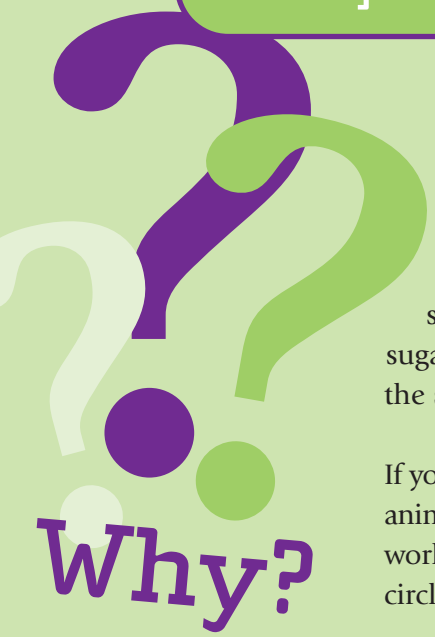
Chapter 1

WHY SCIENCE?

COPYRIGHTED MATERIAL

Chapter 1 – *Why Science?*



First Scientists

At one time in your life, you probably drove everyone around you crazy because you kept asking "Why." Why is water wet? Why does it become a solid at cold temperatures? Why does sugar disappear when I put it in water? Why can't I eat as much sugar as I can possibly stuff in my mouth? And, of course, why is the sky blue?

If you observe a kitten or a puppy, you will see the same curiosity. Young animals will poke their noses into everything to learn more about their world. A kitten may become so curious about its tail that it will spin in circles trying to catch it. Curiosity can be a lot like playing.

Curiosity has helped humans become very successful as a species. Because we can learn about our world and teach each other what we have learned, we have been able to spread to all parts of our planet. We have figured out ways to live in deserts, rainforests, mountaintops, and snow. We have figured out how to hunt fierce animals, stay warm, and grow our own food.

BIG IDEA

Curiosity helped humans succeed as a species.

Our earliest ancestors included scientists. These early scientists did not wear white laboratory coats. Still, we can call them scientists because they carefully observed their environments, and they experimented with the best ways to get food, build shelters, and heal each other. Like scientists today, our ancestors communicated what they learned, and used their group knowledge to explain the past. They could even begin to predict the future.

About 2,000 years ago, the Maya in Central America used detailed observations of the Sun, Moon, and Venus to develop a very accurate calendar. They could predict eclipses of the Sun and Moon, as well as easily know the beginnings of the four

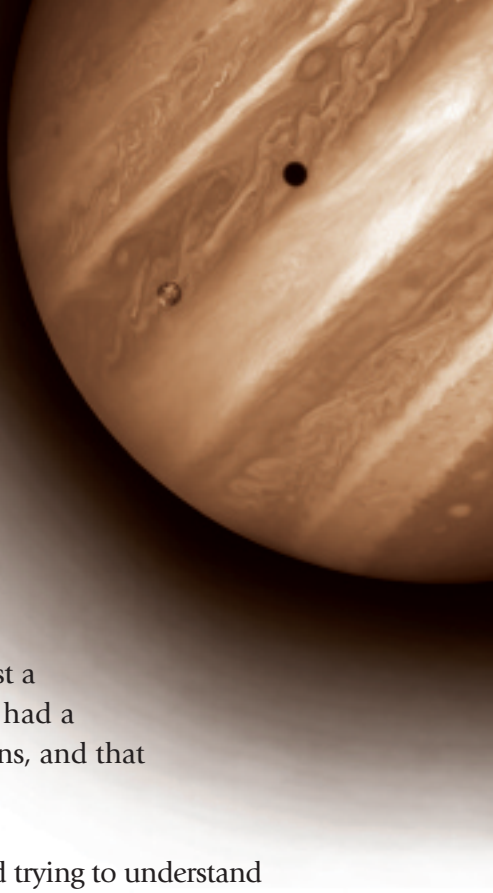
different seasons. Without metal tools or wheels, they built huge, marvelous structures that still stand today.

One of the most famous Mayan structures is a pyramid called El Castillo where the Maya combined their calendar knowledge with their building skills. One special feature of this building is that at the start of spring and autumn, the sunlight catches the top of the edge of the western stairway. The sunlight then descends the edge of the staircase and reaches a carved serpent's head at the bottom. This special effect makes it appear as if a long serpent is creeping down the stairway (the photo above shows people still coming today to stare at the "light snake" descending the stairs on the left side of the pyramid).

Like the Maya, people all over the planet were using science skills to succeed in their different environments. However, modern science did not begin until about 500 years ago in Europe. In that time and place, people began using more tools, mathematics, logic, and communication than they ever had before to ask and answer questions about the world.

Like other humans, European scientists were trying to understand the Sun, Moon, stars, and planets. In the year 1609, the telescope had just

We have figured out ways to live in deserts, rainforests, mountaintops, and snow.



been invented in Holland. Galileo, in Italy, read about it on the Internet, and that same year made a telescope that was seven times stronger.[1] In 1610, carefully examining the night sky with his new tool, he became the first person to see small dots traveling around Jupiter.

By carefully observing these dots and how they traveled, he proved that they were four different moons of Jupiter, and that each one had its own path around that distant planet.

This was the first time that humans knew that our Moon is not the only moon, and that Earth is not the center around which everything moves. At that time, almost everyone believed that the Sun and the planets all traveled around the Earth. Earth was not just a planet. It was the center of everything. It was the only thing that had a moon. Now we knew that at least one other planet has moons, and that those moons travel around Jupiter, not around Earth.

Soon, people all over Europe were using telescopes, and trying to understand everything that they could see. Watching these four moons travel around Jupiter helped humans realize that Earth travels around the Sun. We realized that Earth and the other planets travel around the Sun. This new understanding was a huge change from the old belief that the Sun and all the planets travel around Earth.

BIG IDEA

The telescope changed the way we see ourselves.

The telescope taught us a huge science lesson about our place in the universe. Even more important, science developed from this way of combining observations, tools, logic, mathematics, and communication. As science grew, it became more than a way to satisfy our curiosity. Science could save lives.

Curiosity Saved The Human

Without science, I would not be alive today, which means you would not be reading this book. When I was three years old, I had a dangerous ear infection, and I was rushed

[1] Just kidding. The first telephone, electric lines, and computers would not be invented until hundreds of years later. The STOP & THINK section at the end of this chapter explains why this science book has "just kidding" things in it.

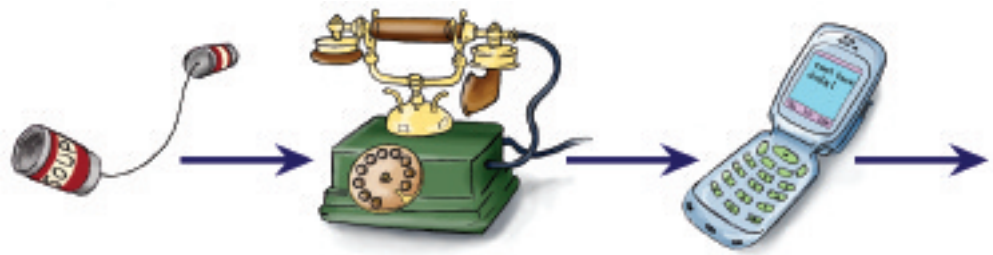
by ambulance to the hospital. I had a very high fever, and the infection was moving toward my brain. Fortunately, about 20 years before I was born, a scientist named Alexander Fleming had discovered natural antibiotics. Just a couple of years before I came into the world, scientists figured out how to make enough of these drugs to treat sick people. Penicillin, the first antibiotic discovered by scientists, saved my life.

Science and technology have continued to change practically everything about our lives. The food we eat, how we cook it, how we prevent and cure diseases, and how we entertain ourselves have all changed in amazing ways since the 1950s when I was a mischievous teenager.

Think about how we communicate with each other. My 1950s apartment had only one telephone. If I wanted to use it, I had to stand right next to its location on the kitchen wall. And sometimes I could not use it because we had a party line.

Party lines were not fun. Since there were not enough phone lines to serve everybody, we had to share our phone line with two other households that we did not even know. If I picked up the phone and heard a voice, I had to wait for someone from one of those other homes to hang up before I could use the phone.

We never dreamed that one day we could have phones to take with us wherever we went. Probably nobody in the 1950s imagined that future phones could be mobile, take photographs, and send those



Tilly Smith, a ten year-old British schoolgirl, was playing with her family on Maikhao Beach in Thailand on December 26, 2004. She noticed that the water "started to go funny." Remembering a science lesson she had learned in school just 2 weeks earlier, she screamed at her family to get off the beach because a tsunami could be coming.

The Smiths ran off the beach, and warned other people. They raced to their hotel, and went up to the third floor. There they watched in horror as three tsunami waves crashed into the hotel. The beach and hotel swimming pool filled with surging water, palm trees, beds, and other debris.

British newspapers reported that Tilly's science knowledge and quick actions had saved herself, her family, and 100 other people.

photos with text messages to people all over the world. That was too far out a fantasy for any of us to imagine.

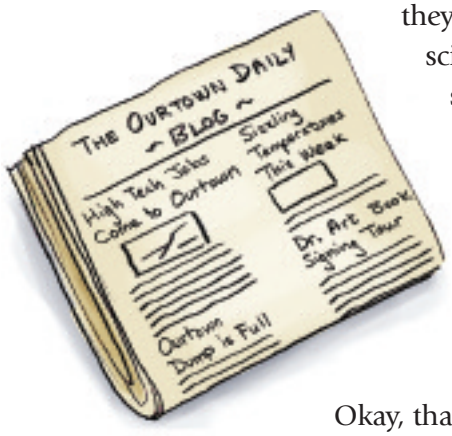
Why Should We Learn Science?

While science makes it possible to have antibiotics, cell phones, and computers, you don't need to understand science to be able to use these modern miracles. Yet, our society has decided that everybody who goes to school needs to learn science. Nations all around the world test their students in science, and compare the scores to keep track of how well their students know science. In the United States, political and business leaders are very concerned because tests show that American students perform poorly in science compared with students from many other countries.

Knowing science will help you make the best decisions for your community, your country, and the planet.

Still, that does not answer the question—why do we need to learn science? Business leaders know that many jobs require a solid science background. They complain that they have a hard time finding workers who have strong enough science skills and knowledge. From your point of view, this means that knowing science can help you get some very interesting, satisfying, enjoyable, and well-paying jobs.

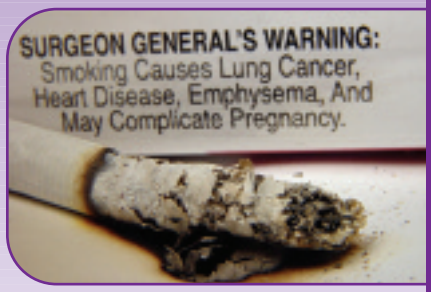
I have one of those kinds of jobs. I work as a science educator, which means that I have training and experience in both science and teaching. As a science educator, I help teachers learn the science they need to know, and I help them learn the best ways to teach science knowledge and skills. I also help states decide what science topics and skills to teach at different grade levels.



Science educators agree that studying science can help students get much better jobs. But we think there is an even more important reason why everyone needs to understand science. It is so science educators like us can have jobs and sell books about learning science.

Okay, that is not our main reason. Science educators think that people need to understand science so they can make the best decisions for themselves, for their family and local community, for their country, and

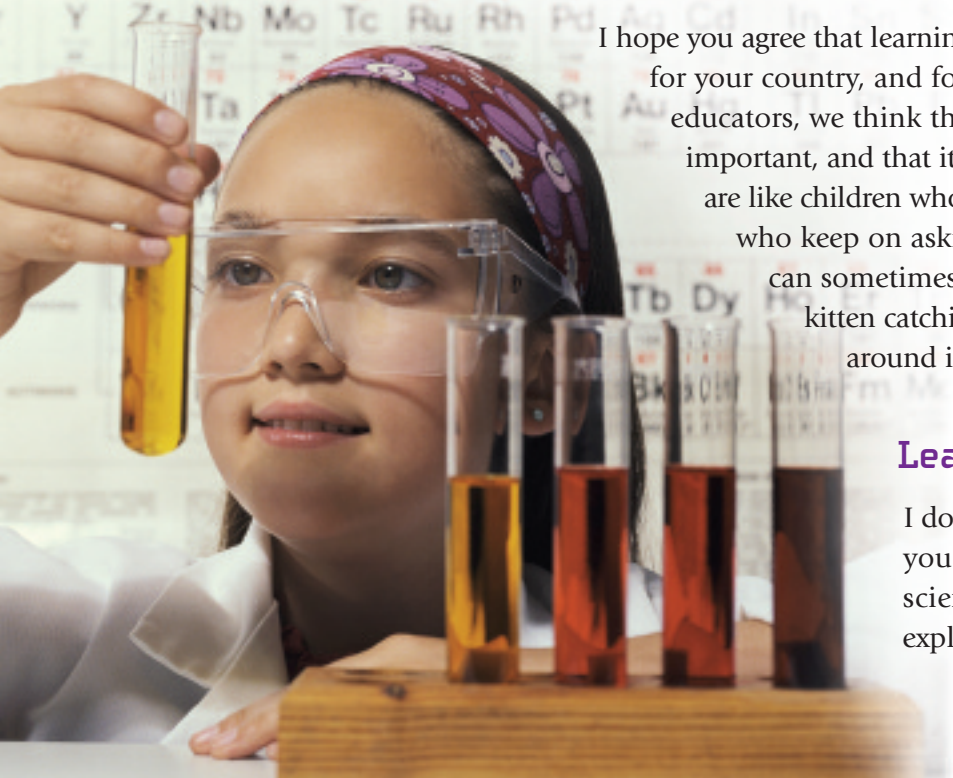
for the one planet that is our home. We call this "science literacy for citizens."



Knowing science will help you make the best decisions for yourself.

Science can help you make the best decisions for yourself. What kind of food should you eat? How can you stay healthy, and what should you do if you have different kinds of illness? How do smoking cigarettes or taking other drugs affect your body? If you hear about something from a friend or television or the Internet, how can you check if it is true or not? Should you use astrology to decide if someone would be a good friend, or even a possible romantic interest?

Science can help you answer those questions about your personal decisions. We also think that science can help you make the best decisions for your local community, your country, and for the planet. Should you care about how much energy and water you use? Should your community provide public transportation, and what would be the best ways? What should be done with all the waste products that your family/town/city produces? Are humans changing Earth's climate? If yes, should you do something about it, and what should you do?



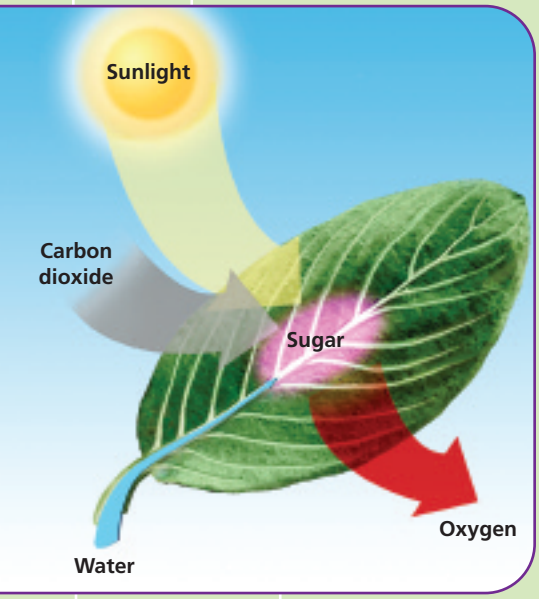
I hope you agree that learning science is good for you, for your country, and for the world. As science educators, we think that learning science is important, and that it is fun. In a way, scientists are like children who never lose their curiosity, who keep on asking why. In science, you can sometimes have as much fun as a kitten catching her tail after running around in a circle.

Learning Science

I don't know what experiences you have had in learning science. I hope that you have explored science topics with

your hands and with your mind. Science involves carefully observing the world and testing ideas to figure out how things work.

While I am a great believer in learning science by doing experiments, this book has very few experiments in it. Instead, the companion website (www.guidetoscience.net) includes experiments, animations, and other features that can take you deeper into the science. This book, *Dr. Art's Guide to Science*, provides the science background that you need, explaining the biggest ideas in science and how these ideas all fit together. These big ideas will help you understand what science is all about. As you read this book, things that you studied in school or saw on television will probably make sense to you in new and surprising ways. You may even discover that reading this book will change how you think about yourself and the world.



As an example of what I mean, let's consider a big science idea called **photosynthesis**. Photosynthesis is what plants do to be able to live. Unlike animals, plants do not eat. Instead of eating, they use the energy from sunlight to make sugar. Plants then use this sugar to make all the chemicals and get all the energy they need.

By doing photosynthesis, plants take carbon dioxide gas from the air and combine it with water to make sugar. As shown in the illustration, they do this by capturing the energy from sunlight. Another very important part of photosynthesis is that plants give off oxygen as a result of this process.

Since science depends so much on accurate communication, scientists pay a lot of attention to the words they use. For example, in describing how plants get their energy, they did not want to always have to say "you know, the thing that plants do when they use the energy from sunlight to make sugar from carbon dioxide and water." So, they call it photosynthesis. Even though it is a 5-syllable word, it is still a lot shorter. Plus the name fits the process that it is describing. "Photo" means light, and "synthesize" means to make (you may have heard

the word "synthetic," which means something that is made out of materials that humans have made).

Photosynthesis is so important that textbooks and school systems want to make sure that students know the word. They usually do that by asking a test question that looks like this:

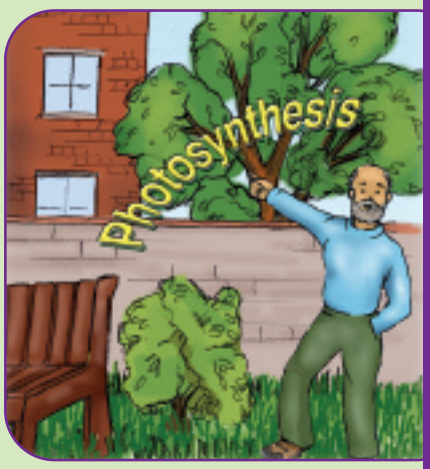
The process by which plants use energy from the Sun to make sugar is called

a) perspiration
b) respiration
c) photosynthesis
d) aggravation
e) photolysis

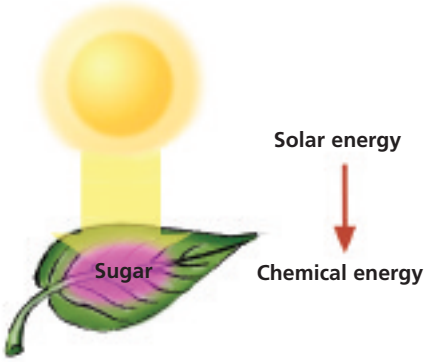
I agree that you should know and recognize the word photosynthesis. However, if you just learn it as a vocabulary word that you have to memorize, you are not going to understand it because all you have done is memorize a word and some phrases that are associated with that word (make sugar, energy from sunlight). Then, you will forget the word because it is too hard to remember a word that you do not really understand, especially when you keep getting new words to memorize.

In contrast, science is about understanding. Memorizing some words is necessary, but understanding is the most important part.

What would it mean to really understand photosynthesis? First of all, it is not just a word in science textbooks. Photosynthesis happens all around you. Look at the sunlight shining on a green plant, tree, bush, or blade of grass. Every one of these plants is doing photosynthesis as you are watching it.

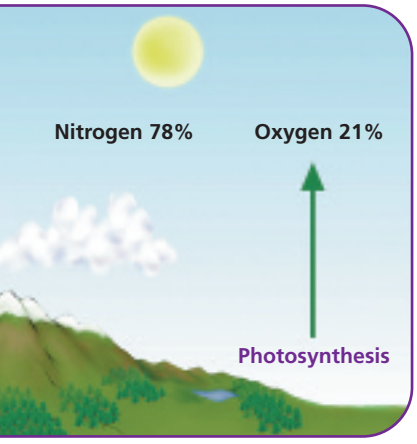


1 Photosynthesis happens all around us.



2 Solar energy is packaged as chemical energy.

Second, through photosynthesis, plants take light energy from the Sun and package it as chemical energy in sugar. No animal can perform this remarkable feat. All of us animals depend on plants to capture the Sun's energy and store it in a form that we can use. From the point of view of Earth's organisms, photosynthesis is the most important thing that any organism does. Plants need photosynthesis to live, and so do we.

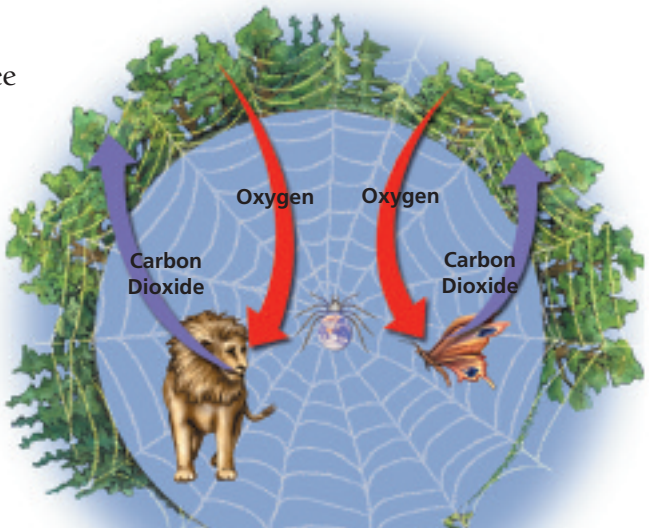


3 Photosynthesis makes the oxygen we breathe.

Third, plants give off oxygen as a result of photosynthesis. Earth's original atmosphere did not have oxygen gas. Today, oxygen makes up 21% of our atmosphere. All that oxygen got into the atmosphere as a result of photosynthesis. Not only does this 5-syllable word explain where animals get their food, it also explains how we get the air that we breathe.

Try to remember to stop the next time you pass some grass, bushes, or trees in the sunlight. Even though you cannot see it, that green living being is putting oxygen into the air around you. You breathe in that oxygen and breathe out carbon dioxide. The plant takes in the carbon dioxide to make the food that supports the communities of living organisms. You are very tightly connected with plant life. Plants and animals are partners in Earth's web of life.

Most of us live in cities and suburbs where we mainly see the human-made world rather than the world of nature. Eating food from supermarkets and restaurants and spending our time in buildings and vehicles,



we may never know a very important part of who we are. By studying photosynthesis, we learn a huge lesson about ourselves. Like all animals, we depend on plants and the Sun's energy. We are all part of Earth's web of life.

The Science Coming Of Age Story

In most cultures, young people have "coming of age" experiences. Their parents and the wise leaders of their community make sure they know the history, customs, and rules of their group. You may have experienced this through your religion or through a community social group.

We live in a science-based society. Practically everything that we touch and do has been shaped in some way by science. However, I bet that you did not have a science "coming of age" experience. Nobody said to you, "We think it is time to make sure that you know what science says about where we came from, who we are, and where we are going."

Well, it turns out that science has an amazing and inspiring description of where we came from, who we are, and where we are going. That is what I hope you will find in this book.

Some of you know that you are already interested in science. That is great. I hope this book takes that interest further and into surprising directions. Some of you may think you are not interested in science. Perhaps you had bad or no experiences with science. Try to read this book with an open mind. As John Lennon, one of the famous rock and roll Beatles, wrote in a song, "Give Science a Chance."

STOP & THINK

You probably have much more experience reading fiction books than a nonfiction book like this. Of course, the actual process of reading the words is the same. Don't get fooled by that. It takes some different reading skills to get the most enjoyment and learning from a nonfiction book.

With a good fiction book, sometimes you want to read faster and faster. What is going to happen next? Will the heroine escape? You forget about yourself, and escape into a fantasy world that the author has created.

With this book, I don't want you to forget about yourself. I want you to be aware of what you are thinking and what you know. As you read, I hope you are figuring out if the ideas make sense to you or not. Are they totally new ideas? Do they fit with what you know? Do they make you think about something in a new way?

You might find yourself reading slower and slower, rather than faster and faster. You might read about a new idea, and then go back a page or more to see how this new idea connects with something you read before. This book will not help you escape into a fantasy world. Instead, I want to take you deeper into reality, and show you how to look at the world with different eyes.

You may remember that I pretended that in 1609 Galileo found out about the telescope by reading about it on the Internet. No way! He lived about 350 years before the first home computer. Why did I do that?

One reason is that I have a weird sense of humor. I admit that. Another reason is that I want to remind you to think about what you are reading. Watch out for my tricks. I will never lie to you about something important, but I will put in "just kidding" stuff like Galileo using the Internet. In case you are not sure, the guidetoscience website has a "just kidding" section where I will admit to all my mischief, such as the title of John Lennon's song.

By the way, "Think about what you are reading" is good advice for other things that you read. Especially if they do not have a "just kidding" section.