Contents

Contents

Contents

CASE STUDIES

ETHICS

Contents

Chapter 1

FOUNDATIONS OF CHEMISTRY

It all begins with a seemingly harmless mosquito bite. But if the mosquito is a host for microorganisms in the genus *Plasmodium*, which causes malaria, the person bitten could end up in a coma. A few days later, he might even be dead. Malaria is a scourge of the world's tropical and subtropical regions, threatening half the world's population. In 2017, about 219 million people were infected, leading to an estimated 435,000 deaths, mostly among children. Sub-Saharan Africa suffers the most due to weather conditions and bad sanitation practices that favor the most aggressive forms of malaria. But scientists, millionaires, politicians, and physicians from around the world have united in the fight against malaria. Their arsenal for vanquishing malaria is expanding with the help of chemistry. In 2015, regulators approved a vaccine for malaria—the first vaccine ever licensed for use against a human parasitic disease. Though the vaccine's success rate is low, it is still considered a major milestone toward eliminating the threat of malaria.

1.1 CHEMISTRY: MODELING MATTER

Chemistry and Worldview

QUESTIONS

- What do chemists study?
- How does worldview affect a chemist's work?
- What is modeling?
- Do scientific models reveal what is true about the world?
- How can Christians tackle ethical issues?

TERMS

chemistry • matter • worldview • model

Our world is full of significant problems that need answers—things like malaria, contaminated drinking water, pollution, and the need to increase crop production. Other problems are more a matter of convenience, like developing alternative fuels for our cars or making smaller and more lightweight computers. Chemistry can enable us to solve such real-world problems. The use of chemistry in this manner is known as *applied science*. But some chemists are engaged in *pure science*, which is an effort to understand how and why things work the way they do. Of course, the two kinds of science are not wholly separate from one another. Scientists must first discover the *how* and *why* of something before they can apply the knowledge gained to problem solving.

But what exactly is chemistry? **Chemistry** is the study of matter and the changes that it undergoes. **Matter,** as you recall from physical science, is anything that takes up space and has mass. You are sitting on, using, wearing, and eating chemicals all the time! This just shows you the scope and impact that chemistry can have on you for life.

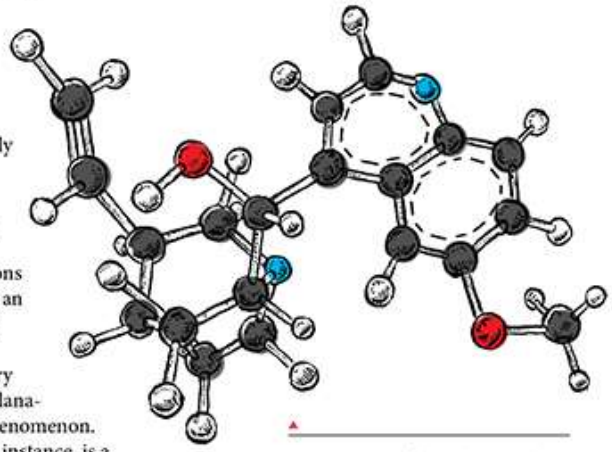
Christians can get excited about applying chemistry to solve problems like malaria. We can also find it very rewarding just to satisfy our curiosity about God's marvelous creation and how it works. The Bible gives us a distinct **worldview**, a perspective from which to see and interpret all of life. Your worldview is made up of what you believe about the most important things in life. Like a pair of glasses, the Bible brings every part of the world into focus, including chemistry. In this textbook, you'll be presented with opportunities to examine how chemistry and a biblical worldview fit together.

Chemistry as Modeling

Chemistry is all about *modeling*. Like all other areas of science, it relies on our observations of the world. But we are limited in our abilities, especially when it comes to relating observations to explanations. To understand complicated things about the world, we have to simplify a problem by leaving some information out. This means that sometimes explanations may not be fully exhaustive—they provide an overall picture of a phenomenon but often omit some finer details.

Scientists have created models for every area of science. A **model** is a workable explanation, description, or representation of a phenomenon. A model of a quinine molecule (right), for instance, is a simplified representation of an actual molecule. People make models all the time to predict the path that a hurricane will take, the reaction when an acid and base are mixed, and changes in climate. Scientific knowledge can be really useful in the framework of an explanatory model.

What is chemistry?



Quinine is one of the oldest medicines used to treat malaria. Each ball in this model represents a different element. This model relies on another model: the atomic model.

Physicist and Nobel Prize recipient Richard Feynman said, "What I cannot create, I do not understand." He also said, "Scientific knowledge is a body of statements of varying degrees of certainty—some most unsure, some nearly sure, but none absolutely certain. Now, we scientists are used to this, and we take it for granted that it is perfectly consistent to be unsure—that it is possible to live and *not know* [italics added]." Feynman summed up an important aspect of science: Science is not about establishing what is true. It is about producing workable models. Only God's Word can tell us what is true.

So how are scientific models useful? Models are essential to solving problems in the world for two reasons. First, they are workable—they help us make sense of data. Second, they have predictive power. They can help us to see what could happen in the future. Models like the atomic model are the foundation of modern chemistry. Feynman used the atomic model when he participated in the Manhattan Project, the secret program that developed the atomic bomb during World War II.

Chemistry IN HISTORY

Chemistry developed over time, often for purely practical reasons. People needed clothing, food, tools, and medicines to make life easier in a world full of discomfort and disease. But people have not always viewed and studied chemistry the way we do now. They had very different ideas about the nature of matter and the changes that it undergoes.

Ancient Chemistry

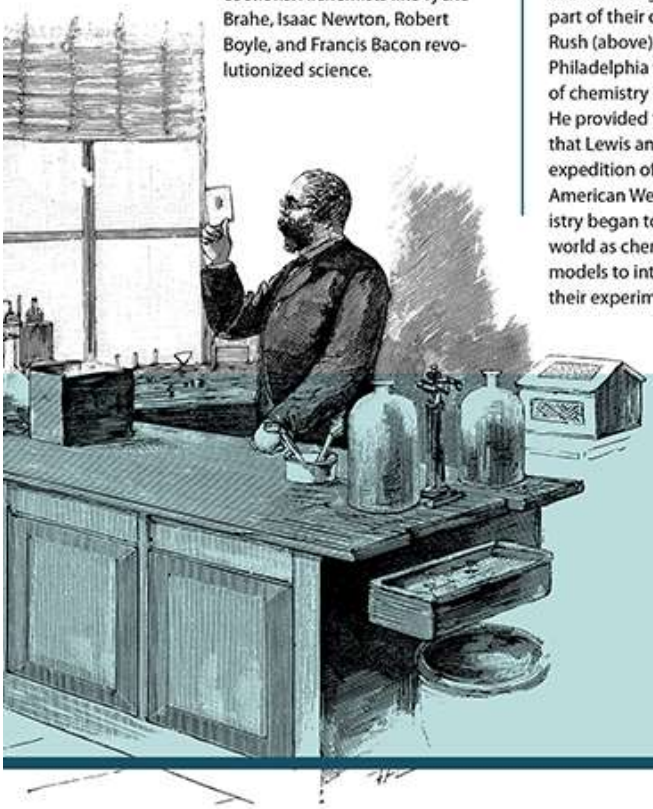
The Bible mentions that even as early as five generations after Cain men began to work with metals. Egypt during Joseph's time had a culture that understood and used the medicines of early pharmacists called *apothecaries*. The "science" of chemistry in ancient times involved a lot of trial and error!

The Philosophers

The ancient Greeks went a step beyond just learning how to use matter—they also applied reasoning to think about the nature of matter. Eventually, the idea that matter was made of atoms rose from this Greek culture. But the Greeks never made it to the laboratory. Their experiments were only in their minds.

The Alchemists

Chemistry as practiced by ancient civilizations, though robustly scientific in many ways, included a strong element of superstition. Eventually, a new emphasis on experimentation led to a surge of scientific discoveries. The odd blend of astrology and mysticism with observation and experimentation was called *alchemy*. Alchemists searched for immortality through medicines, tried to change common metals to gold, and experimented to discover the nature of the elements. They even developed secret languages to encode their recipes for different concoctions. Alchemists like Tycho Brahe, Isaac Newton, Robert Boyle, and Francis Bacon revolutionized science.



Classical Chemistry

By the mid-1600s, widespread acceptance of a new method of scientific inquiry led to rapid developments in chemistry. Elements were redefined and chemists began isolating them in the laboratory. By 1800 chemistry had become an established academic discipline. In America, several colleges made chemistry a part of their curriculum. Benjamin Rush (above) of the College of Philadelphia was the first professor of chemistry in the United States. He provided the medications that Lewis and Clark took on their expedition of discovery in the American West. Branches of chemistry began to develop around the world as chemists used atomic models to interpret the results of their experiments.

Modern Chemistry

The study of chemistry thrives today. People still need clothing, food, tools, and medicines to make life easier in a world full of discomfort and diseases like malaria. But though we do chemistry for the same reasons, we use different models to interpret what we observe about the nature of matter and the changes that it undergoes.

Models and Worldview

Scientists use the models they create within their worldviews, and worldview affects how they interpret evidence and make sense of things. Many scientific models fit within a biblical worldview, but some do not. Some scientists create and promote models that describe the world in ways that do not agree with the Bible. They may even try to use their models to show that the Bible is not true. For example, many scientists believe that life evolved from nonliving compounds. People who believe the Bible cannot accept this because the Bible traces all living things to God's special Creation by His Word. Scientists with a biblical worldview try to create models that accurately model the world and are also faithful to the Bible. An example of this is the catastrophic plate tectonics model, which models how the earth's surface changed very quickly after the Flood.

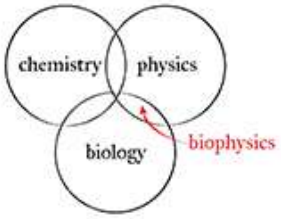
Chemists throughout history have developed and refined the models that we use now to understand matter and the changes that it undergoes. Without useful models, scientists are powerless to understand the world and solve problems that really matter, like the scourge of malaria.

1.1 SECTION REVIEW

1. State a definition of chemistry.
2. What reasons can you give for people to pursue discoveries in chemistry?
3. How does a scientist's worldview affect the way that he does science?
4. Evaluate the statement, "Scientific models reveal what is true about the world."
5. How has human history affected the development of chemistry? Think about the places where chemistry has advanced over time.

6. Do an online search for "history of chemistry." Use this information to create a timeline of key dates in chemistry's history. For historical context, include a few other significant dates in your timeline such as the birth of Christ, fall of Rome, Protestant Reformation, American Revolution, Civil War, end of World Wars I and II, or fall of the Soviet Union.

7. Research the following fields in chemistry and fit them into the Venn diagram below: inorganic chemistry, organic chemistry, biochemistry, nuclear chemistry, physical chemistry, and analytical chemistry. Biophysics has been done as an example for you.



8. Many scientists have a worldview that rejects any supernatural explanation for either the original creation or the development of life on Earth. Scientists who hold to this *naturalistic worldview* usually believe that the universe is the result of the big bang and that all life on Earth has evolved from primitive to more complex forms. Can such a worldview be used as the basis for justifying the expense of developing vaccines? Explain.

MINILAB

SEEING IS BELIEVING?

You may have heard that the process of science involves making observations. One type of observation is simply seeing something with our own eyes. But can we always rely on what our eyes seem to be telling us about something?

Can we rely on our senses to discover truth?

EQUIPMENT

- none

Procedure

A Allow your eyes to scan back and forth over the image at right.

1. What color(s) do the dots appear to be while you are scanning?
2. As you are scanning, do the dots appear to remain the same color?

B Now focus on a single dot.

3. What color is the dot that you focused on?

C Now focus on another dot.

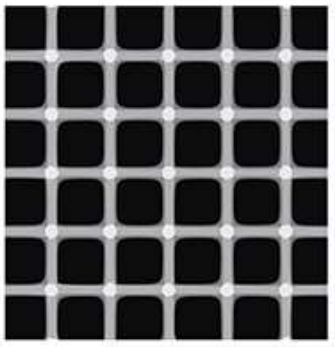
4. What color is the second dot?
5. What color are *all* of the dots in the image?

Conclusion

6. How did your initial observation of dot color compare with a more careful examination of each dot?

Going Further

7. In what way(s) do you think this activity is similar to the modeling nature of science?



Optical illusions work through a variety of methods, but each produces a perception that is different than reality. Natural phenomena can fool our sense of perception as well, which is why good science relies on multiple strands of evidence. Mathematical tools such as statistical analysis also help us find order in situations that our natural senses can't perceive.