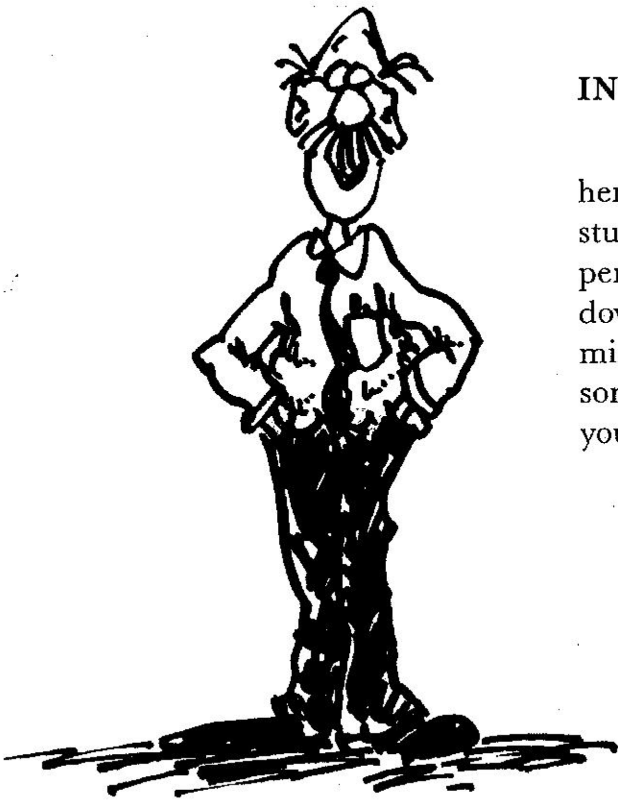
graphing

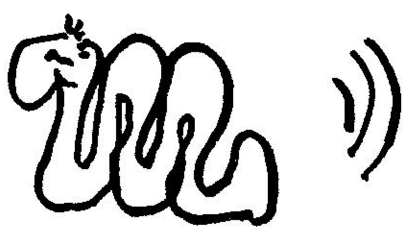
BY

B.K. HIXSON



INTRODUCTION

Welcome to science, whippersnapper! Wilshere A. Smith here, and I have the distinct privilege of being your host as you study graphing. Actually I'm a cartoon character with a lot of personality, but don't let that fool you, I've got this science stuff down pat. I'd like to introduce you to Ophidia, a good friend of mine. She is generally a good helper, but as you'll find out, sometimes she can be quite a bother. So, Ophidia my friend, if you would be so kind as to get out of the way, we'll proceed.



Jargon: a specialized vocabulary used to describe things in a specific field of study.

As your host, I'm going to help you out two ways. First, I need to be sure that we can communicate with one another, so to do that you'll need to learn the scientific **jargon** (jar • gun) for this unit. Look at the left margin. That's where I'll define all of your vocabulary words, which are printed in boldface. Also, each main idea I want you to learn is found in the margin. And just to be sure you don't miss these babies, I'll put stars by them. There is a catch though—these ideas are asked as questions that you need to find the answer to. Once you figure out the answer, get that hot little pencil moving and fill in your answer right beside the question. This way you'll have your own study guide to help you study for tests. So, once again welcome to science. It's nice to have you here.

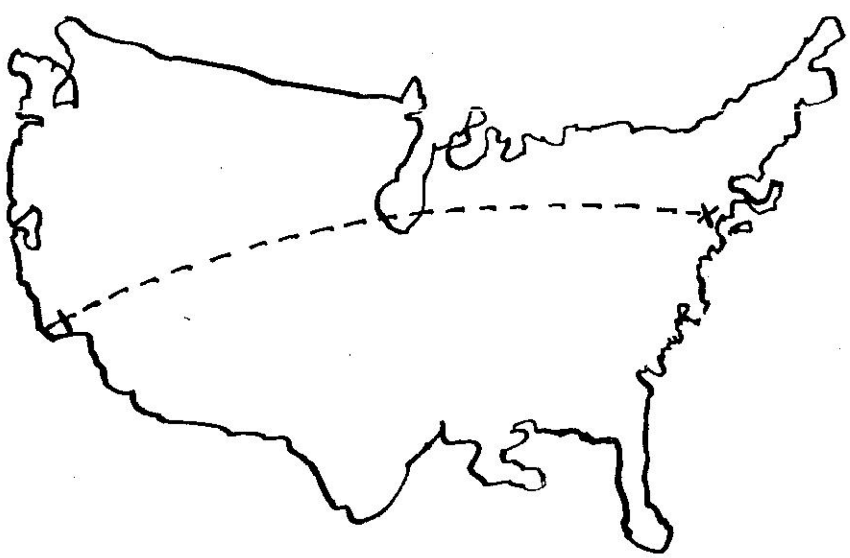
Data: information of observations.

DATA

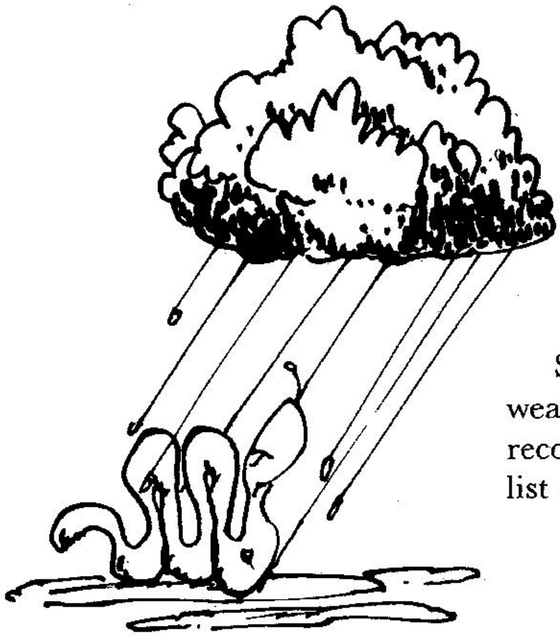
Let's get down to the business at hand. **Data** is information. Pure and simple, data is information. Look at these examples:

- Magic Johnson's height
- The number of centimeters of snow that fell at Timberline Lodge every day for one month

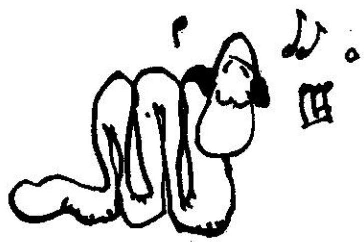
- The number of kilometers from New York to Los Angeles



Each of these three items is a little bit of data.

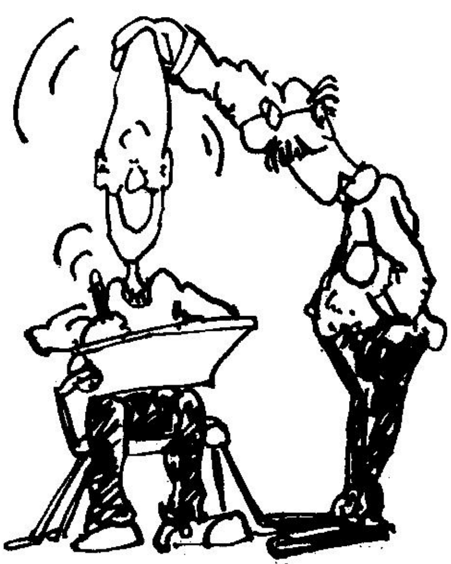


Scientists use data all the time. Data helps predict the weather, improve stereo equipment, and aid in the fast recovery of patients in hospitals. But it doesn't stop there, the list goes on and on.



How is data valuable to scientists?

As scientists, you'll need to be able to record information, evaluate experiments, and draw conclusions. To do all of this, you need to know how to use data tables and draw graphs, which is exactly what this unit is about.



BRAIN STRETCHER #1

DATA TABLES

Data table: a way to organize data in columns so it is neat and readable.

If we collect just a little bit of data it's no problem to keep track of it. But what happens when we get a lot? Right, our organization improves real fast and to organize data we use a **data table.**

Here is a data table constructed for an imaginary science experiment.

Heating of Compound X

Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	20	21	23	27	35	45	61	69	71	73	74

Title: a brief way to describe the content of a book, graph, or data table.

Data tables begin with a **title.** The title of this data table is "Heating of Compound X." The title tells the reader exactly what the data in the table refers to. Without a title, it's possible that the person studying the data table wouldn't be able to figure out what all the numbers meant. And that can be very frustrating. When you construct a data table always be sure to begin with a title that describes the data it contains.

Variable: a word used in a data table to describe what information is being collected.

A data table includes variables and units. A **variable** (vary • a • bull) describes *what* information you are recording. A **unit** tells *how* you are going to measure that variable.

Unit: a word or symbol used in a data table that tells how the information was measured.

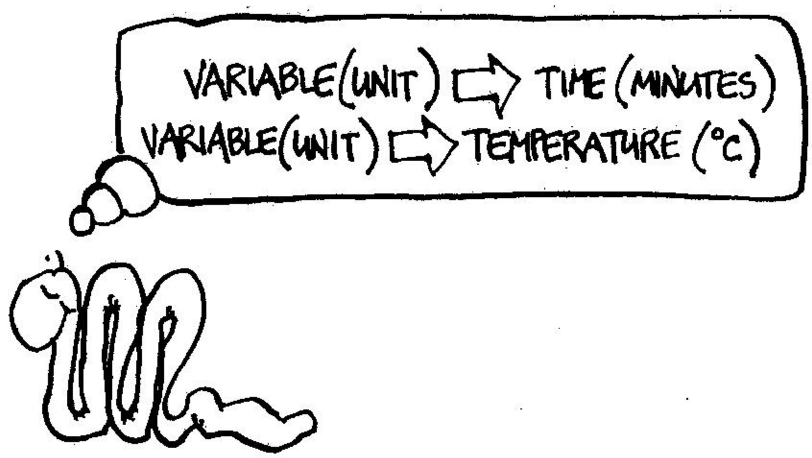
VARIABLE (UNIT) ⇨ WHAT (HOW)

Heating of Compound X

Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	20	21	23	27	35	45	61	69	71	73	74

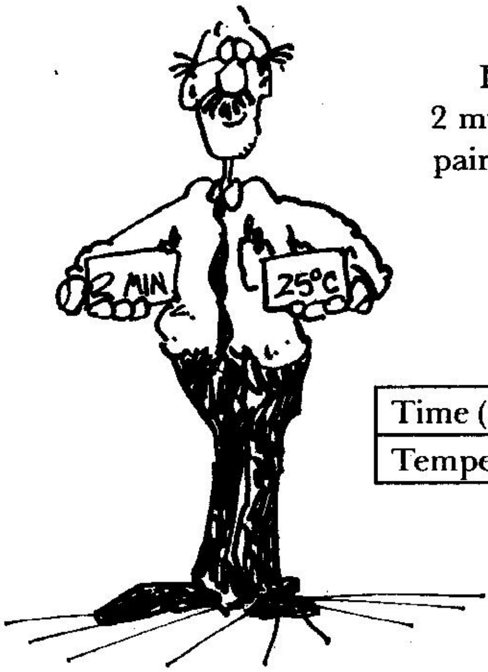
Why is it important to have variables and units included in a data table?

In this data table, the first column of data is the time variable, which is recorded in units of minutes. It's easy to figure out the units because they are always in parentheses. The second column is for the temperature variable measured in degrees Celsius. Think of variables and units in these terms:



Ordered pairs: two pieces of data directly corresponding to one another.

Data is organized in a data table. If you look carefully, you'll find the numbers are organized in groups called **ordered pairs.** They are called ordered pairs because the numbers always go together. It's easy to tell ordered pairs in a data table because they're piled on top of one another.



Look at the data table and you'll see that the combination of 2 minutes and 23 degrees Celsius (2 min, 23 °C) is one ordered pair.

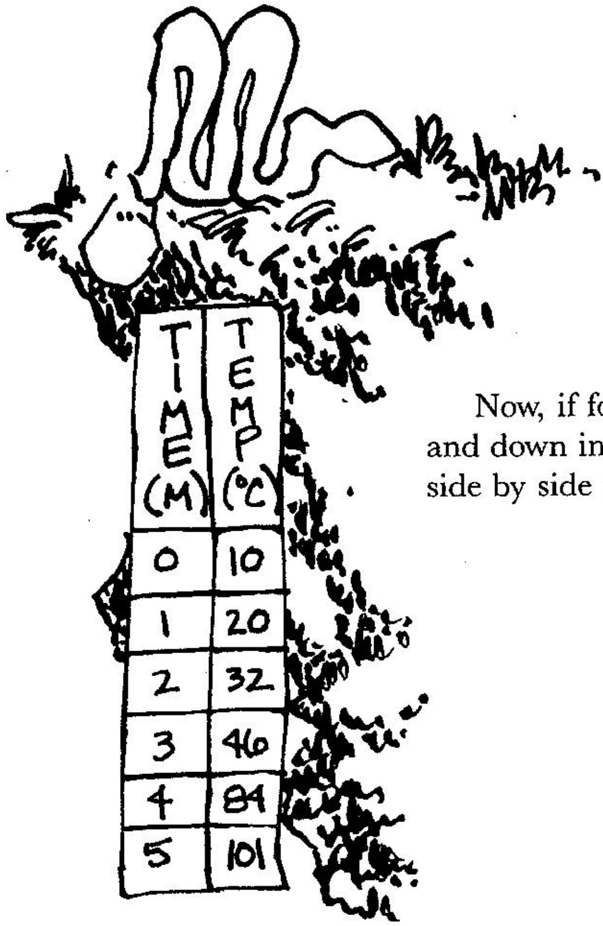
Heating of Compound X

Time (min.)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	20	21	23	27	35	45	61	69	71	73	74

5 minutes and 45 degrees Celsius is another ordered pair (5 min, 45 °C).

There are 11 ordered pairs in this data table:

1. (0 min, 20 °C)
2. (1 min, 21 °C)
3. (2 min, 23 °C)
4. (3 min, 27 °C)
5. (4 min, 35 °C)
6. (5 min, 45 °C)
7. (6 min, 61 °C)
8. (7 min, 69 °C)
9. (8 min, 71 °C)
10. (9 min, 73 °C)
11. (10 min, 79 °C)



Now, if for some reason you find a data table that runs up and down instead of across, the ordered pairs are still there, just side by side now.

Heating of Compound X

Time (minutes)	Temperature (°C)
0	20
1	21
2	23
3	27
4	35
5	45
6	61
7	69
8	71
9	73
10	74

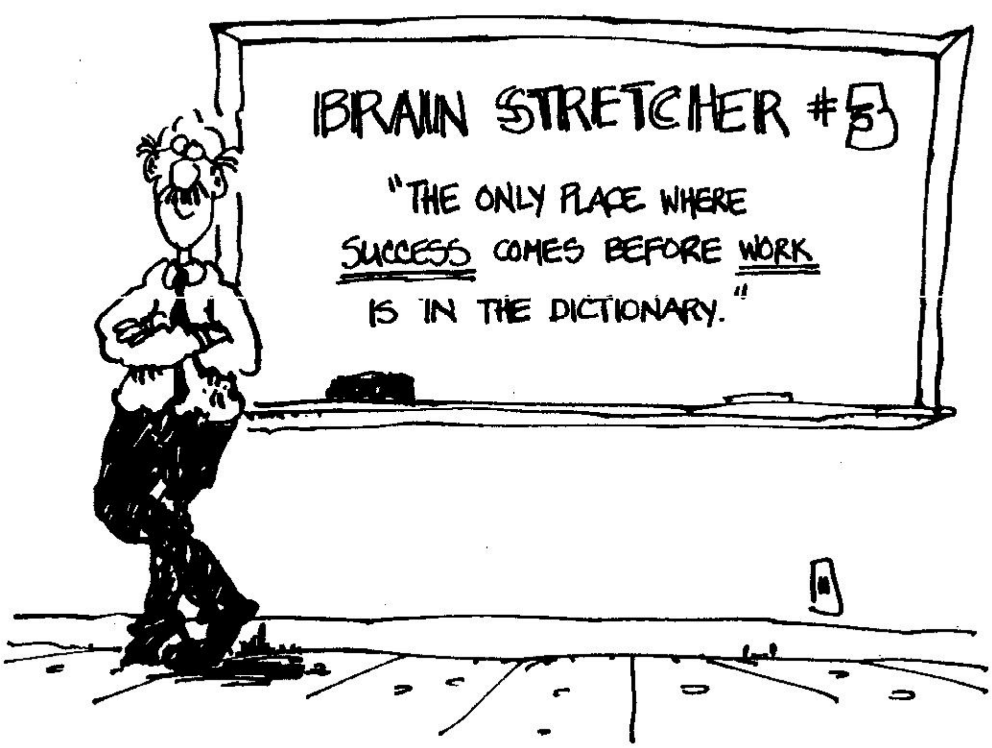
What is the best way to identify an ordered pair?

A COMPLETE DATA TABLE

A properly constructed data table follows these guidelines:

1. a descriptive title
2. variables describing what information has been collected
3. units telling how those variables were measured
4. data collected in ordered pairs
5. all work done neatly

Each time you construct a data table check it against these guidelines to be sure everything is there. Not only will you be getting great grades, but pretty soon you won't need the guidelines and you'll be producing perfect work without even trying.



READING A GRAPH

Graph: a picture of information in a data table.

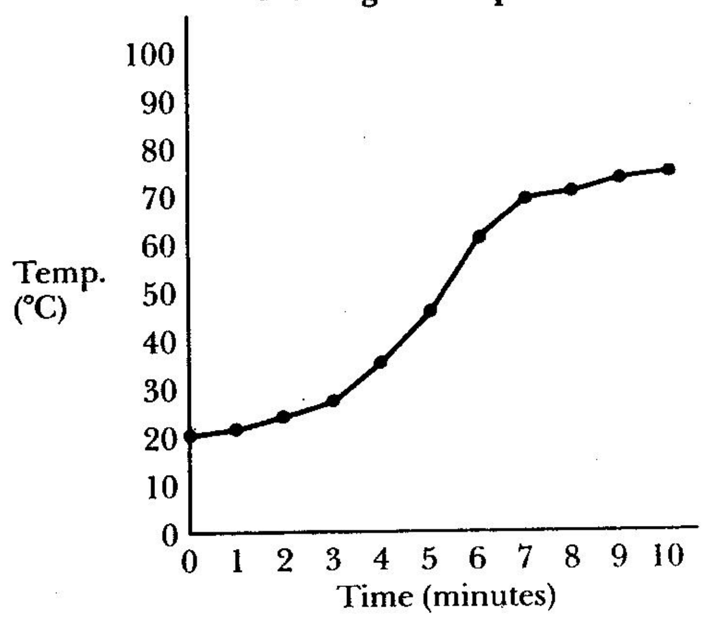
By now you're an expert at reading and constructing data tables. Now it's time to master reading a **graph.** A graph is an exact picture of information in a data table. It's usually a line that shows a relationship between all of the numbers in a data table. The following data table and graph are for the Heating of Compound X.

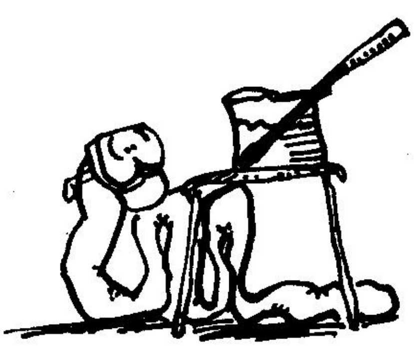
Heating of Compound X

Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	20	21	23	27	35	45	61	69	71	73	74

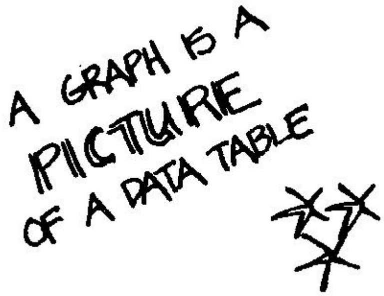
What are the similarities between a data table and a graph?

Heating of Compound X

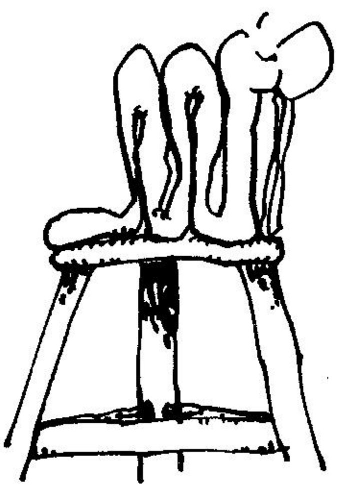




Here's the kicker, if a graph is an exact picture of the data table, then everything that's in the data table has to be in the graph—everything!! Check it out.



1. The same descriptive title—The Heating of Compound X.
2. The same variables and units—time (min) and temp. (°C). One on each side.
3. The same data.



Horizontal axis: the axis that goes across the bottom of the graph

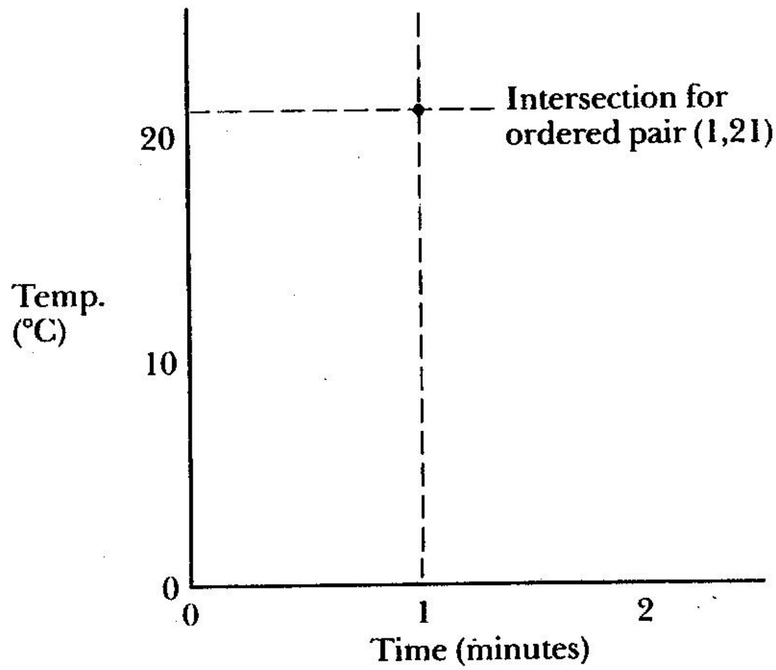
Vertical axis: the axis that runs up and down on the side of the graph.

The secret is knowing what to do with the ordered pairs. Take the second ordered pair (1 min, 21 °C) and split them up. Place the 1 minute along the **horizontal axis** labeled "Time" at the 1 minute mark. Put the 21 °C on the **vertical axis** labeled "Temperature" at the 21 °C mark. Now follow each line into the middle until they both meet.

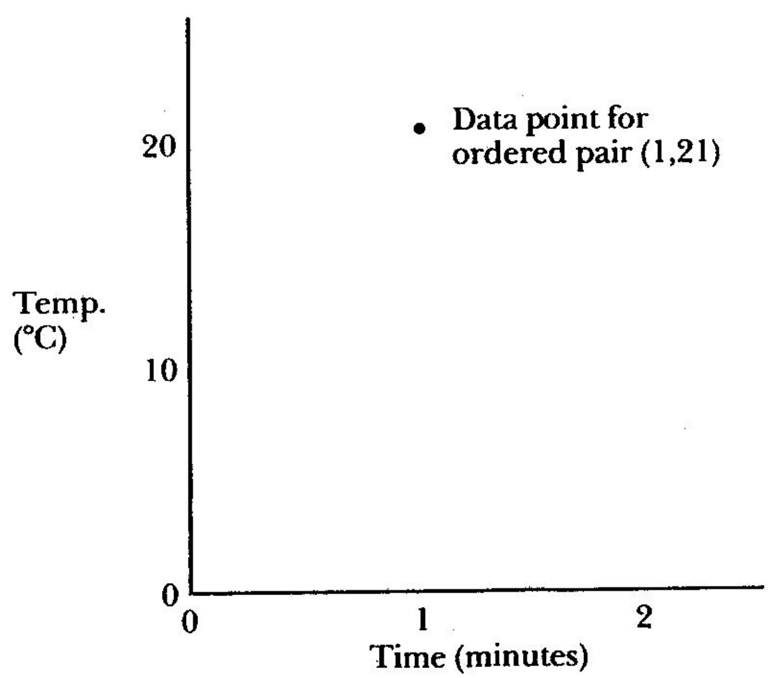
Intersection: the crossing of two lines when graphing.

The point where these two lines cross is called the **intersection** of the lines. And the point showing the location of that intersection is called a **data point.**

Data point: the place where the two data lines cross (or intersect).



(1 min, 21°C)



How do you find the ordered pair given only the data point?

To read a graph find a data point. Simply trace the horizontal and vertical lines back to each axis and you've found the ordered pair for that data point.

Plotting: finding the data point for an ordered pair.

Locating the data point by finding the intersection of the two lines is called **plotting.** Once all the data points are plotted and a line drawn to connect them, you have a simple way to "read" all the data in a data table quickly.

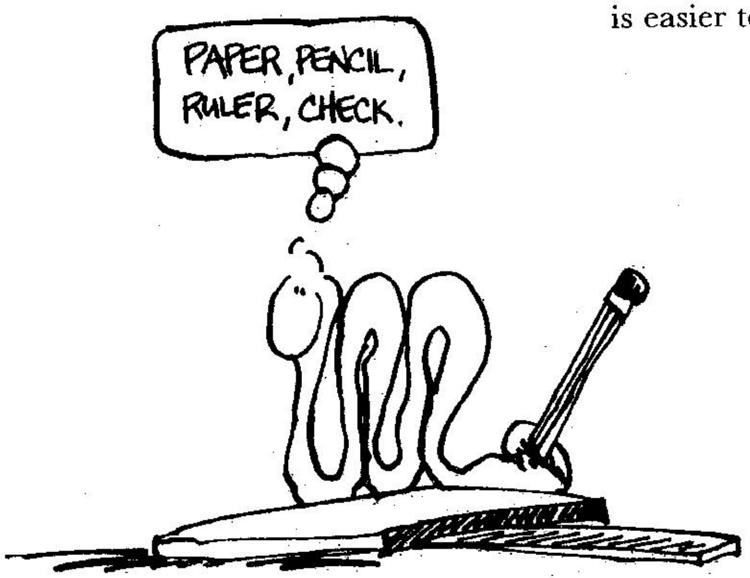
PLOTTING A LINE GRAPH

In order to plot a line graph, you'll need the materials listed below (be sure your brain is plugged in, too). We're going to use Heating Compound X for our example.

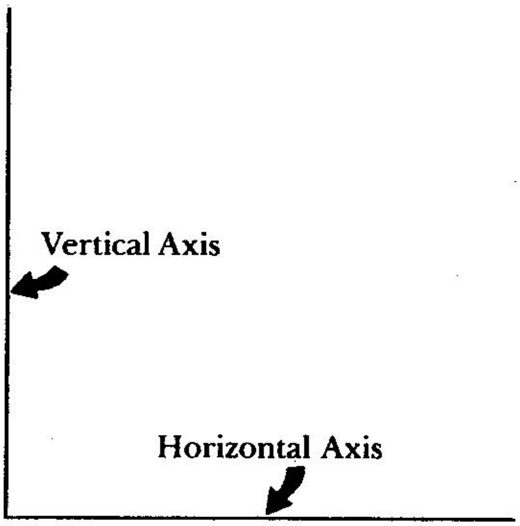
1. Graph paper (naturally)
2. Ruler
3. Pencil with an eraser (pens make permanent mistakes)

You'll also need some guidelines:

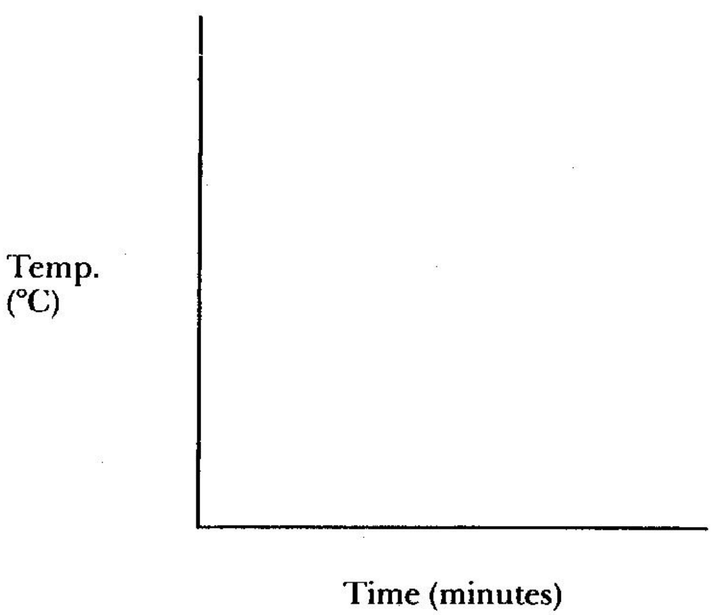
1. Always use graph paper when constructing a graph. It's easier to plot and more accurate than notebook paper.
2. Draw all lines with a ruler. It gives the graph a professional appearance and reduces the chance of error.
3. When drawing the horizontal and vertical axes start no less than three squares from the bottom of the paper and three squares from the left side. This gives you enough margin to label the axes legibly.
4. Do all your work in pencil. Pens don't erase, and neatness *does* count.
5. A complete graph has a descriptive title, both axes labeled correctly, data points plotted neatly, and a line connecting data points drawn with a ruler.
6. Use the whole piece of graph paper to do a graph. It is easier to read than a minigraph.



If you follow these simple guidelines then making a graph is easy. First, draw the horizontal and vertical axes using your ruler. Be sure to indent three spaces.



Next, look at the data table and decide which variable is the most consistent. In our example it's time. *The most consistent variable is labeled on the horizontal axis.* Label the vertical axis with the other variable.



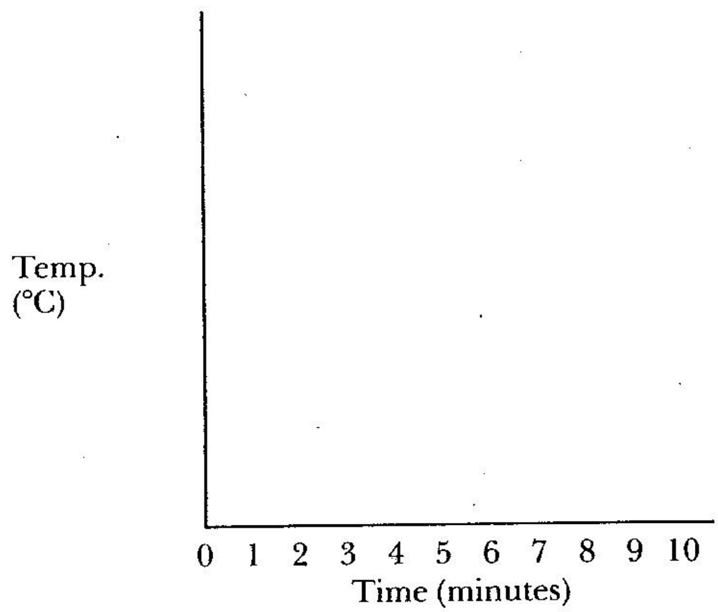
Intervals: an even spacing of the numbers along the axis of the graph.

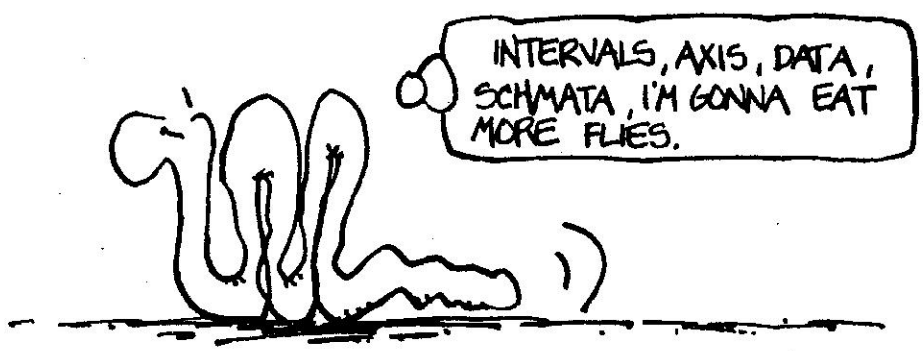
Third, number each axis in even **intervals.** Intervals are determined by looking at the smallest and largest numbers in the data table. Devise an even way to space them along the axis. Here's our data table.

Heating of Compound X

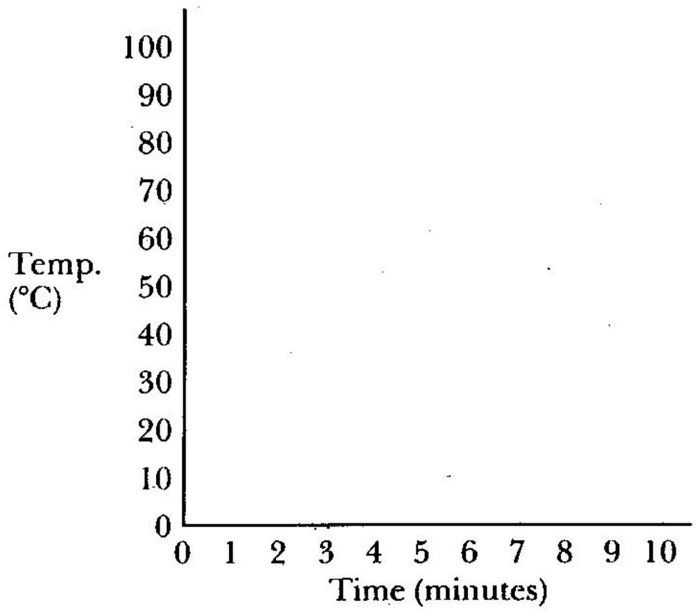
Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	20	21	23	27	35	45	61	69	71	73	74

For time, the smallest number is 0 and the largest is 10. The numbers between are in even intervals of 1's. Because the work is already done, label the horizontal axis straight off the data table.



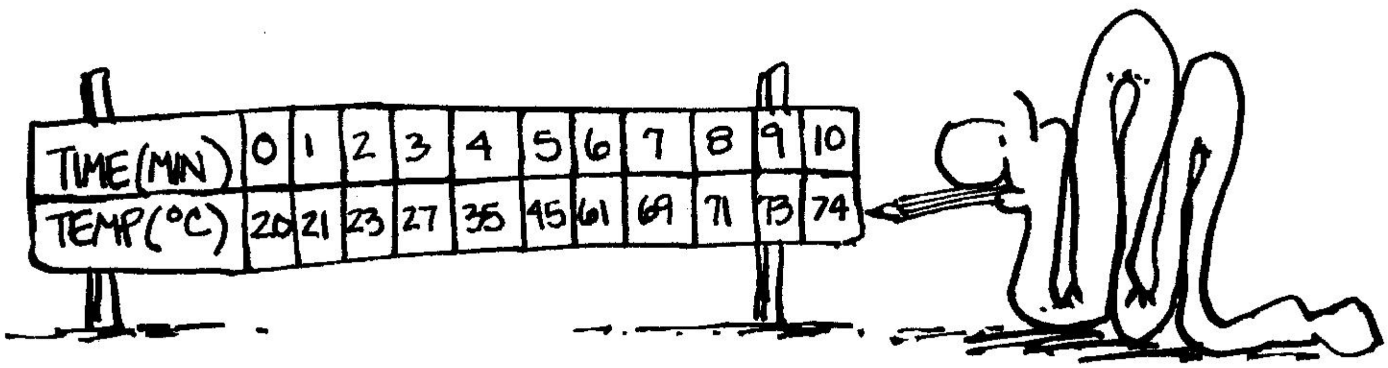


To determine the labels for the vertical axis we need to think a bit. The smallest number is 20, the largest number is 74. The rest of the numbers between are hardly what you would call even. If we label the axis by 10s and then plot the data points, we'll get a good picture of the data. You will most always satisfy your needs if you label the axis in intervals of 5, 10, or 100.

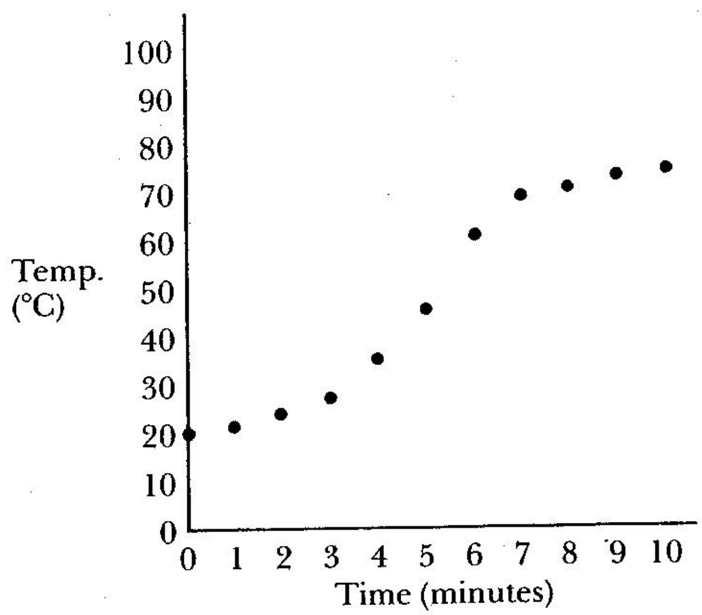


brain stretcher #6

Once the axes are drawn and labeled it's time to plot the data points. Using the data table below, split up the ordered pairs. Find each half of the pair on the respective axis, and follow the lines until they intersect. You can see how all of the ordered pairs should be plotted.



Heating of Compound X

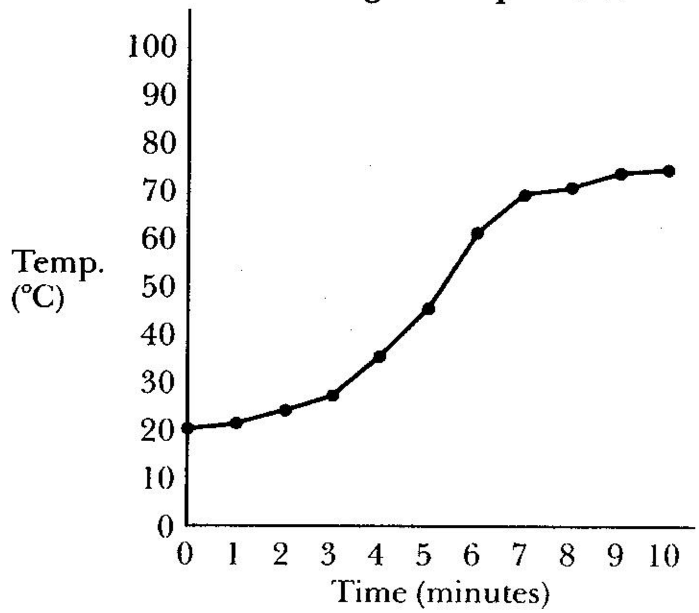


Line graph: a graph drawn using data points.

After all the data points are plotted, get out that hot little pencil. Line up the data points with a ruler, and connect the dots. When all the points are connected, you'll have a **line graph** like the one below.

Explain why an accurate relationship between the ordered pairs is shown only if even intervals are marked on the axes.

Heating of Compound X



Be sure to copy the descriptive title from the top of the data table onto the top of the graph.

BRAIN STRETCHER 7

READING MULTIPLE LINE GRAPHS

When there is just one line on the graph it is called a single line graph. That makes sense. But, if there are two or more lines on a single graph it's called a multiple line graph. The data table below can be used to produce one of these graphs. Multiple line graphs are especially helpful when comparing several different experiments utilizing similar data.

Heating of Compounds X, Y, Z

Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temp. X (°C)	20	21	23	27	35	45	61	69	71	73	74
Temp. Y (°C)	25	30	32	33	33	35	40	60	70	80	83
Temp. Z (°C)	28	35	55	56	57	57	69	75	78	78	79

There are still only two variables; time and temperature. So, the graph is still constructed the same as the first example. The tricky part comes in figuring out the ordered pairs because there are three temperature columns and only one time column. The answer is to recycle the time variable by matching it to the temperatures directly below it each time.

ORDERED PAIRS

X LINE (0,20°)
Y LINE (0,26°)
Z LINE (0,28°)

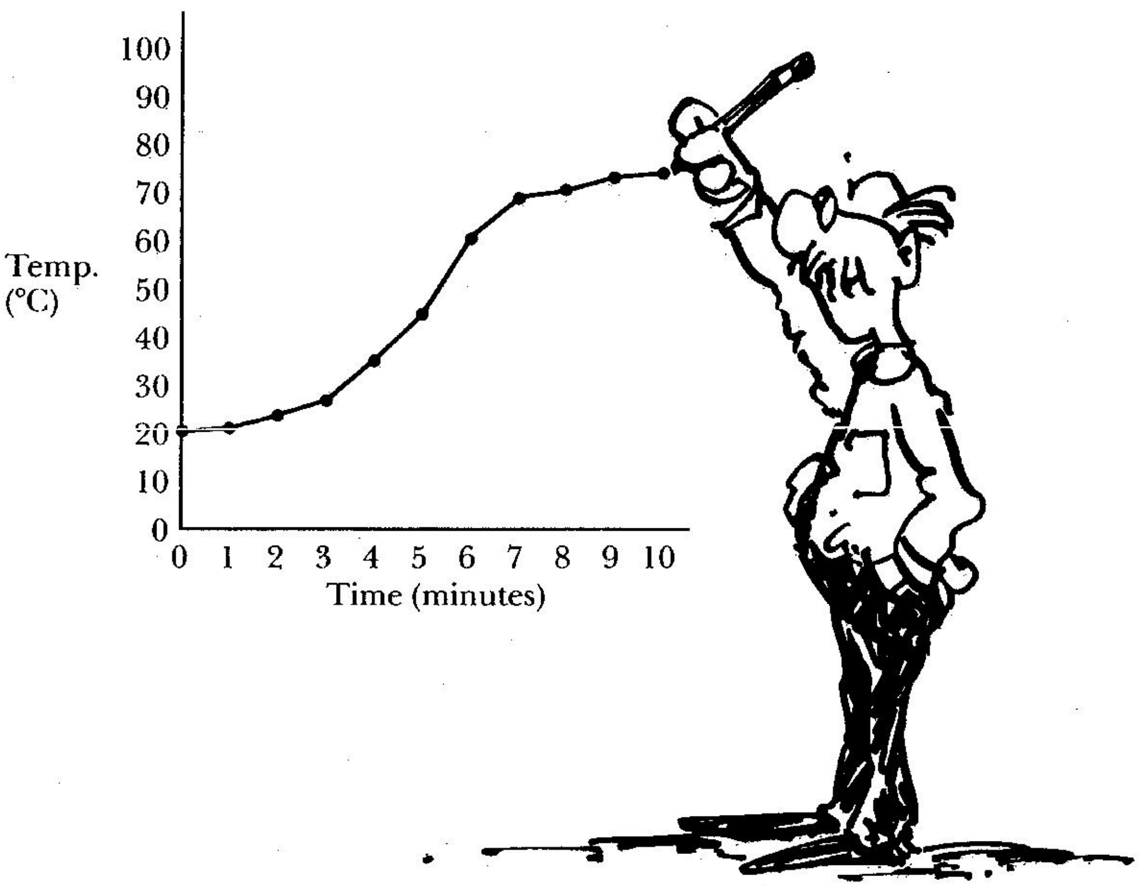
BRAIN STRETCHER 8

CONSTRUCTING A MULTIPLE LINE GRAPH

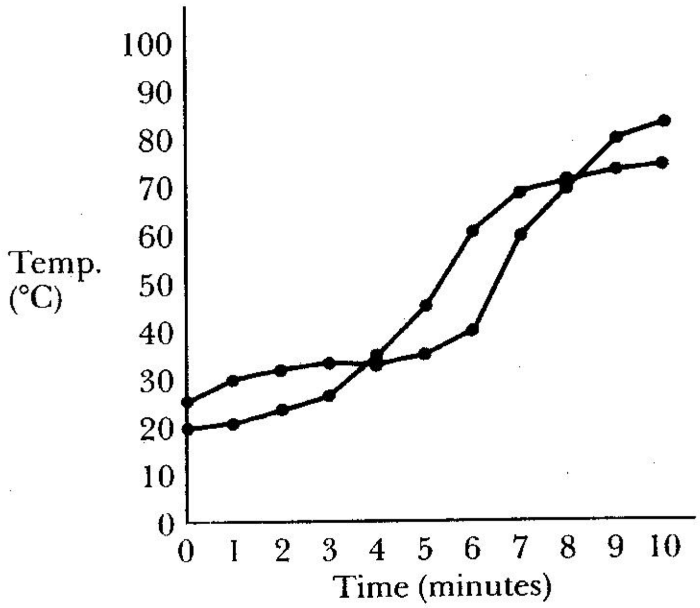
The easiest way to construct a multiple line graph is to plot one line at a time. Using this method reduces the chance of error. Here's how it works, step-by-step. First plot the ordered pairs for time and temperature X. We'll call the line you produce line X.

Heating of Compounds X, Y, Z

Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temp. X (°C)	20	21	23	27	35	45	61	69	71	73	74
Temp. Y (°C)	25	30	32	33	33	35	40	60	70	80	83
Temp. Z (°C)	28	35	55	56	57	57	69	75	78	78	79

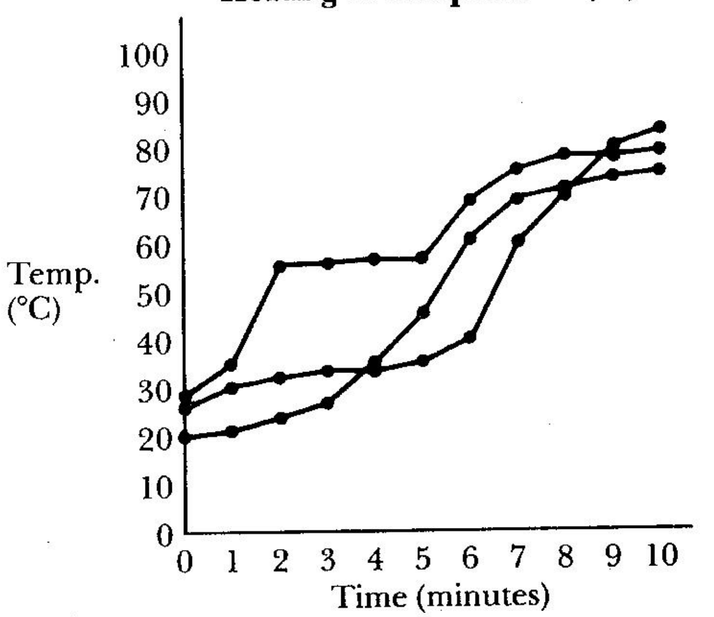


Now that line X is complete move on to line Y. Plot line Y on the same graph.



Lines X and Y are on the graph. As soon as line Z is plotted the graph will be finished.

Heating of Compounds X, Y, Z



What are the advantages to using a multiple line graph?

And there you have it, a finished line graph. For the sake of clarity, you may wish to use a different color for each line or different symbols.

brain stretcher nine

BEST FIT GRAPHS

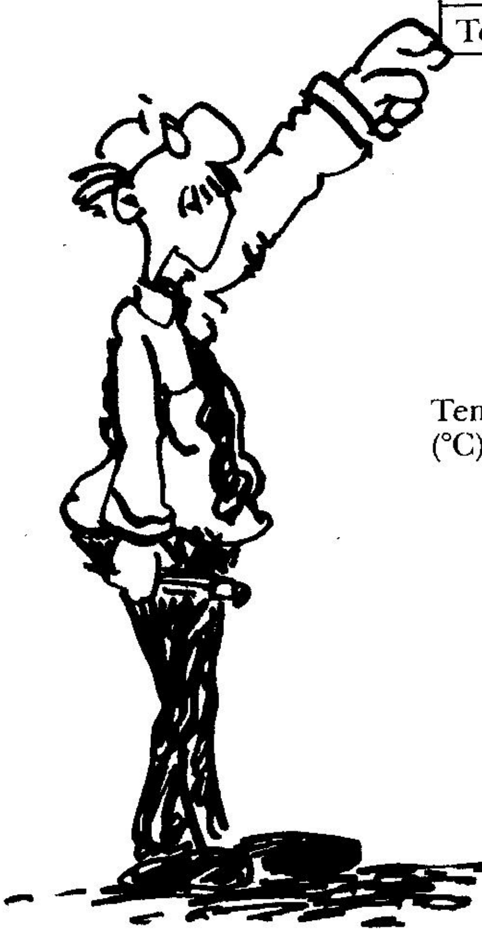
Best fit graph: a graph with a line passing through many but not all plotted points. Best fit graphs allow scientists to predict various unplotted points on a graph.

A line graph is a very precise way of recording data. Sometimes though, scientists prefer to find an average or would like to be able to predict what might happen. To do this they use a **best fit graph.**

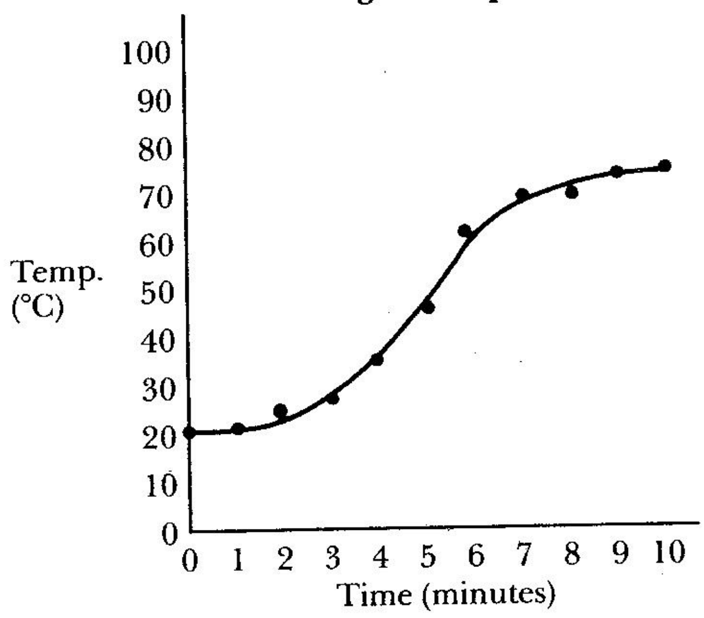
A best fit graph is a guesstimate, somewhere between a guess and an estimate, or an educated guess. You construct the graph and plot the data exactly as you would for a line graph. The difference is the way you draw the line. You can see that the best fit line in the graph below is smooth and continuous. The line flows through most of the data, but doesn't necessarily have to touch all of the data points.

Heating of Compound X

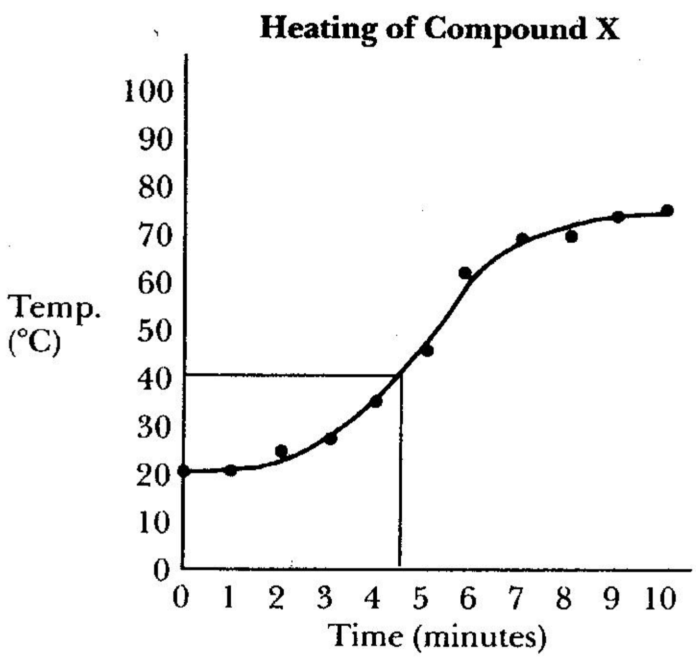
Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	20	21	23	27	35	45	61	69	71	73	74



Heating of Compound X



The best fit line goes through as many of the data points as possible, but remains a smooth curve. The advantage to this kind of graph is that it allows us to predict data that we did not collect. The prediction may not be exact, but it will be very close. For example, what would be the temperature after 4 1/2 minutes of heating? We didn't directly measure the temperature at that point, but we can look at the graph and make a good guess at the probable temperature.



The answer to our question is probably close to 40 °C.

What are the differences between a line graph and a best fit graph?

Best fit graphs are valuable for two reasons:

1. Best fit graphs allow us to predict information by showing a representative curve of the data collected.
2. Best fit graphs save time because they can be plotted using a small sample of data.

★ BRAIN STRETCHERS 10 & 11

Name ______________________ Class ______________ Date ______________

BRAIN STRETCHER

Directions: Flip a penny 5, 10, 15, 20, 25, 30, and 35 times separately. Record the number of times the coin lands heads up for each test. Organize your data here below. There is no right or wrong way to organize your data. Just make sure you record it accurately.

Vocabulary: Define the following words.

1. Jargon—

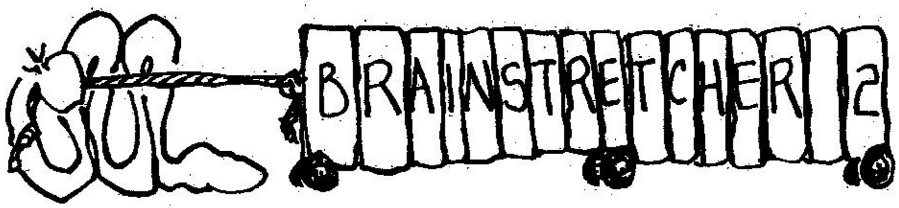
2. Data—

Question: Answer the following question.
How is data valuable to scientists?

____

____

Name ____________________ Class ____________________ Date ____________________



Directions: Identify the different parts of the data table by answering the questions that follow it.

High Daily Temperature

Time (days)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature (°C)	27	28	31	30	34	38	42	18	20	24	21	29	33	28	38

1. The title is ____________________.

2. The two variables are __________ and __________.

3. The unit for time is __________ and for temperature is __

4. List the ordered pairs.

__________ __________ __________

__________ __________ __________

__________ __________ __________

__________ __________ __________

__________ __________ __________

5. The highest daily temperature was __________, which occurred on day __________.

6. Day 10 had a temperature of ____________________.

7. On two days, the temperature recorded was 28°C. One was day __________ and the other was day __________.

Vocabulary: Define the following words.

1. Data table—

2. Title—

3. Variable—

4. Unit—

5. Ordered pair—

Questions: Answer the following questions.

Why is it important to have variables and units included in a data table?

What is the best way to identify an ordered pair?

Name ____________________ Class ____________________ Date ____________________

BRAIN STRETCHER #5

Directions: Using the guidelines in your graphing booklet, correct each of the following data tables.

1.

Height of Corn Plants

Time	1	2	3	4	5	6	7	8
Height	5	25	70	82	120	306	420	570

2.

Time (weeks)	1	2	3	4	5	6	7	8
Height (cm)	5	25	70	82	120	306	420	570

3.

Time	1	2	3	4	5	6	7	8
Height	5	25	70	82	120	306	420	570

4.

Height of Corn Plants

Height (cm)								

5.

Height of Corn Plants

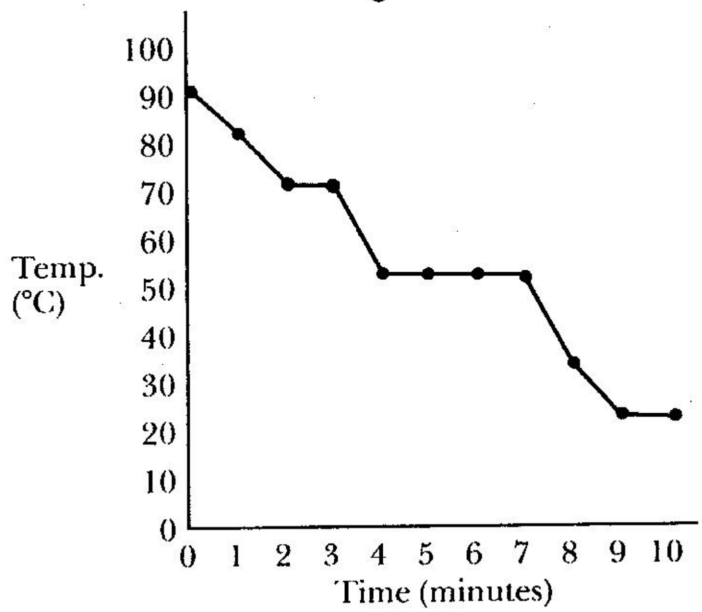
(weeks)	1	2	3	4	5	6	7	8
(cm)	5	25	70	82	120	306	420	570

Name ______________________ Class ______________ Date ______________

brain stretcher 4

Directions: Using the graph, answer the questions that follow it.

Cooling of Substance Z



1. The title of the graph is ______________________.

2. The two variables are ______________ and __________.

3. The unit for time is ________ and for temperature is ______ __________.

4. At __3__ minutes it was ______________________ °C.

5. At __9__ minutes it was ______________________ °C.

6. At __70 °C__ the time was ____________________ minutes.

7. At __30 °C__ the time was ____________________ minutes.

8. At what temperature did substance Z level off for 4 minutes?

____

9. What was the starting temperature of substance Z? ________.

10. The total temperature loss for substance Z was ______________________.

Vocabulary: Define the following words.

1. Graph—

2. Horizontal axis—

3. Vertical axis—

4. Intersection—

5. Data point—

6. Plot—

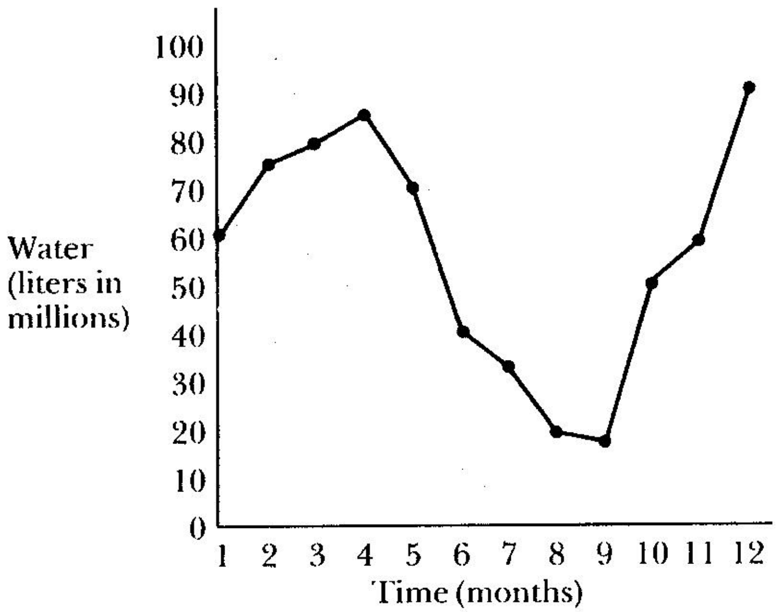
Question: Answer the following question.
What are the similarities between a data table and a graph?

Name ____________________ Class ____________________ Date ____________________

brain stretcher 5

Directions: Using the following graph, construct a data table in the space below. Remember the guidelines in the graphing booklet.

Water Flow Over a Dam



Question: Answer the following question.
How do you find an ordered pair given only the data point?

Name ________________ Class ________________ Date ________________

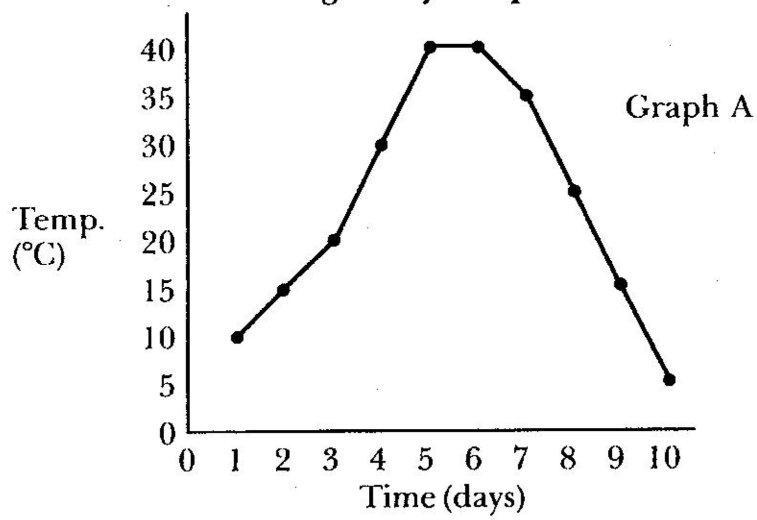
brain stretcher #6

Directions: Compare the data table with the two graphs and answer the questions.

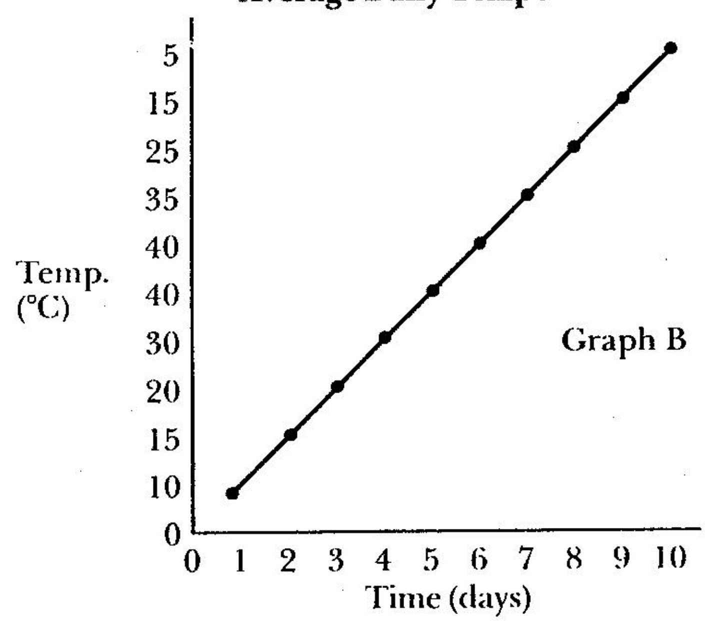
Average Daily Temperatures

Time (days)	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	10	15	20	30	40	40	35	25	15	5

Average Daily Temperatures



Average Daily Temperatures



1. What does the line in graph A show the temperature doing over 10 days?

2. What does the line in graph B show the temperature doing over 10 days?

3. What is the major difference in the lines of the two graphs?

4. Look at the data for temperature in the data table. Describe what happens to the temperature.

5. Which graph shows an accurate picture of the data?

6. How would you change the graph that does not show an accurate picture of the data?

Name ____________________ Class ____________________ Date ____________________

BRAIN STRETCHER 7

Directions: Using the data tables below, construct a line graph for each. Use a separate sheet of graph paper for each graph.

Average Rainfall in Willamette Valley

Time (months)	1	2	3	4	5	6	7	8	9	10	11	12
Rainfall (mL)	15	21	28	24	16	8	2	1	2	3	5	10

High Daily Temperatures

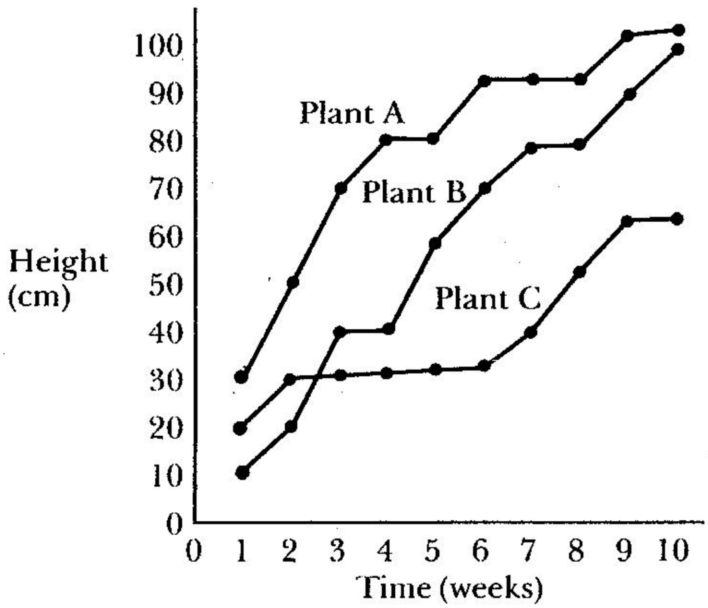
Time (days)	1	2	3	4	5	6	7	8	9	10	11	12
Temperature (°C)	27	28	31	30	33	37	36	18	20	21	24	30

Name ______________________ Class ______________ Date ____________

BRAIN STRETCHER 8

Directions: Using this graph, answer the following questions.

Growth of Three Pea Plants



1. For the weeks given, record the heights of the three plants.

Week	Plant A	Plant B	Plant C
3	______	______	______
7	______	______	______
10	______	______	______

2. How many weeks did it take for plant A to reach 90 cm? ______.

3. Which plant remained at about 30 cm for 4 weeks? ________.

4. Which plant remained at 90 cm for 2 weeks? ______________.

5. When plant A was 50 cm tall how tall was plant C? ________.

6. Which plant grew the most? ______________________________.

7. Which plant grew the least? ______________________________

8. Which plant was probably sick?

Name ______________________ Class ______________ Date ______________

Brain Stretcher Nine

Directions: Construct a multiple line graph for each of the two data tables below. Use a separate piece of graph paper for each graph.

Gain in Mass of Young Mice

Time (weeks)	1	2	3	4	5	6	7	8	9	10
Mass 1 (mg)	25	115	140	210	400	720	780	810	830	900
Mass 2 (mg)	20	120	125	200	250	300	400	520	540	570
Mass 3 (mg)	30	140	160	220	380	680	690	770	800	950

High Temperatures For Three Cities

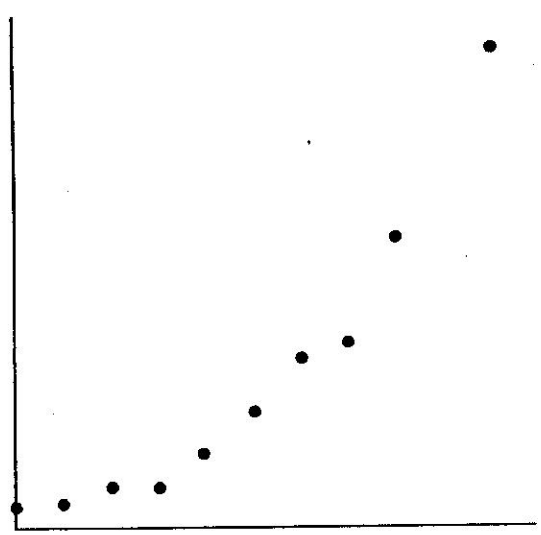
Time (days)	1	2	3	4	5	6	7	8	9	10
Temp. (LA) (°C)	28	29	22	27	26	27	29	31	30	24
Temp. (SF) (°C)	18	22	20	17	21	21	20	18	21	19
Temp. (PD) (°C)	11	10	14	13	15	16	15	11	15	17

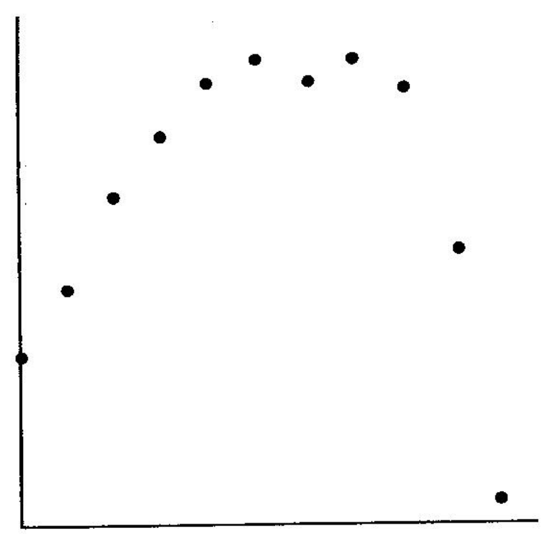
Question: Answer the following question.
What are the advantages of a multiple line graph?

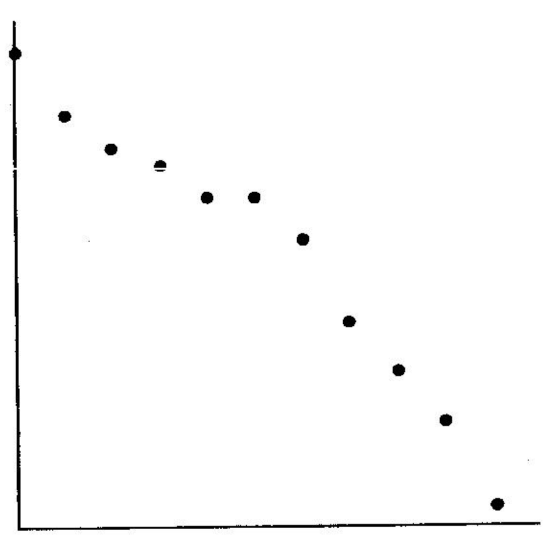
Name ______________________ Class ______________ Date ______________

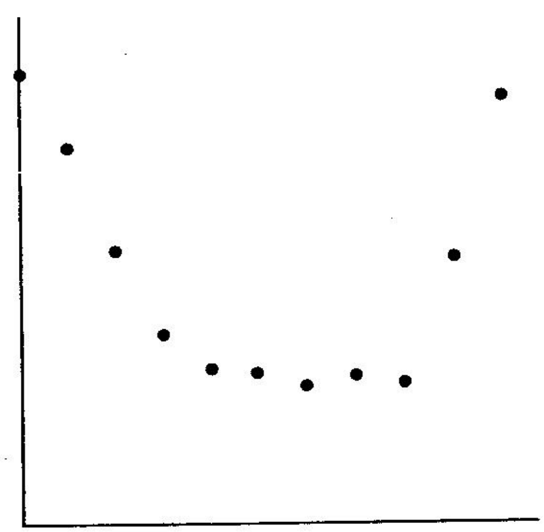
brain stretcher 10

Directions: Practice making a smooth curve on the following graphs.









Question: Answer the following question.
What are the differences between a line and best fit graph?

Name ____________________ Class ____________________ Date ____________________

BRAIN STRETCHER #12

Directions: Construct a best fit graph for each of the two data tables below. Use a separate piece of graph paper for each graph.

Height of Corn Plants

Time (weeks)	1	2	3	4	5	6	7	8
Height (cm)	5	25	70	82	120	306	420	570

High Daily Temperature

Time (days)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Temperature (°C)	27	28	31	30	34	37	37	18	20	24	21	29	32	37