Exploring Creation With General Science

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MODULE #1: A Brief History of Science

Introduction

This course will take you on a tour of what I consider to be the most interesting of all human endeavors: **science**. Now, of course, I am well aware that many people (perhaps even you) do not think science is interesting. Nevertheless, I do believe that most people's dislike of science comes from bad curriculum and/or bad teachers, not the subject itself. Hopefully, as you go through this course, you will see why I find science so incredibly interesting, and if nothing else, you will at least develop an appreciation for this fascinating field of study.

So what is science, anyway? Well, the word "science" comes from the Latin word "scientia" (sye en' tee uh), which means "to have knowledge." It can be generally defined as follows:

Science – An endeavor dedicated to the accumulation and classification of observable facts in order to formulate general laws about the natural world

That's a nice definition, but what does it mean? It means that the *purpose* of science is to develop general laws that explain how the world around us works and why things happen the way they do. How do we accomplish such a feat? That's where the "accumulation and classification of observable facts" comes in. The *practice* of science involves experimentation and observation. Scientists observe the world around them and collect facts. They also design experiments that alter the circumstances they are observing, which in turn leads to the collection of more facts. These facts might eventually allow scientists to learn enough about the world around them so they can develop ideas that help us understand how the natural world works.

As is the case with any other field, the only way to truly understand where we are in science today is to look at what happened in the past. The history of science can teach us many lessons about how science should and should not be practiced. It can also help us understand the direction in which science is heading today. In the end, then, no one should undertake a serious study of science without first taking a look at its history. That's where we will start in the course. This module will provide you with a brief history of human scientific inquiry. If you do not like history, please stick with this module. You will start to sink your teeth into science in the next module. Without a historical perspective, however, you will not fully appreciate what science is.

The First Inklings of Science (From Ancient Times to 600 B.C.)

Some of the earliest records from history indicate that 3,000 years before Christ, the ancient Egyptians already had reasonably sophisticated medical practices. Sometime around 2650 B.C., for example, a man named **Imhotep** (eem' oh tep) was renowned for his knowledge of medicine. People traveled from all over the Middle East to visit Imhotep, hoping he would cure their illnesses.

Most historians agree that the heart of Egyptian medicine was trial and error. Egyptian doctors would try one remedy, and if it worked, they would continue to use it. If a remedy they tried didn't work, the patient might die, but at least the doctors learned that next time they should try a different remedy. Despite the fact that such practices sound primitive, the results were, sometimes, surprisingly effective. For example, Egyptian doctors learned that if you covered an open wound with moldy

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bread, the wound would heal quickly and cleanly. As a result, most Egyptian doctors applied moldy bread to their patients' wounds. Modern science tells us that certain bread molds produce **penicillin**, a chemical that kills germs that infect wounds! Thus, even though the Egyptian doctors knew *nothing* about germs, they were able to treat wounds in a way that helped avoid infections!

Another example of the surprisingly effective art of ancient Egyptian medicine can be seen in the way they treated pain. In order to relieve a patient who was in pain, Egyptian doctors would feed the patient seeds from a flowering plant called the **poppy**. Eating these **poppy seeds** seemed to relieve the patient's pain. Modern science tells us *why* this worked. Poppy seeds contain both **morphine** and **codeine**, which are excellent pain-relieving drugs still used today!

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FIGURE 1.1
Natural Remedies Used By Ancient Egyptians

Poppy photo © Tihis
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Since some bread molds produce germ-fighting chemicals, they can aid in healing wounds.

Poppy seeds (and other parts of the plant) contain chemicals that help relieve pain.

Why was Egyptian medicine advanced compared to the medicine of other ancient nations? Well, at least one reason was the Egyptian invention of **papyrus** (puh pye' rus).

<u>Papyrus</u> – An ancient form of paper, made from a plant of the same name

As early as 3,000 years before Christ, Egyptians took thin slices of the stem of the papyrus plant, laid them crosswise on top of each other, moistened them, and then pressed and dried them. The result was a form of paper that was reasonably easy to write on and store.

The invention of this ancient form of paper revolutionized the way information was transmitted from person to person and generation to generation. Before papyrus, Egyptians, Sumerians, and other races wrote on clay tablets or smooth rocks. This was a time-consuming process, and the products were not easy to store or transport. When Egyptians began writing on papyrus, all of that changed.

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Papyrus was easy to roll into scrolls. Thus, Egyptian writings became easy to store and transport. As a result, the knowledge of one scholar could be easily transferred to other scholars. As this accumulated knowledge was passed down from generation to generation, Egyptian medicine became the most respected form of medicine in the known world!

Although the Egyptians were renowned for their medicine and for papyrus, other cultures had impressive inventions of their own. Around the time that papyrus was first being used in Egypt, the Mesopotamians were making pottery using the first known potter's wheel. Not long after, horse-drawn chariots were being used. As early as 1,000 years before Christ, the Chinese were using compasses to aid themselves in their travels. The ancient world, then, was filled with inventions that, although they sound commonplace today, revolutionized life during those times. These inventions are history's first inklings of science.

As you progress through this course, you will see that it is divided into sections. Usually, at the end of each section, you will find one or two "On Your Own" questions. You should answer these questions as soon as you come to them in the reading. They are designed to make you think about what you have just read. These questions are often not very easy to answer, because you cannot simply look back over the reading and find the answer. You must *think* about what you have learned and make some conclusions in order to answer the question. You will find your first such question below. Answer it on a separate sheet of paper and then check your answer against the solution provided at the end of this module.

ON YOUR OWN

1.1 Although the ancient Egyptians had reasonably advanced medical practices for their times, and although there were many inventions that revolutionized life in the ancient world, most historians of science do not think of Egyptian doctors and ancient inventors as scientists. Why? (Hint: Look at the entire definition of science.)

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True Science Begins to Emerge (600 B.C. to 500 A.D.)

As far as historians can tell, the first true scientists were the ancient Greeks. Remember, science consists of collecting facts and observations and then using those observations to explain the natural world. Although many cultures like the ancient Egyptians, Mesopotamians, and Chinese had collected observations and facts, they had not tried to use those facts to develop explanations of the world around them. As near as historians can tell, that didn't happen until the 6th century B.C., with three individuals known as **Thales**, **Anaximander** (an axe' uh man der), and **Anaximenes** (an axe' uh me' neez). Many historians view these three individuals as humanity's first real scientists.

Thales studied the heavens and tried to develop a unifying theme that would explain the movement of the heavenly bodies (the planets and stars). He was at least partially successful, as history tells us he used his ideas to predict certain planetary events. For example, he gained a great reputation throughout the known world when he correctly predicted the "short-term disappearance of the sun." What he predicted, of course, was a solar eclipse, an event in which the moon moves between the earth and the sun, mostly blocking the sun from view.

Anaximander was probably a pupil of Thales. He was much more interested in the study of life, however. As far as we know, he was the first scientist who tried to explain the origin of the human race without reference to a creator. He believed that all life began in the sea, and at one time, humans were actually some sort of fish. This idea was later resurrected by other scientists, most notably Charles Darwin, and is today called evolution. Later on in this course, I will discuss evolution, showing how the data we currently have do not support it.

Anaximenes was probably an associate of Anaximander. He believed that air was the most basic substance in nature. In fact, he believed all things were constructed of air. When air is thinned out, he thought, it grows warm and becomes fire. When air is thickened, he thought, it condenses into liquid and solid matter. We know, of course, that these ideas are wrong. Nevertheless, his attempts to explain all things in nature as being made of a single substance led to one of the most important scientific ideas introduced by the Greeks: the concept of **atoms**.

Leucippus (loo sip' us) was a Greek scientist who lived perhaps 100 to 150 years after Anaximenes. Although little is known about him, historians believe that he built on the concepts of Anaximenes and proposed that all matter is composed of little units called "atoms." As a result, Leucippus is known as the father of atomic theory. The works of his student **Democritus** (duh mah' crit us) are much better preserved.

Democritus used the following illustration to communicate his ideas about atoms: Think about walking towards a sandy beach. When you are a long way from the beach, the sand looks like a smooth, yellow blanket. As you get closer to the beach, you might notice that there are bumps and valleys in the sand, but the sand still looks solid. When you reach the beach and actually kneel down and examine the sand, you find that it is not solid at all. Instead, it is composed of tiny particles called "grains."

Democritus believed that all matter was similar to sand. Even though a piece of wood appears to be solid, it is, in fact, made up of little individual particles that Democritus and his teacher called atoms. Perform the following experiment to see the kind of observation best explained using the concept of atoms.

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EXPERIMENT 1.1
Density in Nature

Supplies

- Vegetable oil
- Water
- Maple or corn syrup
- A grape
- A piece of cork
- An ice cube
- A small rock
- A tall glass
- Eye protection such as goggles or safety glasses

Introduction: Observations such as the ones you will make in this experiment are easy to explain when you assume the existence of atoms.

Procedure:

1. Take the glass and fill it about ¼ of the way with the vegetable oil.
2. Add an equal amount of water to the glass.
3. Add an equal amount of maple syrup to the glass.
4. Now look at the glass from the side. What do you see? In your laboratory notebook, make a sketch of what you see.
5. Drop the rock, the grape, the ice cube, and the piece of cork into the glass. Now what do you see? Add the rock, grape, ice cube, and cork to the sketch you made in step 4.
6. Clean up your mess and put everything away.

What did you see in the experiment? If everything went well, you should have seen that the liquids formed layers in the glass. The vegetable oil formed a layer on top, the water layer was in the middle, and the syrup layer was at the bottom. In addition, the cork should have floated on top of the vegetable oil; the ice cube should have floated on top of the water layer; the grape should have floated on top of the syrup layer, and the rock should have sunk to the bottom of the glass.

How in the world is this experiment evidence for the existence of atoms? Well, according to Democritus, the water, vegetable oil, and syrup are all made of individual particles called atoms. The way those atoms are packed together will determine each object's characteristics. For example, assuming that the atoms in water are packed more closely than those in vegetable oil, the water will be able to pass between the atoms in the vegetable oil, sinking to the bottom of the glass. In the same way, the atoms in the syrup are more tightly packed than those in water or vegetable oil, so the syrup's atoms were able to fall in between the atoms of both the vegetable oil and the water to land at the bottom of the glass.

Even solid objects are made up of atoms. Thus, the cork's atoms are packed together very loosely. As a result, the cork doesn't have much weight and cannot push its way through the atoms in the vegetable oil. That's why it floats on top of the vegetable oil. The atoms in the ice cube, however, are more tightly packed and make the ice cube heavy enough to push the atoms in vegetable oil out of the way. This allows it to sink through the vegetable oil. However, they are not tightly packed enough to allow the ice cube to push through the atoms in the water.

If substances were not composed of smaller particles (like atoms), it would be hard to understand how one substance could pass through another substance. However, if you imagine every substance to be made up of little grains (like sand), then passing through a substance would just be a matter of fitting between the grains or pushing the grains out of the way. Thus, if you assume the existence of atoms, results of experiments like the one you just did are easy to understand.

At this point, I am done discussing the experiment. Now that you know what the experiment shows, you can write a summary of it in your laboratory notebook. Write a brief description of what you did, followed by a discussion of what you learned. The goal you should have in mind is that someone who has never read this book should be able to read your laboratory notebook and understand what you did and what you learned. You should do this for *every* experiment.

Democritus was not well received in his time, but later scientists picked up on his ideas and refined them. Today, we know that all matter is made up of atoms. Indeed, today we can actually

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calculate how atoms pack together to make a given substance. This allows us to understand the concept of **density**, which describes how tightly packed the matter in a substance is. The more tightly packed the matter that makes up a substance, the higher its density. In your experiment, then, the syrup had a higher density than the water.

FIGURE 1.2
Democritus

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We don't really know what Democritus looked like, but this is how Dutch painter Hendrick ter Brugghen imagined him. He was called the "Laughing Philosopher," but no one is exactly sure why. Some suggest it is because he considered cheerfulness to be an important goal in life. Others suggest it is because he was prone to laugh when he thought someone else was making a stupid mistake.

Although Democritus was right about all things being composed of atoms, he was wrong about most of the details regarding what atoms are really like. He believed, for example, that atoms are indestructible. We now know that is wrong. After all, the atomic bomb and nuclear energy are both based on our ability to split atoms. He also thought that atoms were distinguished based on their shape and size. We now know it is a *lot* more complicated than that.

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While Democritus was wrong on many of the details related to atoms, there was one detail he got right. He thought that atoms were in constant motion. For example, if a glass of water is sitting on a table, you might think the water is not in motion. To some extent, you would be right. After all, the water in the glass stays in the glass, and the glass itself stays on the table. At the same time, however, the atoms that make up the water are in *constant* motion. They move around within the confines of the glass, rebounding off the walls of the glass and colliding into each other. You might find it hard to believe that the atoms within a glass of water are in motion when the water itself is not. However, you might find it a little easier to believe after performing the following experiment.

EXPERIMENT 1.2
Atomic Motion

Supplies:

- Two glass canning jars or peanut butter jars (both the same size)
- Food coloring (any color)
- A pan and stove to boil water, and a hotpad to hold the pan
- Eye protection such as goggles or safety glasses

call the **Bohr Model**. This picture of the atom was based on solid mathematics, and it required the assumption that energy comes in small packets. Using the Bohr Model, many of the mysteries of the atom were revealed. In the end, the weight of the evidence overwhelmed the scientific community's devotion to Newton's laws, and quantum mechanics became the new guiding principle in science.

Now it is important to note that quantum mechanics does not really contradict Newton's laws. Newton's laws are still considered valid today. However, we now realize that Newton's laws are simply an *approximation* of quantum mechanics. When the objects you study are large, Newton's laws are valid, because they are equivalent to the laws of quantum mechanics. However, as the size of the object decreases, there are differences between the laws of quantum mechanics and Newton's laws. In those cases, the laws of quantum mechanics are correct. Thus, Newton's laws are useful for large objects (objects we can see), but for tiny objects (like atoms), the laws of quantum mechanics must be used.

FIGURE 1.10
Three Important Figures in Quantum Mechanics

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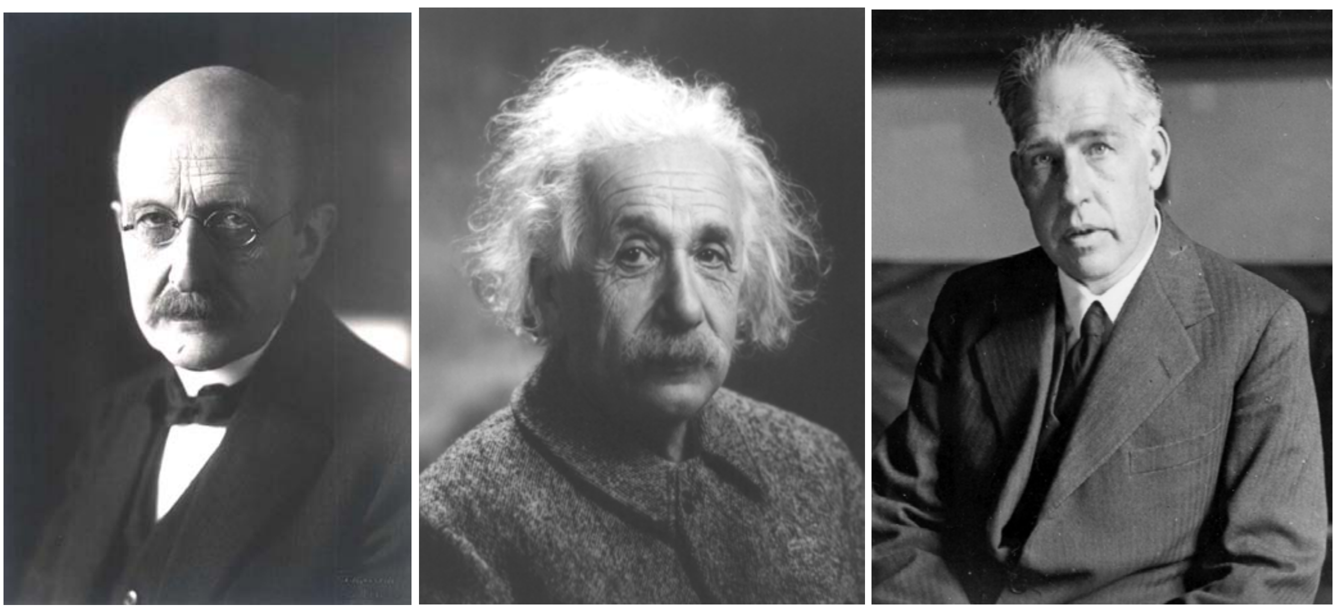

Max Planck was the first to propose that energy came in small "packets." This has led science historians to call him the father of quantum mechanics.

Albert Einstein used Planck's idea to develop an explanation for one of the most puzzling effects in physics, known as the photoelectric effect.

Niels Bohr used Planck's idea to develop a mathematical description of the atom. This description allowed scientists to understand experiments they were previously unable to understand.

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Although I first mentioned Einstein in terms of the quantum mechanical revolution, he is also an important figure in many other areas of science. For example, Einstein developed a new way of looking at light, matter, and gravity. His **special theory of relativity** explained how matter is really just another form of energy. He used this theory to explain the famous equation $E=mc^2$, which says that matter can be converted to energy and vice versa. Einstein also developed the **general theory of relativity** which is an explanation of *how* gravity works. You will learn more about both of these theories when you take physical science.

Quantum mechanics and relativity have become the guiding principles of science today. The knowledge gained from these ideas has led to numerous advances in medicine, technology, and industry. In many ways, these advances have made life easier for everyone. People live longer today, there are fewer diseases, there is more food per person today than ever before, and increased productivity has led to increased material prosperity. Also, we simply have a clearer picture of *how* creation works. With all these advances, however, do not fall into the trap of thinking we have "figured it all out." Remember, scientists thought that was the case more than 100 years ago. Look what we have learned since then! Science is constantly uncovering new ideas and new ways of looking at things. That's what makes science interesting!

Summing It Up

I hope you have gained something from this overview of science history. If you don't like history, I hope you have at least learned a few lessons from the mistakes scientists have made in the past. If you can learn from those mistakes, you will be a better scientist in the end.

Before you finish with the module, however, I need to make two points. The first is about philosophy. The history of science is rich and detailed. Entire books have been devoted to just portions of the history of science. Thus, there is *no way* I could have covered everything about the history of science in just one module of this course. I am sure there will be some who dispute what I have chosen to cover. Nevertheless, in my opinion, given the constraints of one module, I have presented to you a solid view of how science got to where it is today. I have certainly left a great many things out, so don't think this is the full story. It is, however, a reasonable overview.

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The second point I need to make is more practical. You are eventually going to take a test over this. You should be wondering what you need to study. Well, on page 33, you will find a study guide that helps you understand what I consider to be the important material from the module. That ought to help you focus your study for the test. As you work through the study guide, you will see that I do not want you to memorize dates. Rather, I want you to remember the major names and what they were responsible for.

Even though the study guide helps you focus on what to study, there is still *a lot* of information you will need to know for the test. How can you possibly remember it all? Here is a suggestion: Since the study guide covers the material I think is important, make some study aids based on the study guide. For example, I like to make notecards when I have a lot of information to keep straight. On one side of the notecard, I will write a term, a name, or a concept. On the other side, I will write what I need to know about it. For example, the first thing you will see on the study guide is a list of the vocabulary words you need to know. Write the word on one side and the definition on the other. The third question asks, "Who was Imhotep?" Write "Imhotep" on one side of the card and who he was on the other. Once you have done this for the entire study guide, go through your stack of notecards a few times. First, look at one side (the name, for example), and then try to say what is on the other side of the notecard (who he was). Then, *turn the notecards over and go through them the other way*. Thus, when you get to the card about Imhotep, you will look at who he was and then try to say his name. You will be amazed at how well this helps you remember things!

The multimedia CD has a review of some of the great scientists discussed in this module.

ANSWERS TO THE "ON YOUR OWN" PROBLEMS

1.1 If you look at the definition of science, it contains two parts. Science consists of collecting facts, but it also consists of using those facts to explain the world around us. The Egyptian doctors and the inventors of the ancient world collected lots of facts, but they did not use them to explain the world around them.

1.2 The more tightly packed the matter in a substance, the farther down it fell in the glass. Since density is a measure of how tightly the matter is packed in a substance, the farther the substance fell in the glass, the denser it was. Thus, the least dense item was the cork, and the most dense item was the stone. The vegetable oil was more dense than the cork, but less dense than the water. Continuing that kind of reasoning, then, the order is cork, vegetable oil, ice cube, water, grape, syrup, rock.

1.3 Experiment 1.2 demonstrated that the warmer the substance is, the faster its atoms move. To make ice from water, you must cool the water. Thus, ice is colder than water, which means the atoms in ice move more slowly than those in water.

1.4 Despite the fact that Dr. Hawking is brilliant, he can be wrong, just like many other brilliant scientists. The story of spontaneous generation tells how Aristotle was wrong, despite the fact that he was the greatest thinker of his time. The story of the geocentric system also tells how a great thinker turned out to be wrong. Either story should illustrate that we should not make scientific decisions based on *people*. Instead, we should make them based on *data*.

1.5 The story of the geocentric system tells us we must leave personal bias behind when doing science. The Roman Catholic Church held onto the geocentric system too long because of bias, not data.

1.6 Today's scientists are worried about the future of science because the progress of science depends on cultural support. Science stalled in the Dark Ages due to the Roman culture. If our culture stops supporting science, science will stall again.

1.7 Grosseteste is the first modern scientist because he was the first to work with the scientific method.

1.8 There is no right or wrong answer to this question. You must decide for yourself. Personally, my church means a lot to me. However, I would probably get kicked out rather than give up a belief I truly thought was correct. Since churches are the products of human beings, they are flawed. Only God and Christ are perfect. Thus, a church can be wrong, even about spiritual issues. Of course, I could be wrong, too. If so, I could end up being kicked out of my church for no good reason!

1.9 Newton would not like such textbooks. Newton believed that science had to be linked to math.

1.10 There are several possible answers to these questions. Any one of the first three scientists all advanced science but were wrong. Democritus, Leucippus, Aristotle, Ptolemy, Newton, and many others all advanced the cause of science, but they were all wrong about certain things.

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STUDY GUIDE FOR MODULE #1

1. Define the following terms:

a. Science
b. Papyrus
c. Spontaneous generation

2. There were three lessons from the history of science I specifically mentioned in the text. What are they?

3. Who was Imhotep?

4. Although the ancient Egyptians had incredibly advanced medical practices for their time, we do not consider them scientists. Why not?

5. Who were Thales, Anaximander, and Anaximenes?

6. Leucippus and his student, Democritus, are remembered for what idea?

7. Who championed the idea of spontaneous generation and is responsible for it being believed for so long?

8. Who came up with the first classification scheme for living creatures?

9. What is the main difference between the geocentric system and the heliocentric system? Which is correct?

10. What was the main goal of the alchemists?

11. Why don't we consider the alchemists to be scientists?

12. What was the main reason that science progressed near the end of the Dark Ages?

13. Who is considered to be the first modern scientist and why does he deserve that honor?

14. Two great works were published in 1543. Who were the authors and what were the subjects?

15. Although Galileo collected an enormous amount of data in support of the heliocentric system, he was forced to publicly reject it. Why?

16. Galileo built an instrument based on descriptions he had heard of a military device. This allowed him to collect a lot more data about the heavens. What did he build?

17. Who was Sir Isaac Newton? Name at least three of his accomplishments.

18. A major change in scientific approach took place during the Enlightenment. What was good about the change and what was bad about it?

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19. What was Lavoisier's greatest contribution to science?

20. What is John Dalton remembered for?

21. What is Charles Darwin remembered for?

22. What does "immutability of species" mean, and who showed that this notion is wrong?

23. What is Gregor Mendel remembered for?

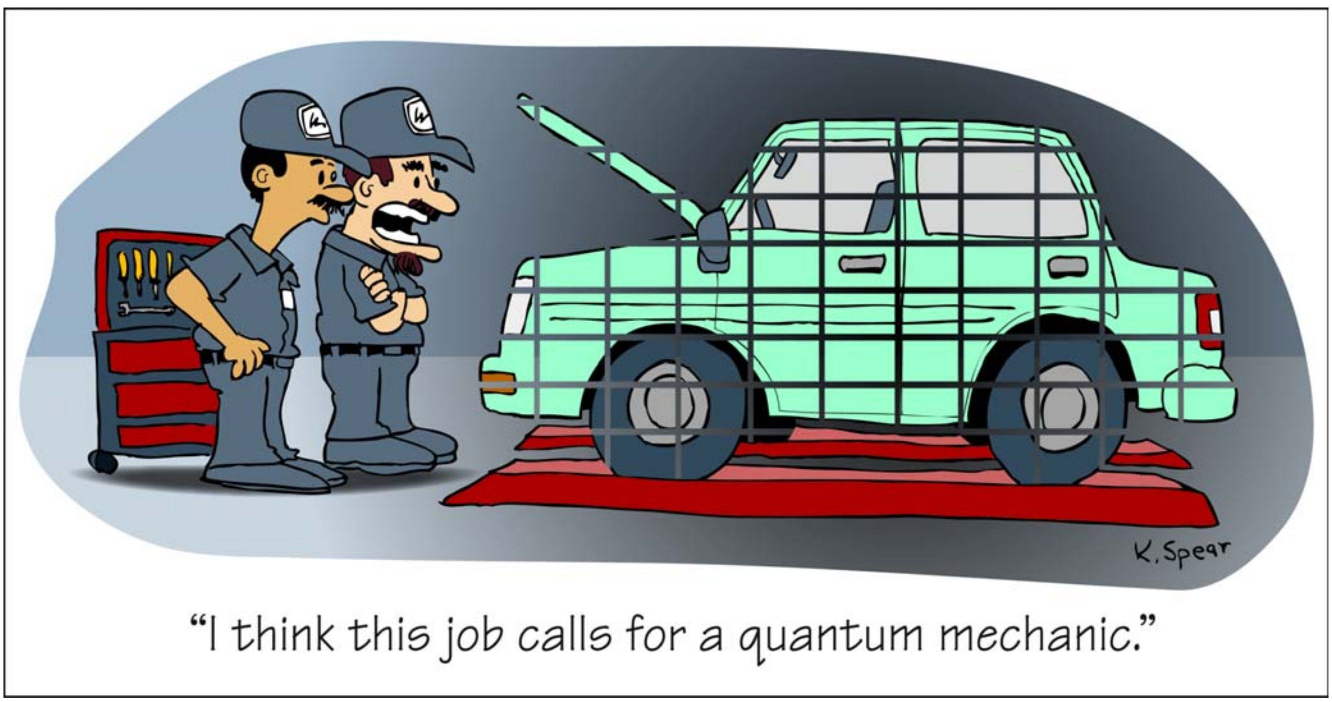
24. James Clerk Maxwell is known as the founder of modern _____________.

25. What law did James Joule demonstrate to be true?

26. What is the fundamental assumption behind quantum mechanics? Who first proposed it?

27. What is Niels Bohr remembered for?

28. Einstein was one of the founders of the quantum mechanical revolution. He also is famous for two other ideas. What are they?



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