Chapter 1:

“What Is Physical Science” And Other Stuff That's Always In The Front Of Textbooks

Physical science textbooks always start off with a photograph of somebody doing something extremely complex and scientific with equipment that will not be mentioned anywhere in this text. Frankly, I'm not even sure what this is supposed to be.

1.1: What Is Science?

Let's imagine that your neighbor threw a big bag of powder over the fence and it landed on your cat. Now, imagine that your cat turned blue and grew to a height of 4.7 meters.

If you're a normal person, you'd run screaming from your home and tell the military to reduce your neighborhood to smoking rubble. However, if you're a scientist, you'll do experiments designed to figure out what the powder was, what happened to the cat, and how to deal with it. We all know you'd probably end up calling the military anyway, but at least you'd know what you were blowing up.

Pictured: Science

Science is a systematic process for learning stuff. When pursuing scientific inquiry, it's not enough to simply do random experiments in the hope that something interesting will happen. Rather, science requires that we go about solving problems in a methodical and reproducible way. Scientific discoveries not only need to explain *what's* happening, but they have to be *repeatable* by different people in different places.

Why Do We Need Reproducible Results?

Let's say that you've filled your dad's car to the top with crickets because you're interested to see if it will still work. When you take out the crickets, you may find that the car doesn't, in fact, still run. If you've done this experiment only once, this could be because of the crickets – or because the car's engine has a problem, the car is out of gas, or somebody stole the battery. In order to be sure that the crickets caused the problem, you'd need to do the experiments many different times under different conditions.[1]

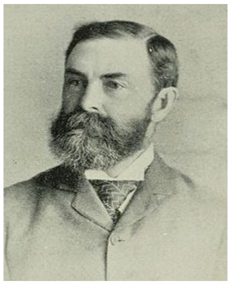
1 *For the record, crickets probably won't break your car, but may damage the paint. http://carcapsule.com/blog/dont-let-insects-bug-your-car-insect-damage-and-repair-techniques/*

What's the difference between science and engineering?

This depends on who you're talking to. However, because this is a textbook, the answer I give you is, by definition, correct.

It is traditional to say that science is the discovery of pure knowledge and engineering is the process by which this knowledge is used to solve a particular problem. By this definition, electricity was described by scientists, while engineers used this knowledge to make light bulbs and microwave ovens.

In reality, science and engineering are pretty much the same thing. Scientists don't just discover stuff for no reason – they're trying to learn about something to solve a particular problem. Likewise, engineers aren't just people who stuff a bunch of wires into a box – they need to understand the science behind a subject or they won't be able to get anything done. Science and engineering don't exist independently of one another – they're pretty much just different ways of figuring out how to get something done.[2]



This guy was a train engineer back in the 1800's. He is included here because old-timey pictures look good in textbooks.

When all is said and done, the product of science and engineering is most visible in **technology,** which is the thing that's produced when science and engineering have solved a problem. Let's see how all of these things are related to one another:

- **Problem**: I have a lot of time to kill. Make me a machine that can help me do this.
- **Scientist**: I've done a bunch of work and have figured out that by messing with silicon and electricity and stuff, I can play Pac-Man on a machine the size of a school bus.
- **Engineer**: I've done a bunch more work and figured out how to make everything more awesome. I can now play Pac-Man on a machine the size of a box of matches.

In this example, science is the knowledge that allows computers to be constructed and engineering is the knowledge that allows computers to match the needs of the end user. Technology is the computer itself.

---

2 *There is, however, and interesting rivalry of sorts between scientists and engineers. Scientists jokingly refer to engineers as being akin to plumbers, while engineers think of scientists as ignoring the practical aspects of what they discover. Scientists are, of course, correct.*

And bioengineering creates the nightmares that haunt your soul.

The Branches of Science

Just as people like to pretend that scientists and engineers are completely different from one another, they also like to pretend that the different types of science are also different. In reality, all scientists solve problems using the same basic principles.

Saying that somebody is a “scientist” doesn't really make it clear what they do. As a result, the sciences are described by the subject matter they study. One caution: There's a lot of overlap between the sciences, making the following only a rough guide.

Physical sciences

Physical sciences usually deal with nonliving things. Some examples:

- **Physics** studies how matter and energy interact with each other over time. You use physics every time you slam your finger in a car door or detonate a thermonuclear weapon.

Physics.

- **Chemistry** studies what things are made of and how they change into other things. Burning a pizza and putting your tongue on a battery are both examples of chemistry.

- **Astronomy** studies the stuff in the sky. When you wish upon a star, that's not astronomy, though. It has to be science to be astronomy.

It's important to know the difference between astronomy, which is a science, and astrology, which is the nonsense shown in this picture.

- **Geology** explores the stuff that happens inside of the earth. They do a lot of learning about rocks and earthquakes and stuff like that.

Life Sciences

Life sciences deal with living things. Biology is what we normally when we think of when we imagine the life sciences. The other life sciences such as medicine and anatomy are more or less types of biology.

Biology

Social sciences

Social sciences include things like psychology, sociology, anthropology, and economics. The social sciences aren't strictly sciences because the methodology isn't strictly systematic and the results are rarely reproducible. Scientists usually refer to these fields as the humanities.[3]

3 *Referring to a sociologist as a scientist will make the heads of actual scientists explode.*

1.2: The Scientific Method

As mentioned earlier, scientists don't just sit around doing science stuff and hoping that they learn something. Instead, scientists study things for some of the following reasons:

- **Basic science:** This is when people learn about stuff simply because it seems interesting for one reason or another. This is the sort of scientific activity that occurs in supercolliders and in space probes to Pluto.[4]

- **Applied science:** Applied science occurs when people are motivated to solve a problem of one sort or another.

The CSIRO radio telescope (left) is one of the finest examples of pure science in the world. "Silly String" (right) is the product of applied science.[5]

A big issue when performing scientific inquiry involves money. After all, it's not like spaceships and laser pointers build themselves. Some of the major sources of scientific funding are listed below:

- **Government funding**: Governments fund both basic and applied science on the principle that discoveries in basic science will lay the groundwork for future applied science. Medical and military research are examples of this sort of funding.

- **Corporate funding**: Large businesses fund a great deal of science. Much of this science is applied science, and is motivated by a desire to build products that can be sold for huge sums of money. This may sound selfish, but research of this type serves to make products available to the consumer at lower cost.

---

4 *Lest you think that this implies that basic science is a waste of time, consider that the determination of the structure of DNA was basic science that didn't have any particular practical use at the time.*

5 *"Silly String" is a trademark owned by the Car-Freshner Corporation, the same people who make those little trees that hang from rear view mirrors. And no, I didn't misspell the name of that corporation – it's actually spelled "Freshner."*

Without corporate funding, this watch would cost $12 million and take up three city blocks.

The Scientific Method Itself:

The big thing that differentiates scientific discovery from screwing around is that science requires a disciplined methodology and has the goal of obtaining reproducible results. Screwing around, on the other hand, involves only a hammer and a mouse.

Image unavailable.

The term **scientific method** is used to describe the method by which the world can be better understood. It should be noted that the scientific method isn't really that great at making discoveries, but does a pretty good job of describing how these discoveries actually work. The scientific method involves the following steps:

1. **Figure out what you're studying**. As described earlier, there are a lot of different reasons that you might be interested in learning more about the world. Necessity usually determines what the subject of our research will be.

2. **Make a hypothesis**. A **hypothesis** is a tentative solution to whatever problem you have and is the basis for your investigation. Hypotheses are based on observations, prior experiments, and occasionally lucky guesses. A general form of a hypothesis is "If [independent variable], then [dependent variable]", where the **independent variable** is the thing that you think causes the outcome and the **dependent variable** is the outcome itself.

3. **Perform an experiment**. Experiments are carefully-controlled studies in which you attempt to discover whether your hypothesis is correct or incorrect. Good experiments control the variables being studied by limiting the effect of outside influences.

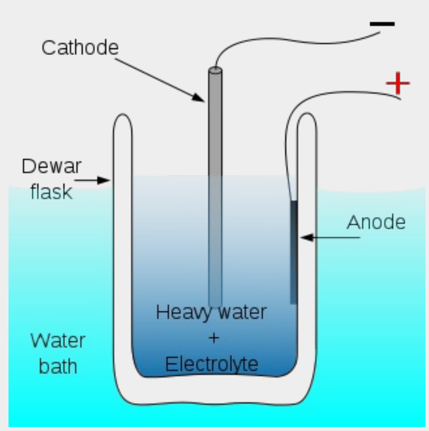
FYI: A freezer full of cash counts as an outside influence.

4. **Perform the experiment over and over again**. One of the hallmarks of science is that something has to be reproducible under various sets of circumstances. Getting the same experimental result many times lends stronger support to our hypothesis. If at any time during the process the experiment fails, it's time to head back to the drawing board in step 2 above.

5. **Verify, verify, verify!** When you have determined that the data support your hypothesis, it's time to publish your experiment in a peer-reviewed journal. **Peer-review** occurs when you publish your hypothesis and experimental data to other scientists in the field so that they may test it for themselves. If they find that the hypothesis has not been supported, it's time to go back to step 2 and make another one. If it is supported, your knowledge will become part of the larger body of scientific knowledge we all use.[6]

Why Bypassing Peer Review Is Bad

In 1989, Stanley Pons and Martin Fleischmann announced in a press conference that they had performed nuclear fusion in water at 30º Celsius. Unfortunately for them, they hadn't actually published their findings in a peer-reviewed journal and when other scientists repeated their experiments, they found that these groundbreaking results never actually happened. As a result, cold fusion was referred to in an international conference as "pathological science" and as the "incompetence and delusion of Pons and Fleischmann." Needless to say, this was not a positive career boost for either.



Remember, drawing something with MS Paint doesn't make it science.

No experiment can prove that a hypothesis is correct. Hypotheses can be supported by experimental data, but scientists always leave open the possibility that there will be some experiment that can disprove, or at least require the revision of a hypothesis. A hypothesis that has a great deal of supporting data is called a strong hypothesis.

6 *Plus you'll be more likely to get funding for future projects.*

Hypotheses, Theories, Laws, and Models

The terms hypothesis, theory, law, and model are some of the most misunderstood in all of science. Whether science is being discussed by politicians or by real people, these terms can be confusing and contradictory.

As mentioned earlier, a **hypothesis** is a guess about what will happen in some particular situation. For example, one common hypothesis among students is that if they study hard the night before an exam, then they will be sure to do well. Hypotheses are tested by scientific experiments, the results of which serve to support or disprove them.

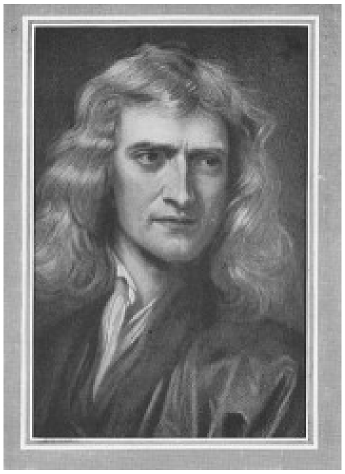
The hypothesis that cats enjoy wearing clothes was disproved long ago.

Theories are explanations that can be used to explain why related series of phenomena take place. Unlike a hypotheses, scientific theories aren't just explanations about why one or two things happen, but ideas that explain why *many* things take place. The key idea here is *explanation*, because the intent of a theory is to describe how something happens on a deeper level. In order for something to be a scientific theory, it has to be supported by a wide-variety of data and about a zillion experiments.

Why is Evolution Only a Theory?

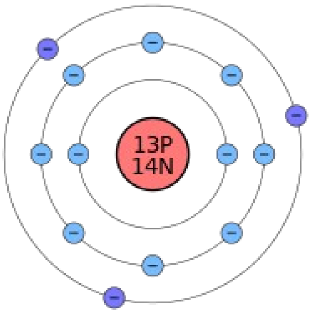
When people disbelieve in the concept of evolution, they sometimes cite the fact that even scientists only consider it a "theory." This may sound like it's not something people really believe in, because a theory in our everyday lives is something that we only sort of think will be true. However, in science, something is only called a theory when it is provides an explanation for a wide variety of phenomena and when it is widely considered to be true. Because evolution explains how life came to be in its current variety and complexity and is also considered to be true by most scientists, we refer to it as a theory and consider it to be true.[7]

Laws are generally simple statements that tell you how the world works in some fundamental way. Laws can be described either mathematically or in words, but all of them basically just "tell you how it is." The big job of explaining *why* it happens is left to theories.



Isaac Newton (1643-1727) came up with three laws describing the motion of objects. I can't think of any of them, however, because his awesome hair is so distracting.

A scientific **model** is a depiction that we use to help us understand how something works. Think of it as a simile, where we say that [something] is like [something else] in order to make better sense of it. For example, you may be familiar with the Bohr model of the atom, which looks something like this:

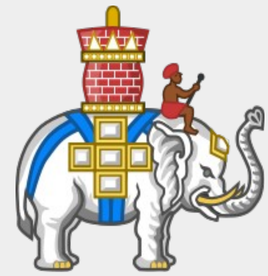


7 *This article at nih.gov explains the scientific consensus behind evolution, estimating that 99.9% of scientists believe in the truth of evolution: https://nihrecord.nih.gov/newsletters/2006/07_28_2006/story03.htm. Interestingly, there are far more scientists with the name "Steve" who believe in evolution than there are scientists of any name who believe in intelligent design (link: https://ncse.com/project-steve).*

Though people have undoubtedly told you that this is what atoms look like, real atoms don't actually look anything like this. Even Bohr knew that atoms didn't look like this, and he came up with the model in the first place! However, we still use this model of the atom, not because it is correct, but because it allows us to mentally picture aspects of how real atoms work. Quantum mechanics provides another (and more precise) model of how atoms work, but it's just that – a model.

Scientific Spotlight!

Niels Bohr (1885-1962) advanced our understanding of the atom through his model of the atom and in theoretical quantum mechanical work. For these achievements, he was awarded the Order of the Elephant in 1947 by Danish King Frederick IX. Seriously.



1.3: Measuring Stuff

Scientists like to do experiments. It's just one of those things that they do. Seriously, they're totally crazy about measuring things. And after they've done their experiments, they typically write down the outcome. The information that's collected in scientific experiments is called **data**.

In order to take good scientific data, it's important to know the following things. So let's learn them.

Scientific notation

Let's say that you have six things in a box. When people ask you how many things are in the box, you tell them "There are six things in the box." Now, imagine that you have 433,000,000,000,000,000,000 things in a box. When people ask you how many things are in the box, it would be entirely correct to say "four hundred and thirty-three sextillion things." After you said that, the person you talked to would try to remember how many zeroes[8] are in a sextillion, and would probably end up saying "screw it" and getting a burrito.

It's because of this that we express very large and very small numbers in a format called scientific notation. **Scientific notation** is when numbers are expressed as being between 1-10, raised to some power of 10. One example of this is 6.02×10^{23}(pronounced "six point oh-two times ten to the twenty-third") which represents the number 602,000,000,000,000,000,000,000. This is an extraordinarily large number, and corresponds to the number of molecules in 18.0 mL of water.

8 *It's correct to spell this word either "zeros" or "zeroes", so if you wondered about this, relax already.*

Water is the fancy chemical term for "that stuff you drink when you're out of soda."

To write numbers in scientific notation, move the decimal place of that number so that it's right after the first digit. For example, the number 43,000 would be expressed as "4.3", and 0.086 would be expressed as "8.6." To figure out the "x $10^{[whatever]}$" part, compare the original number to the one that you wrote down.

- If the original number is more than 10, figure out how far you'd need to move the decimal to the right in the revised number to get the original one. In the 43,000 example, the decimal in 4.3 would have to be moved four places to the right to give you 43,000. Because of this, this number is called "4.3 x 10^4" in scientific notation.

- If the original number is less than 1, figure out how far you'd need to move the decimal to the left in the revised number to get the original one. In our example, you'd need to move the decimal in 8.6 to the left by two places in order to get 0.086. As a result, we'd say that this number is "8.6 x 10^{-3}" in scientific notation.

But what if the number is already between 1 and 10?

If somebody tells you to come up with the scientific notation for the number 6.1, then you don't need to move the decimal at all to make it between 1 and 10. Because you move the decimal by zero places, this number is expressed as 6.1 x 10^0 in scientific notation.

This never actually happens, though. Seriously, if you're trying to make something easier to express, adding an unnecessary "x 10^0" is a big waste of time. Still, your teacher may try to pull this, so keep your eyes open.

International System of Units (SI units)

If you live in the United States, you probably tell everybody that your height is "five foot seven inches" and that your weight is "140 pounds."[9] However, if you were to go to France, you would instead tell people that your height is "170 centimeters" and your weight is "64 kilograms."[10]

---

9 *Unless your height and weight are either higher or lower than this, that is.*
10 *As with all textbooks, the height and weight here corresponds to that of a very healthy person. The author of this book, for example, is only a small bit taller than this but considerably heavier. But he's working on it.*

The reason that French people talk like this is because they (and most other countries in the world) use a standard set of units rather than the Imperial units used in the United States[11]. In fact, they invented this set of units, called the *Systéme International d'Unités.* We call it these units **SI units** because we have trouble pronouncing Systéme International d'Unités. These standard units are often also referred to as the **metric system**.[12]

This is another thing the French do. So there's that.

The SI system has seven different **base units** which are used for the basis of all measurements. These base units are:

Base unit	What it measures
meter (m)	Length
kilogram (kg)	Mass
seconds (s)	Time
ampere (A)	Electric current
Kelvin (K)[13]	Temperature
mole (mol)	Amount of stuff
candela (cd)	Brightness of light

Derived units are SI units obtained by manipulating the seven base units. For example, the unit of pressure, Pascals (Pa), is equal to $kg/m \cdot s^2$ and a common unit for density is g/cm^3. There are a whole bunch of derived units out there, so if you see something that's not an SI base unit, try not to freak out.

11 *SI units are the official units for most places in the world, but different countries vary somewhat in how completely they've been adopted. For example, the English frequently refer to the weight of people in "stone" for some reason or another (64 kg = 10 stone).*
12 *There's a small difference between SI and metric units and the metric, but they're really not that important.*
13 *The unit is "Kelvin", not "degrees Kelvin" or "Kelvins."*

Unit Prefixes

Though the units used in the SI system are pretty cool, they're not always the most handy thing in the world to use for a particular measurement. For example, if you were to say that Chicago were 452,000 meters away, people would look at you as if you'd lost your mind.[14] However, saying that you live 452 kilometers away makes a lot more sense.

This old theater is about 452 km from Chicago, which explains why people want to move 452 km away.

In the example above, "kilo-" is the SI prefix for "thousand." As a result, when you say "452 kilometers", you're literally saying "452 x 1,000 meters." Likewise, the prefix "centi-" means "0.01", so "4.5 centimeters" is equal to "4.5 x 0.01 meters", or 0.045 m. The most commonly-used SI prefixes are shown in the table below.

Prefix	What it means	Example
mega- (M)	one million, 10^6	1 MPa = 1,000,000,000 Pa
kilo- (k)	one thousand, 10^3	1 kg = 1,000 g
centi- (c)	one hundredth, 10^{-2}	1 cm = 0.01 m
milli- (m)	one thousandth, 10^{-3}	1 mL = 0.001 L
micro- (μ)	one millionth, 10^{-6}	1 μm = 0.000001 m[15]
nano- (n)	one billionth, 10^{-9}	1 nm = 0.000000001 m

14 *And not just because you live in Detroit.*
15 *Oddly, 1 μm is not usually referred to as a "micrometer", though it's technically right. The more common term is "micron."*

There are a bunch of other prefixes in the SI system, but people don't use them much. For example, there's nothing wrong with saying that you've got a yoctogram (10^{24} grams) of sugar in your cupboard. Well, except that this amount of sugar would be approximately half the size of the planet earth.

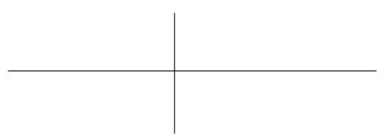
I hope you like sweet tea.

Converting from one metric prefix to another

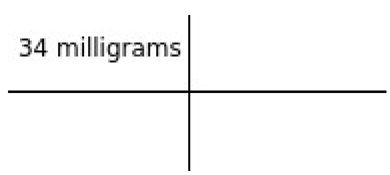
Let's say that your teacher asked you to convert 34 milligrams into kilograms. I have no idea why anybody would ever need to do this conversion, but let's pretend that, for some reason or another, this is desirable. How would you do it?[16]

To do this, we need to first convert milligrams into grams, and then grams into kilograms. To do this, we'll use the t-chart method for unit conversions.[17] Let's go through the steps of it now:

- **Step 1: Draw a big t**. Like this:



- **Step 2: Write the thing you're trying to convert in the top left corner of the t**. In this case, we've been told to convert 34 milligrams into kilograms, so we'll write “34 milligrams” in the top left.



16 *Aside from the obvious use of Google.*
17 *This is also referred to as the “factor-label” method.*

- **Step 3: Write the units for the number you just wrote in the bottom right**. You just wrote “milligrams”, so write “milligrams” in the bottom right.

34 milligrams	
	milligrams

- **Step 4: Write the units for whatever you're trying to find in the top right**. In this case, we're converting milligrams to grams (it's a two-step problem, remember), so write “grams” in the top right.

34 milligrams	grams
	milligrams

- **Step 5: Write “1” in front of the unit with the metric prefix**. As you can see, you have blank spaces in front of “milligrams” and “grams”. Because “milli” is a metric prefix, write a “1” in front of it.

34 milligrams	grams
	1 milligrams

- **Step 6: Write whatever the prefix means in front of the bare unit**. Since “milli” means “0.001”, write that in front of “grams.”

34 milligrams	0.001 grams
	1 milligrams

- **Step 7: Do the math**. This can be done by multiplying the numbers on the top and then dividing them by the number on the bottom. To wrap it up, write whatever unit was in the top right after this number. You've done the first step of this conversion!

34 milligrams	0.001 grams
	1 milligrams

$$= \frac{\text{34 milligrams x 0.001 grams}}{\text{1 milligrams}} = \text{0.034 grams}$$

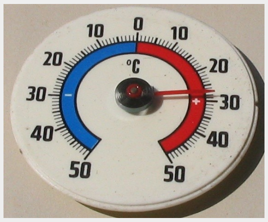
Because we now need to convert grams to kilograms, we do the same process over again, this time putting the answer from the calculation we just did into the top left of our next t. Going through the steps again, we can see that our calculation will look like this:

0.034 grams	1 kilogram
	1000 grams

$$= \frac{\text{0.034 grams x 1 kilogram}}{\text{1000 grams}} = \text{0.000034 kg } (3.4 \times 10^{-5} \text{ kg})$$

How about temperature?

Temperature in Kelvin is same as that in degrees Celsius, plus 273. As a result, if it were 14 degrees Celsius outside, it would be correct (but strange) to say that the temperature was 287 Kelvin. In equation form, °C + 273 = K



Fahrenheit, on the other hand, is for losers.

Precision and Accuracy

Whenever we do a scientific measurement, we have to consider the precision and accuracy of our measurement. You've already seen these words in your daily life and probably think they mean the same thing. They don't, which is why I mention them here.

Accuracy tells you how close your measurement is to the true value. For example, it is accurate to say that my dog weighs 24 kilograms because my dog actually does weigh 24 kilograms. On the other hand, if your scale had said 4,560 kilograms, it would have been an inaccurate measurement.

This is not what my dog looked like before mauling 16 people on Thanksgiving Day, no matter what the police reports say.

Precision tells you how reproducible your answer is. Put another, less fancy, way, it tells you about the confidence you have about your answer. For example, let's say that you were to weigh your mother on a truck scale. Her weight might be something like "200 pounds." However, let's say that you weighed her on a bathroom scale. Her weight might say "165 pounds." If you round to the nearest hundred pounds, these answers are the same. However, by writing one of them as "165 pounds", you're telling people that the bathroom scale you used gives you a more exact / precise answer.

Your mom.

Are accuracy and precision the same thing?

Nope. A very high precision measuring tool can give a wrong answer as well as a low precision one. This happens if the instrument is either broken or needs to be calibrated.

1.4: Making Your Data Comprehensible

If you can collect good data, everybody will be happy. However, if you write each datum on a piece of paper and stick it into a paper sack, this happiness will turn to annoyance. Because we scientists try not to act like jerks unless it's totally necessary[18], we organize the data before giving it to people.

Tables:

The best way to collect and present raw data is in tabular form. Rather than do a lot of talking about what these tables ought to look like, I'll just show you a table that I totally didn't just make up:[19]

Time (hours)	Distance traveled (km)
0	0
1	110
2	230
3	300
4	430
5	560
6	650
7	780

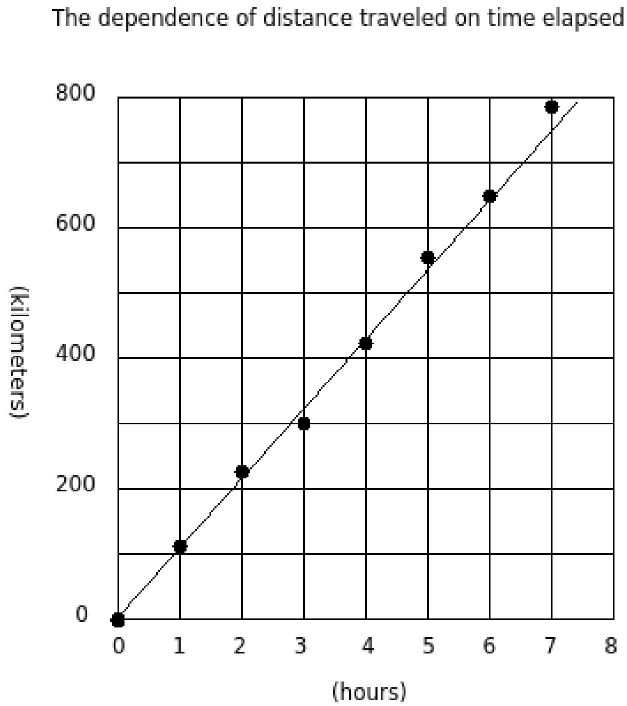
A table like this isn't complicated, but the units used for each column should be given. After all, the meaning of these data would be very different if time was measured in years or if distance traveled was in centimeters.

For the second edition of this book, I plan to collect new data for this table using my rocket car.

18 *Or unless we have tenure.*
19 *I totally did. Seriously, does anybody actually think that the data to make graphs like this are real?*

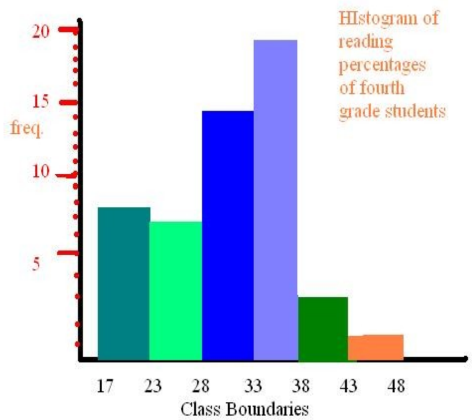
Graphs

Graphs are basically the same as data tables, except that they show the data in picture form. Here's a good graph of the data shown in the table above:



For a graph to be scientifically useful, it should have the following characteristics:

1. **It must be a line graph**: The graph above is an example of a line graph. Bar graphs and pie charts have their uses, but they're not generally useful in the sciences.



This bar graph isn't appropriate for showing scientific data. It also has a grammatical mistake.

2. **It must not connect-the-dots**. You'll notice that the line graph above has several points that don't sit on the line itself. This is because scientists understand that real-world data are imperfect and won't fit on a perfectly straight line. The line shown above is called a “best fit” line because it is written to best interpret the data as a whole.

But why can't we connect the dots?

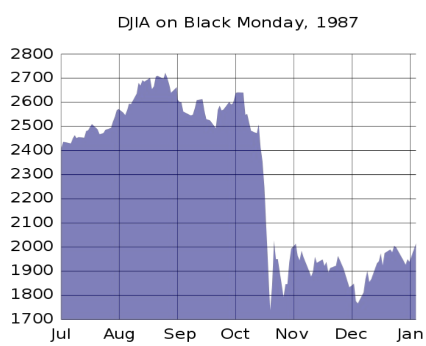
Graphs are intended to show the general trend of how things work. We assume that the best-fit line is how the data actually look, while the data we really collected are flawed due to experimental error. Experimental error always exists, and this is one of the ways we deal with it.

3. **It should have clearly labeled x- and y-axes**. Each axis should contain the entire range of data collected and the units for each axis should be written out.

4. **The x-axis should represent the independent variable and the y-axis should represent the independent variable**. If you can't remember which variable is which, think of the following statement: "When I did [A], [B] happened." In this statement, A is the independent variable (cause) and B is the dependent variable (outcome). A handy hint: Time is always an independent variable.

5. **The title should be in the form**: "The dependence of [dependent variable] on [independent variable]" or "The effect of [independent variable] on [dependent variable]." Both statements mean the same thing, so either is fine.

6. **The data should fill the available space**. Don't cram all of the data into one little corner – give it room to breathe!



This graph is terrible, because it makes it look that the Dow Jones Industrial Average dropped by about 95% between October and November. However, careful examination shows that the lowest value on the y-axis is not zero but 1700! This apparent huge drop makes the graph exciting, but nowhere near as realistic as the actual data (which show only a 30% drop).[20]

20 *The trick of showing data like this is usually used by people who want to get a strong reaction out of others (i.e. the media and politicians.) By presenting things in this way, they can honestly say that they didn't lie about the data while simultaneously misrepresenting them.*

The Main Ideas In Chapter 1:

- Science involves solving problems in systematic and reproducible ways. It should, anyway.
- Scientists and engineers are pretty much the same thing, though they approach problems with different viewpoints.
- There are a bunch of different branches of science, but there's a ton of overlap between them. The social sciences, however, aren't actually sciences.[21]
- The scientific method gives us a methodical approach toward learning science stuff.
- Scientific notation is a thing.[22]
- SI units are used by scientists when taking measurements. They're also used by regular people in most parts of the world.
- Accuracy and precision are two ways of discussing the quality of data.
- Tables and graphs are good ways of presenting data.

---

21 *If your mom/dad is a sociologist or psychologist, don't show this to her/him because she/he will find it upsetting. Even though it's 100% true.*

22 *Not an interesting thing, but an extremely useful thing.*

Image credits:

- **The guy with his hands in a glove box**: By CDC/Betty Partin [Public domain], via Wikimedia Commons. Glove boxes are used to work with things that, for whatever reason, have to be isolated from their environment. This guy is working with a biohazardous material in a biosafety level three (BSL-3) cabinet.
- **Napalm drop**: By U.S. Air Force [Public domain], via Wikimedia Commons. Napalm is a sticky petroleum-based material that sticks to whatever it touches. 388,000 tons were dropped on Vietnam during the U.S. Vietnam conflict in the 1960s and 1970s.
- **Cricket**: By Mazzanti [Public domain], via Wikimedia Commons. Crickets are rarely this well-mannered.
- **Engineer guy**: By Internet Archive Book Images [No restrictions], via Wikimedia Commons. This engineer is named Edmund Wragge, and he was the first guy to build narrow-gauge railways in North America. He was born in England but retired to Canada. In other words, not that interesting a guy.
- **Busted finger**: By The Photographer (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons. It's not entirely clear if thumbs count as fingers. Generally speaking, texts avoid the question by saying that hands have five "digits."
- **Pac-Men**: By William Tung from USA (SDCC13 - Pac-Man Uploaded by daisydeee) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons. If you search for "Pac-Man" on Google, the first search result is a little playable Pac-Man game.
- **Zodiac**: By Micheletb [Public domain], via Wikimedia Commons. Astrology is the belief that you can guess what will happen to a person based on when they were born. This is, needless to say, stupid.
- **Squirrel**: By Yathin S Krishnappa (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. There are documented cases of purple squirrels existing, though nobody knows why this should happen.
- **CSIRO telescope**: CSIRO [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons. CSIRO, an Australian science organization, runs something known as the Australian Dung Beetle Project.
- **Silly string dude**: By Infrogmation of New Orleans (Photo by Infrogmation) [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via **Wikimedia Commons**. Silly string is used by soldiers in several NATO countries to detect booby-trap tripwires.
- **Wristwatch**: By Ashley Pomeroy (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. The F91W in this picture has been used by terrorists as bomb timers.
- **X**: By Wolf Lambert (Own work) [CC0], via Wikimedia Commons. As far as I know, there's no picture showing this sort of experimental activity. It's just a joke, so relax.
- **Freezer full of cash**: By Unnamed photographer for U.S. Attorney's Office [Public domain], via Wikimedia Commons. This picture was evidence in the prosecution of Rep. William Jefferson (R-La) on corruption charges. He got 13 years.
- **Cold fusion nonsense**: By Pbroks13 [GFDL (http://www.gnu.org/copyleft/fdl.html), CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons.
- **Cat in clothes**: By Andrés Nieto Porras from Palma de Mallorca, España (¡¡¡QUE ME DEJEIS YA!!!) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons.
- **Isaac Newton**: By From: Arthur Shuster & Arthur E. Shipley: Britain's Heritage of Science. London, 1917. (A Temple of Worthies) [Public domain], via Wikimedia Commons. Newton's study of the Bible led him to believe that the end of the world would come no sooner than 2060, so feel free to make plans for the weekend.
- **Aluminum atom**: By User:ARTE (Own work) [Public domain], via Wikimedia Commons. Fun fact: People in foreign lands spell aluminum as "aluminium"! Or, if you're in a foreign land, can you believe people spell aluminium as "aluminum"?
- **Order of the Elephant**: By Sodacan [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. Members of the Order of the Elephant (of which there are no more than 30 at a time) get a cool little elephant necklace.
- **Water**: W.J.Pilsak at the German language Wikipedia [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons. There's water vapor in the atmosphere of the planet Mercury, though not enough to drink.
- **Some French thing or another**: By Maelor at English Wikipedia [Public domain], via Wikimedia Commons. I'm guessing this has something to do with the navy, but since I don't speak French I really don't know.
- **Old theater**: By Albert duce (Own work) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons. It's easy to make fun of Detroit, but many people think it has a real future. Of course, people have been saying that for the past 30 years, so it's not exactly reliable information.
- **Earth**: By NASA / Bill Anders [Public domain], via Wikimedia Commons. You are here.
- **Big red dog**: By Loozrboy from Toronto, Canada (Clifford) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons. The original Clifford was based by the author on a family dog that mauled the mailman (hence, the red). OK... I made that up, but it would be a great story, wouldn't it?
- **Truck / your mom**: By Elkawe (Own work) [Public domain or CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons. The first "yo mama" joke recorded is in the Bible, 2 Kings 9:22, where Jehu calls Joram's mom a whore. That's cold, Jehu.

- **Rocket car**: Jon 'ShakataGaNai' Davis [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons. Hydrogen peroxide powered rocket cars are no longer allowed in drag races in the United States, as they're too overpowered.
- **Bar graph**: By JLW87 (Own work) [Public domain], via Wikimedia Commons. Seriously, don't use bar graphs.
- **Graph of stock market drop**: By Lalala666 [Copyrighted free use], via Wikimedia Commons. A good book about misleading statistics is *How to Lie With Statistics*, by Daniel Huff.