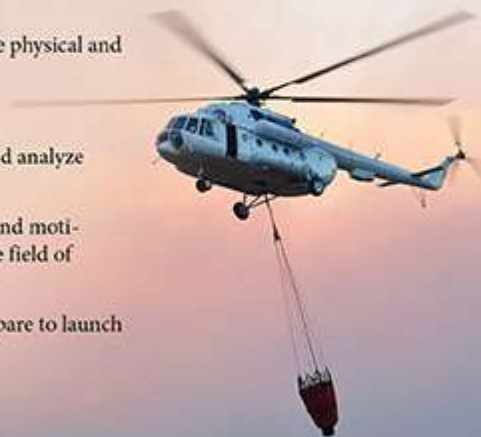


But what exactly is science? You might think that it's discovering truth about the world around us. In reality it is about *creating models* that seek to explain and describe what we observe in the world. You're probably familiar with physical models, perhaps of ships, airplanes, or even atoms. But models can also be conceptual or mathematical—they can even be computer simulations.

PHYSICAL SCIENCE 6th Edition will provide you with the foundation for further study in the fields of chemistry and physics. These two sciences are ones that you do all the time, though you may not realize it. Chemistry impacts your life when you eat, when you use cleaners, and when you cook. Physics is instrumental in playing sports, doing art, and playing an instrument. In your study of physical science, you will learn of the models that scientists have developed and modified throughout history to better explain and describe the world around them. This study of physical science will have you answer the following questions.

1. How do scientists use models in science?
2. What are the limitations to models in science?
3. How accurately have scientific theories predicted results throughout history?
4. What does the periodic table tell me about the physical and chemical properties of elements?
5. How are energy and matter related?
6. How can I use models to describe, explain, and analyze chemical and physical systems?
7. How can I use biblical principles, outcomes, and motivations to decide what is right or wrong in the field of physical science?

So make sure your seat belts are securely fastened and prepare to launch into our study of physical science!



TAKE A PEEK INSIDE!

We've designed this textbook with you in mind. We hope it will help you appreciate the wonders of God's creation even more. Flip through the following pages to see the features that we've included to help you succeed in *PHYSICAL SCIENCE*. In the back of the book you'll find appendixes, a glossary, an index, and the periodic table of the elements.

Essential Question—the big question that you will learn about in a section

Key Questions—the smaller questions that you can ask along the way through a section to help you answer the essential question

Vocabulary Terms—the key terms that will be introduced in a section

Bold-Faced Terms—vocabulary terms that you need to know

Italicized Terms—terms that will be defined later in the textbook or that are important terms in other scientific fields

7A | CHEMICAL CHANGES
How can I tell whether a chemical change has taken place?

7.1 CHEMICAL REACTIONS
Exploding fireworks are a vibrant example of a chemical reaction. All life depends on less spectacular, but more useful, chemical reactions. The digestion of food, the release of energy through cellular respiration and the growth of new cells all depend on chemical reactions. Other chemical reactions heat our homes, produce the fibers used in our clothing, and power the cars we drive. **A chemical reaction** is a process that changes a substance into one or more different substances. In a chemical reaction, the chemical bonds in the original substance are broken and its atoms are rearranged. New chemical bonds form between the rearranged atoms, producing a substance that is different from the original.

When a chemical change takes place through a chemical reaction, there are usually clear signs that one has happened. Some are obvious, like the sound and light produced by a firework. Others can be more subtle. Let's take a look at some signs that a chemical reaction has taken place.

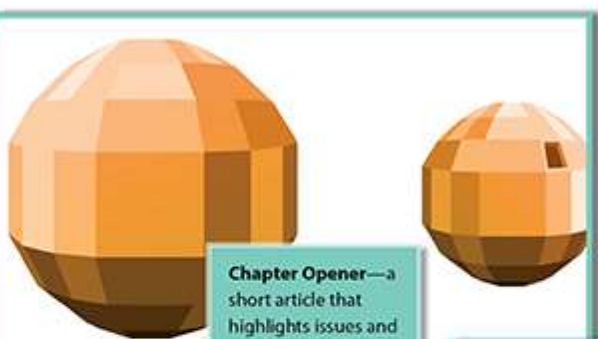
EVIDENCE OF CHEMICAL CHANGE

BUBBLES
A chemical reaction between two liquids may produce a gas. The gas is seen as tiny bubbles.

PRECIPITATE
Sometimes when two liquids are mixed, a solid will separate from the mixture. The solid is called a *precipitate*.

ENERGY RELEASED
Many chemical reactions release energy, which can be in any of many forms. Bending a glow stick mixes two chemicals that release light energy as they react.

144 CHAPTER 7



Chapter Opener—a short article that highlights issues and developments in physical science that demonstrate how science intersects with your life.

Worldview Sleuthing Boxes—inquiry-based investigations that help you think through current topics in physical science through the lens of Scripture.

CHAPTER 2 Matter

IMITATING GECKOS

Geckos have a superpower: defying gravity. The ability of the gecko on the left is not due to its feet being sticky; it's because they are hairy. The tiny hairs on its feet are about 1,000th the diameter of a human hair, and there are thousands of them on every square millimeter of a gecko's foot. With each step, the gecko spreads his hairs, maximizing the contact area of each foot. This action creates a tiny electrostatic attraction with the surface. The combination of these tiny forces creates a substantial attractive force, negligible for the gecko. God also designed geckos so that they can release that attraction!

Materials scientists are studying the gecko to see whether they can copy this natural design to create new materials. Visit www.usra.com for more information.

- 24. **Classify Matter**
- 25. **States of Matter**
- 26. **Properties of Matter**
- 27. **Changes of Matter**

WORLDVIEW SLEUTHING BOX: BULLETPROOF!

Advanced technology is an extension of the ancient art of armor-making. Armor proved ineffective against modern weaponry, and metal suits are too heavy for the modern battlefield. Materials scientists started to investigate synthetic materials. In the late 1980s, a doctor in Britain discovered that silk could keep a bullet from penetrating the body, but silk was also extremely expensive. Over time, scientists searched for other natural and synthetic (man-made) fibers with similar properties. Today scientists are looking at other applications for these materials.

FOCUS
You are working as a clothing designer for the nation's Olympic sports team. You have been assigned to research advanced ballistic materials to be used in clothing that will perform well and prevent speed skaters from being injured during accidents. You are to write a one-page proposal for a material to be used for these skaters.

CONCLUSION
We just commanded an airplane to serve others, but we did it by meeting the needs of people involved in. Developing materials such as these can protect the lives of athletes. Could they also help protect the lives of military and law enforcement personnel?

4. Write your proposal and show it to another person for feedback.

CHAPTER 2 REVIEW



5A. UNDERSTANDING MATTER

- Matter is anything that has mass and takes up space. According to the particle model of matter, all matter is made of tiny particles (atoms and molecules) in constant random motion.
- The particle model of matter is very useful as it explains most of our observations about matter.
- Density is calculated by dividing the mass of an object by its volume.
- Mass is the amount of matter in an object, while weight is the force of gravity acting on that object.

24 Terms	25
law of definite proportions	26
particle model of matter	26
atom	27
molecule	27
mass	28
volume	28
density	28
weight	28

7A. CLASSIFYING MATTER

- We classify matter by its physical and chemical properties.
- Matter is classified as either a pure substance or a mixture.
- Pure substances (elements and compounds) contain only one type of substance.
- Mixtures (heterogeneous or homogeneous) are physical combinations of two or more substances in changeable proportions.



8A. STATES OF MATTER

- Particles in solids have low kinetic energy compared with the forces between particles. Solids have fixed shape and volume, high density, and low compressibility due to their close packing and low energy.
- Liquid particles have enough kinetic energy to overcome some of the forces between particles. Liquids have fixed volume, high density, low compressibility due to their close packing and low energy. They stay in their shape, but they can flow.
- Gas particles have sufficiently high energy to overcome all the forces between them. The particles' wide spacing causes gases to have low density and high compressibility. Their rapid motion allows them to fully occupy their container, to matter its shape or volume.

24 Terms	25
solid	33
liquid	33
gas	33
plasma	33

20 | REVIEW QUESTIONS

1. Explain what is happening to the particles in a solid as you melt it to its melting point.
2. Define boiling point.
3. Compare evaporation and boiling.
4. State the law of conservation of matter.
5. List the changes of state that involve adding energy.

Chapter Summary—handy statements of the big ideas of the chapter, including vocabulary lists.

REVIEW

23. What is the percent by volume of a solution made by mixing 140 mL of ethanol with enough water to form 1.0 L of solution?
24. Create a concept map using the terms solute, solvent, solution, solubility, concentration, concentration, dilute, unsaturated solution, saturated solution, supersaturated solution, percent by mass, percent by volume, and molarity.

Critical Thinking

25. Where would saturated, unsaturated, and supersaturated solutions be on the graph on page 220?
26. Calculate the percent by mass of 115 g of a solution that contains 142 g of solvent.
27. How many grams of salt should be added to 100 g of water to make a 14.3% salt solution?
28. Show how you could convert a percent by mass to a percent by volume. Show how you could convert mass and volume and related by density ($d = m/V$).
29. Some climates tell you that if they are 100 mL of a 0.5 M sugar solution with 100 mL of a 0.5 M sugar solution, they will have 200 mL of a 0.5 M solution. Are they correct? Explain.

Use the Case Study at right to answer Questions 29–32.

29. Which material is the solvent and which is the solute in the sap?
30. What process is being used to separate the water from the sucrose in the sap?
31. What is the percent by mass of sucrose when done?
32. Why does the boiling point rise while the water is boiling off?
- Use the Ethics Box below to answer Question 33.
33. Using the strategy presented in Chapter 3, write a one-page essay about how Christians should approach this issue.

Review Questions—questions that will have you recall facts, demonstrate your understanding of concepts, and cause you to use critical thinking

Case Studies—opportunities to apply what you have learned in physical science to a real-life example

Career Boxes—information about careers in physical science that can be pursued to wisely use God's world and help people

ETHICS POLLUTION

The Issue: Air Pollution

Air pollution is an issue in many areas around the world. The compounds that cause air pollution come from sources that are both natural (volcanoes, plants, and animals) and human (factories and motor vehicles). Factories, power plants, motor vehicles, and airplanes release many pollutants that are harmful to humans and the environment. The impact of air pollution can be seen in smog, acid rain, and global warming. Air pollution can damage both the natural environment and man-made structures. The health impact is enormous, increasing the number of cases of asthma and allergies as well as lung and heart disease. The World Health Organization estimates that air pollution causes about 7 million deaths each year.

Ethics Boxes—opportunities to apply a biblical worldview to ethical issues in physical science

Case Study: MAPLE SYRUP

Many people love the sweet taste of maple syrup, which is a mixture made of primarily sucrose and water. The syrup is made from the sap of the sugar maple tree. The sap is collected in late winter and early spring. All of the collected sap is then boiled, removing much of the water. The process is complete when the boiling point has risen to 104.1 °C. The final syrup contains about 65 g of sucrose for every 100 g of syrup.

Science as a Public Issue: KEEPING THE FOOD FLOWING

Natural gas, heating, ice cream—each is a fluid product that is transported through a complex system of pipes. Fluid engineers are mechanical or electrical engineers who specialize in designing pipe systems, designing a facility with efficient-sized tanks, storage tanks, and a maze of pipes connecting them is not as simple as it may seem. Many factors come into play, such as the temperature and viscosity of the product, pressure changes that occur when the diameter of a pipe changes, and choosing the most efficient route for pipes through a plant. Pipes full of liquid can be heavy, too, so the design must include sufficient support for all the equipment.



Pipe to his retirement, Dave Lombard served as a pipe engineer in California's agricultural rich Central Valley. He helped design many piping systems used in the processing and packaging of foods and beverages. Dave says, "I really enjoy how and how much work because everyone needs to eat. It's very fulfilling to be a part of that." If you like challenging work, a career in piping engineering might be a good choice for you!

You might expect that faster-flowing fluids have higher fluid pressures, but in fact they don't. They actually have lower fluid pressures. This relationship between the increasing speed of a fluid and its decreasing pressure is known as **Bernoulli's principle**. A Swiss mathematician, Daniel Bernoulli, described the phenomenon in 1738. Bernoulli's principle can be put to many practical uses. It partly accounts for the lift generated by aircraft wings. A curved upper wing surface is shaped so that air flows faster over the top of the wing, creating lower pressure on that side. How wind sprayers, used for applying fertilizers to lawns and gardens, operate on Bernoulli's principle too. Water passing over a tube inside the sprayer creates low pressure that draws the fertilizer up the tube and into the stream of water. The hourglass shape of a de Laval nozzle creates a region of low pressure in the exhaust gas of a rocket motor. The low pressure increases the speed of the exhaust gas, providing more thrust for a rocket.



16C | REVIEW QUESTIONS

- How does Pascal's principle explain the operation of a hydraulic lift?
 - What quantity remains constant within a fluid system regardless of the fluid's velocity or pressure?
 - State Bernoulli's principle.
24. The powerhead shown at right is a type of aqueduct pump that circulates water. If a piece of plastic tubing is inserted into the discharge pipe on the ground level, a stream of air can be drawn into the flowing water. Use Bernoulli's principle to explain how this is possible.



MINI LAB

BEADING LIGHT

Rainbows are created when white light from the sun is refracted and reflected by tiny water droplets in the atmosphere. The different colors within white light don't bend at the same rate, so they separate as they bend. You've probably seen a prism used to produce the same kind of separation. But once the colors are separated, is it possible to recombine them into all six light colors? Your teacher will use a light ray box and several kinds of lenses to help you think about the question.

Essential Question
Can a rainbow be undone?

1. Do the colors of light separated by the prism follow the progression described in Subsection 22.1?
2. On the basis of what you observe, which color of light is bent the most and which the least? How can you tell?
3. Do you think it will be possible to recombine the separated colors back into white light using a lens? If so, what lens do you think will work?
4. Describe how each kind of lens affects the separated colors.

CONCLUSION
Different kinds of lenses differ in how they bend light rays. As you read further, you'll learn about these different lenses and see how they can be used to benefit people.

In the example on the right, you can see how light bends as it passes through different media. The ray first bends as it passes from air into water because water's index of refraction is greater than air's. The ray is bent again as it passes into glass because glass has a greater index of refraction than water. Because the boundaries in this example are parallel, the ray returns to its original direction of travel as it passes out of the glass and back into air.

Total Internal Reflection
In some situations, a ray of light can't pass from one medium to another. Instead, the ray reflects off the boundary between the two media and remains within the first medium. This phenomenon is called **total internal reflection** (TIR). It happens when a light ray's angle of incidence exceeds a certain critical value when going from a medium with a lower index of refraction.

LIGHT AND OPTICS 116

Mini Labs—short hands-on activities to get you thinking and working like a scientist

How It Works—examples of physical science applications in everyday items

18C | USING SOUND WAVES

18.7 SOUND TECHNOLOGIES

Acoustic Amplification

Since sound is a form of energy, it makes sense that such energy can be put to good use. And indeed, not only people but animals too use sound energy for many purposes. In this section, we'll explore some of those uses.

Acoustic amplification is the process of making a sound louder. A megaphone is a simple kind of amplifier known as an acoustic horn. Normally when a person speaks, the sound waves of his voice spread out over a large area. A megaphone focuses that sound energy into one specific direction, making it sound louder. If you point the large end of a megaphone at the source of a sound and listen at the smaller end, the same thing happens. This is why people sometimes cup their ears to hear better. Amplification also happens in one enclosed space with hard surfaces, where sound reflection occurs easily.

HOW IT WORKS

Speakers
Many speakers are decorated with some strange terms: Woofer, midrange, tweeter...just what do these things mean? And how does a speaker work anyway? A speaker contains a cone (1) made of stiff material connected to a voice coil (2) made of wound copper wire. The voice coil is suspended inside a powerful circular magnet (3). An amplified electrical signal enters the voice coil, creating an electromagnet (see Chapter 15). The electrical signal causes the voice coil's magnetic field to rapidly change polarity many times per second. As this rapidly changing field interacts with the field of the magnet, the voice coil vibrates back and forth, the vibrating speaker cone pushes against the air, creating sound waves.

The size of the cone relates to the frequency of the tones produced. Large cones are needed to produce deep, low-frequency sounds—the bass end of what humans can hear. These speakers are the "woofers" in a small home speaker, "tweeters" are the small cones that produce high-pitched, high-frequency sounds. Larger speakers may have three or more cones, including mid-range cones. Each speaker can create able to reproduce the variety of tones carried by an electrical signal. Single cone speakers are limited in the range of frequencies that they can produce. They are often unable to produce some low and high end frequencies well.

188 CHAPTER 18

Science is a beautiful gift to
humanity; we should not distort it.

A. P. J. Abdul Kalam (1931–2015),
physicist, engineer, former president of India

