

The Nature of Science

Objective 1

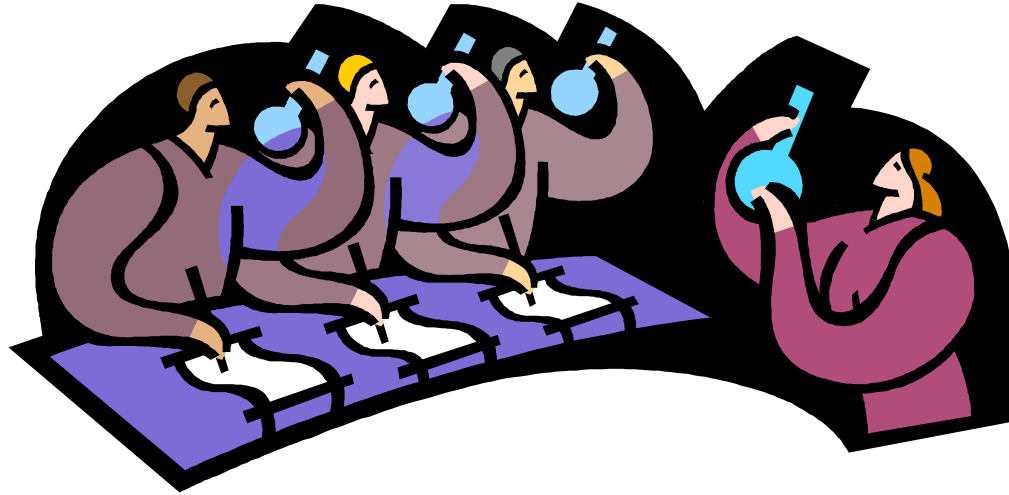
Day 1

Scientific Method and Safety

Science vs. Technology

- Science is the knowledge gained from experimentation.
- Newton's Laws
- Theory of Relativity
- Ohm's Law
- Human Genome Project
- Technology is the use of science knowledge to make things.
- Calculators & computers
- Atomic Energy
- Electric motors
- Gene therapy
- Antibiotics

Scientific Method



- Propose an hypothesis based upon observations.
- Plan an experiment with only 1 variable to change.
- Conduct the experiment many times.
- Analyze the data for trends and comparisons.
- Make a conclusion based upon the data and observed trends and propose a new hypothesis to test.

46 Two science students discovered that the mass of a sample of acetone in an open beaker decreased within a few minutes. One student hypothesized that the acetone reacted with oxygen to form a gaseous compound that escaped. The other student believed that the acetone evaporated into the air. What should the students do to test these hypotheses?

- F** Combine the hypotheses so they give valid predictions of the acetone's behavior
- G** Conduct a study of original papers describing the experiments leading to acetone's discovery
- H** Perform an experiment that attempts to identify the gas above the open beaker
- J** Ask a classmate's opinion about the chemical and physical properties of acetone

Let's look at each answer . . .

F Combine the hypotheses so they give valid predictions of the acetone's behavior

- This would require testing for a chemical reaction AND the presence of acetone above the beaker.
- T O O M A N Y
V A R I A B L E S

G Conduct a study of original papers describing the experiments leading to acetone's discovery

- This may tell us a lot about acetone, but it will not answer our question. We still won't know if it evaporated or not.

Your classmates' opinions although they may be smart won't answer the question either. Throw out J.

H Perform an experiment that attempts to identify the gas above the open beaker

This looks like our best answer, it involves actually trying to identify the gas above the beaker, which will tell us if it is still acetone. If it is, then it evaporated.

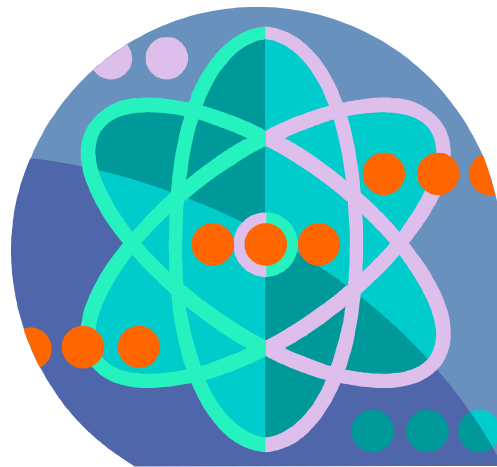
What if the data doesn't support the hypothesis?



- Some very important discoveries occurred when the scientist was actually looking for something else. For example, antibiotics and rubber.

When the hypothesis doesn't fit

1. Make a new hypothesis, based on the observations.
2. Make an inference. What could the data be showing, even if it is not **DIRECTLY OBSERVABLE**?



A scientist has hypothesized that the existence of life on Mars is likely because Mars's atmosphere is 95% carbon dioxide.

36 Which question is valid in testing this hypothesis?

F Do most other scientists agree with the hypothesis?

G Could abiotic processes account for the carbon dioxide?

H What is the percent of argon compared to carbon dioxide in the Martian atmosphere?

J Have the scientist's other predictions about Mars been validated?

36 Which question is valid in testing this hypothesis?

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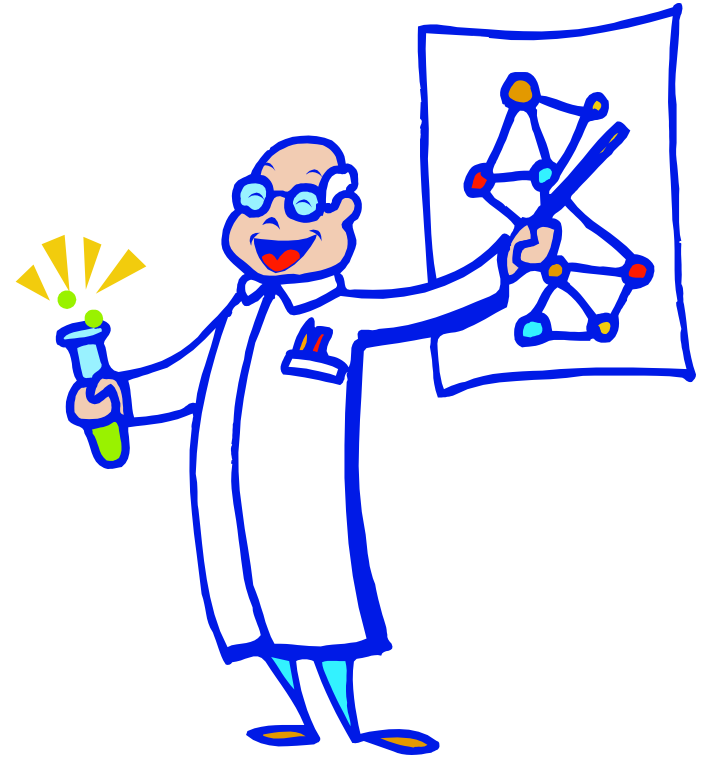
H What is the percent of argon compared to carbon dioxide in the Martian atmosphere?

J Have the scientist's other predictions about Mars been validated?

When testing an hypothesis, there should be only one variable changed at a time. If this is not possible, then all possible reasons for an outcome need to be considered. In this case, carbon dioxide can be produced by chemical reactions other than cellular respiration, which is a biotic process. That is why answer G is the best answer

When analyzing data . . .

- Compare the data trend to the hypothesis.
- Does the data agree?
- Does it show the opposite?
- Could there be another reason that the trend agrees with the hypothesis? Did all other factors get controlled?



Scientific Theory

- Theories are based upon experimental data.
- Confirmed by repeated experiments.
- Modified as new information is gathered.



Scientific Law



- Theories become Laws when nothing changes for hundreds of years.
- Laws become theories again when new information changes them.

5 The smell of an ammonia solution used to clean a floor can quickly be detected throughout a house. Scientists explain this phenomenon by theorizing that gas molecules from the ammonia are in continuous random high-speed motion, drifting rapidly and permeating the air. Which statement best demonstrates the strength of this theory?

And your choices were . . .

- A** Scientists have observed tiny smoke particles moved by unseen particles in a rapid, irregular fashion.
- B** Scientists have unanimously agreed on this theory since Thomas Graham's experiments in the 1820s.
- C** The possibility of another theory being formed to explain the phenomenon as well is very remote.
- D** Reason, as opposed to experimentation, is superior to any explanation found through chemical testing.

- A** Scientists have observed tiny smoke particles moved by unseen particles in a rapid, irregular fashion.
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- D** Reason, as opposed to experimentation, is superior to any explanation found through chemical testing.

A compares the ammonia movement to something known. **A** is good evidence!

B, I don't think so, it takes hundreds of years for scientists to agree on any theory.

C, Other theories are proposed all the time, so throw this one out.

D, Experimentation is always the preferred method, so this one is out, too.

Therefore, you were right!
It is **A**!

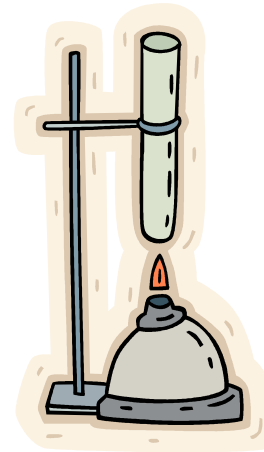
Experimentation and Safety



- Use only labeled materials.
- Read labels twice to make sure.
- Know the procedure.
- Ask about the MSDS if you are not familiar with the substance.

Safety with Temperature Changes

- Do not handle hot or cold containers.
- Use the proper holder for the container.
- When heating a substance, aim it away from everyone.



Safety with Gases

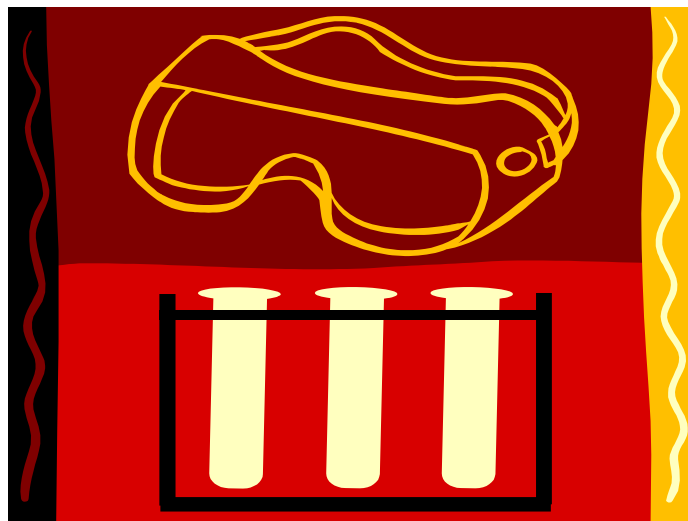


- Odors are tested by wafting.
- Reactions which produce gases should be done in a fume hood.
- Gases should be trapped only in a large volume container to provide for rapid expansion.

55 A science class is conducting an experiment that produces noxious fumes. Because of inadequate ventilation, some students begin to feel nauseated and dizzy. The first response should be to —

- A** neutralize the acid that is reacting to produce the noxious fumes.
Not A — Acids are not the only producers of fumes, and adding something else could make it worse!
- B** carry the reactants outside, away from other students.
Don't move it anywhere except under a fume hood. Too dangerous! Not B
- C** leave the room and go to an area with fresh air
- D** spray the reaction with a fire extinguisher.
Not D — Extinguishers should only be used on fires.

Safety Equipment



- Protective goggles are worn in lab at all times.
- Non-ventilated are worn if contact lenses are worn.
- Aprons should be worn when handling chemicals.
- Follow MSDS for safe handling of all chemicals.

1 The safest way to dilute concentrated sulfuric acid is to add —

A a series of small volumes of water to the acid while stirring

B the acid to water slowly while stirring constantly

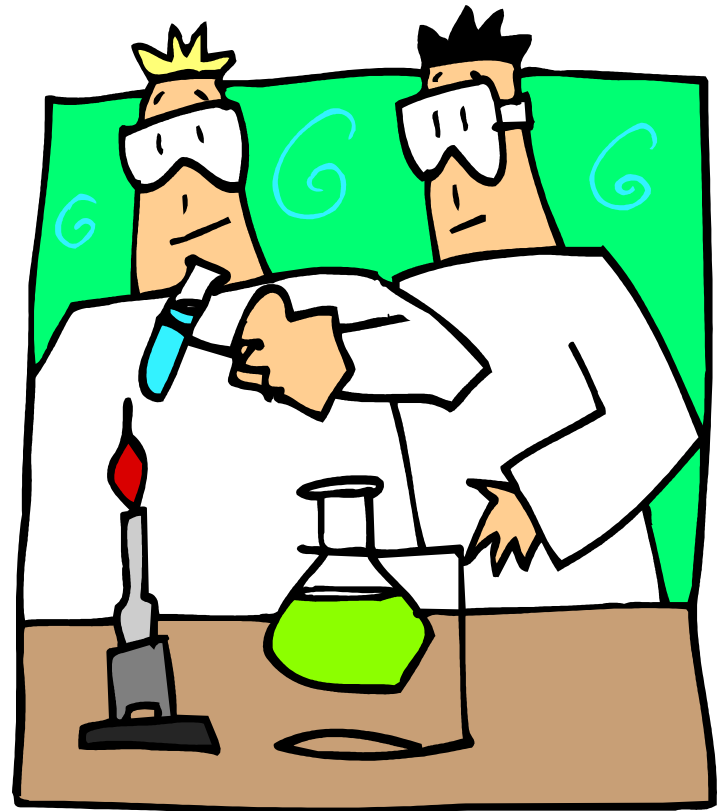
C the acid to a small volume of water and then add more water

D dilute sulfuric acid to a small volume of the concentrated acid

- The safety rule says always add acid to water, so A & C are out since they both add water to acid.
- D doesn't even make sense since you can't make concentrated acid out of a dilute acid by adding to it.
- So the answer is

Variables – MIX

Manipulated or
Independent
Variable is the one
you are changing
and is first in a
data table and
plotted on the **X**-
axis of the graph.



Variables - DRY



Dependent or **R**esponding variable is second column in a data table, and plotted on the **Y**-axis of a graph.

A **Control** vs. **Controlled Variables**

- **Control** or control group is one that participates in the experiment without the change being tested. (Receives a placebo, or grown under the same conditions.)
- **Controlled Variables** are the other factors in an experiment that might affect the results. (Amount of water, sunlight, strength of the drug, food.)

Time Required for Water Evaporation

Container	A	B
Volume of Water (mL)	25	25
Temperature (°C)	-15	25
Time Required (h)	72	24

28 The table shows times required for water to evaporate from identical containers. Which of these is the best question to ask before developing a reasonable hypothesis to explain the data?

What do you know? Identical containers, and same volume of water.

F Why does a lower temperature slow the rate of evaporation?

G What is the boiling point of the water after both samples are heated?

H Why does water exist as a solid at -15°C and as a liquid at 25°C ?

J How does the rate of evaporation change when a different container is used?

- J is out since the containers are identical.
- H has nothing to do with the rate of evaporation so it is out
- G is out, because the boiling point of a substance is a physical property that can identify a substance, so it is out
- That leaves F, which asks about temperature and a rate “slow”.

Data Collection and Sample Size

The larger the amount
of data collected,
The larger the sample
size,
The more times the
experiment is
repeated,
The more valid are the
results.



30 An herbal company advertises that its product will help people lose weight if they take a tablespoon of the product with a glass of water at bedtime each night. Weight loss is guaranteed if a person does not eat for at least 3 hours before bedtime, gets moderate exercise, and drinks 8 glasses of water each day. Why is the company's claim difficult to verify?

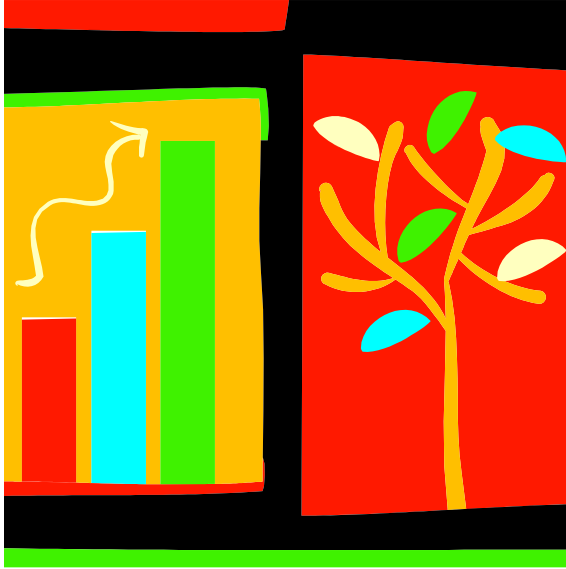
F Not eating before bedtime is recommended for all weight loss programs, and it takes several hours to digest and absorb anything you take, so this statement is invalid.

G Numerous uncontrolled variables are involved in evaluating results. **True and also correct!!**

True, but still doesn't control any of the other factors.

J The advertisement lacks data from before and after the weight loss.

Analysis of the Data



- Data tables, flow charts and graphs present the information collected during an experiment.
- What the data shows, any trend in information is explained in the analysis of data.

31 An environmental-science company measured the ozone pollutant levels at two different locations in a metropolitan area. Which statement is best supported by these data?

Ozone Levels for a Metropolitan Area

Date	Location	High Temperature (°C)	Prevailing Wind	Ozone Level (ppm)
1/15/99	Downtown	13	NE 5 mph	0.01
	NW Station	11	NE 10 mph	Trace
3/15/99	Downtown	22	Calm	0.03
	NW Station	21	Calm	0.03
5/15/99	Downtown	30	SE 10 mph	0.05
	NW Station	31	SE 5 mph	0.06
7/15/99	Downtown	38	S 5 mph	0.12*
	NW Station	38	S 5 mph	0.14*

Look for the unsafe levels and where and when they occur.

*Unsafe levels of ozone above 0.10 ppm

Both occurred on 7/15 at a temperature of 38 °C, so . . .

- A** Lower fuel efficiency and northerly winds in the **winter** increase ozone pollution the most.
- B** Northwest winds in the **spring** transport ozone pollution into the metropolitan area.
- C** High summer temperatures and southerly winds contribute to high levels of ozone.
- D** Heavy use of automobiles changes ozone levels the most.

This is true, however not supported by the data in the table since both downtown and northwest areas had increases

Data Presentation and Analysis

- Data tables are lists of information that may or may not show a relationship.
- Graphs are pictorial representations of information to aid in seeing any relation between them.



Reading Tables and Graphs

1. When a question includes a table or graph, **read it first**, before the question.
2. Don't just Look at it READ IT.
3. What is the Title, what is being measured or compared? What units (grams, mLs, minutes, years) are given?
4. Are the numbers or slope increasing, decreasing?
5. After reading the data, now read the question!

22 The table shows environmental factors and soybean production for three regions.

Texas Soybean Production

Study Region	1			2			3		
Soil Type	Loam/clay			Loam/clay			Loam/clay		
Year	1998	1999	2000	1998	1999	2000	1998	1999	2000
Annual Rainfall (centimeters)	123	134	122	120	132	117	132	136	115
Average O ₃ Level (parts/million)	0.04	0.08	0.09	0.08	0.08	0.07	0.10	0.08	0.06
Average Crop Yield (bushels/acre)	34	28	26	28	27	29	25	28	31

Which of the following probably accounts for the decrease in soybean yield in Region 1?

- **F** High levels of ozone damaged the soybean plants, decreasing the average yield.
- **G** Low rainfall amounts failed to meet the plants' moisture needs and inhibited growth.
- **H** Poor mineral levels found in the soil in that region limited the soybean harvest.
- **J** Higher-than-normal rainfall increased pest activity, decreasing the average yield.

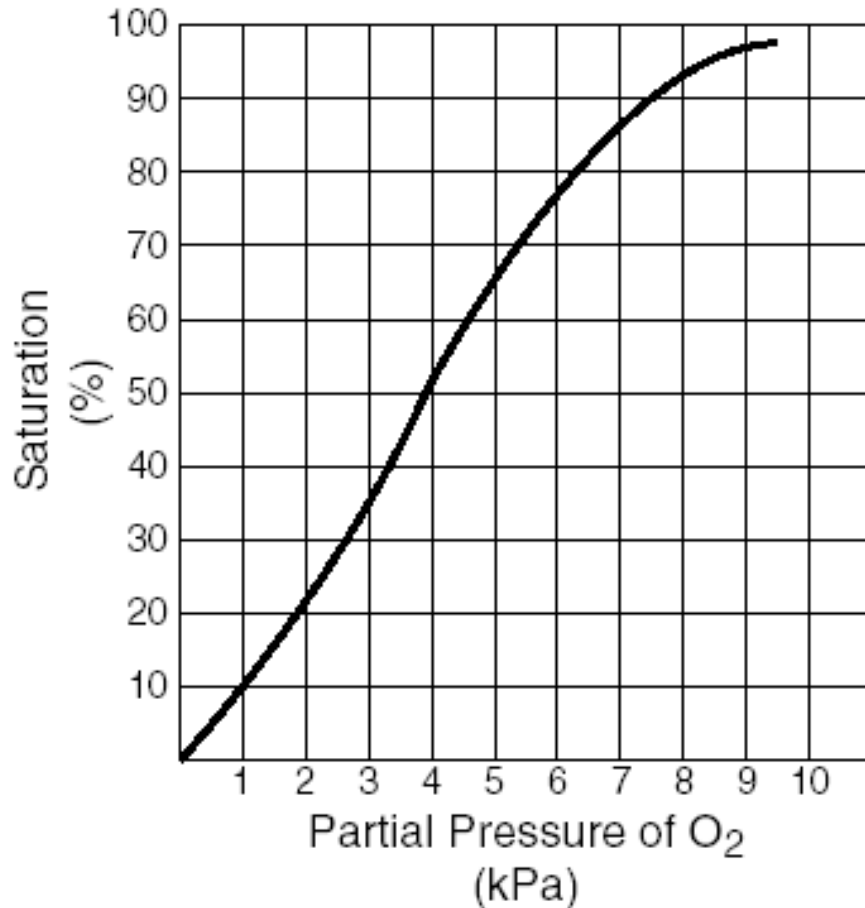
What do you have to know?

- 1st you really only have two choices, decreased rainfall, or O₃ level.
- Since the rainfall did not decrease consistently (it actually increased in 1999) that would not be a good answer.
- Therefore, it must be the O₃, which is the chemical formula for ozone.
- Answer?

F

Reading Graphs

Hemoglobin Saturation vs.
Partial Pressure of Oxygen



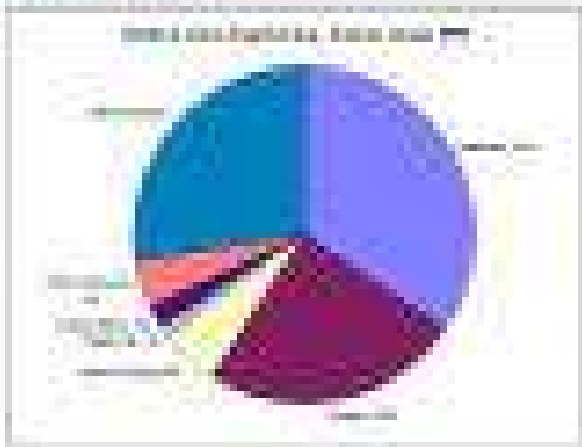
Always read the title.

Read the x- & y-axis labels & UNITS.

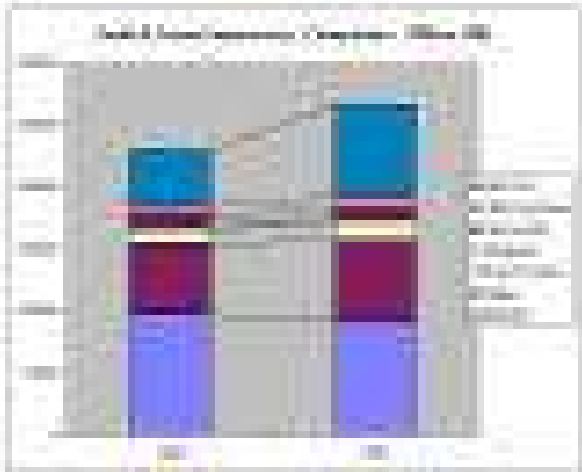
What is happening?

As the pressure of oxygen increases, the % saturation is increased.

Graph Types – Pie and Bar



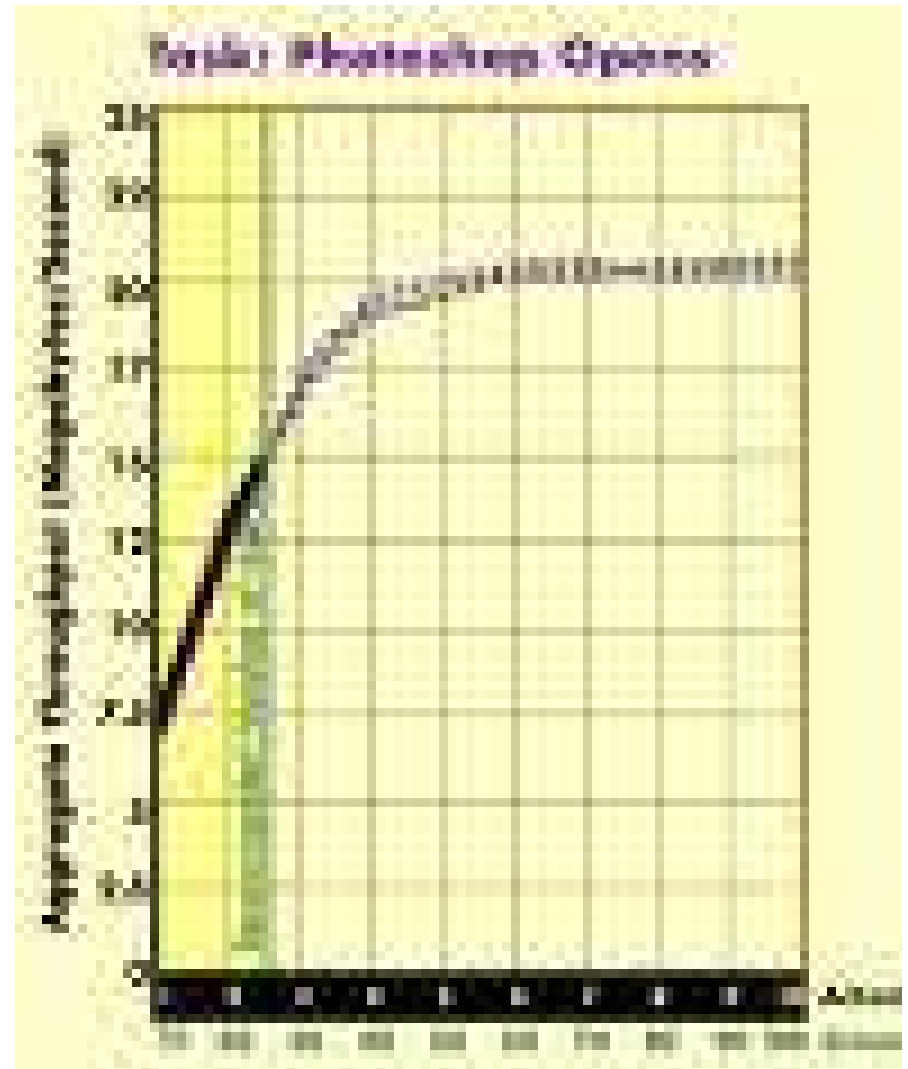
Pie Graphs are used to show parts of a whole and percent distributions.



Bar Graphs show noncontinuous data such as number of males and females in each science class with different hair colors.

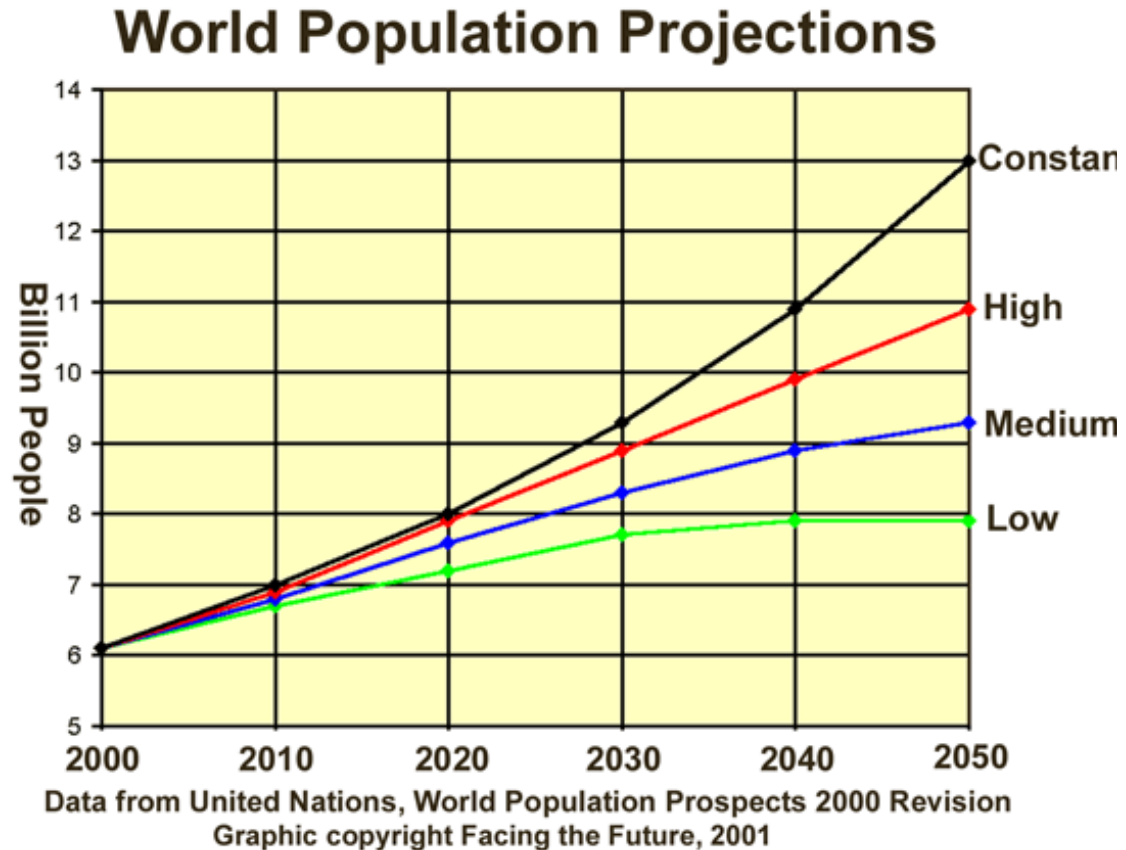
Graphs – Line or Curves

Line Graphs show continuous data like distance vs. time, acceleration, or plant growth over 6 weeks



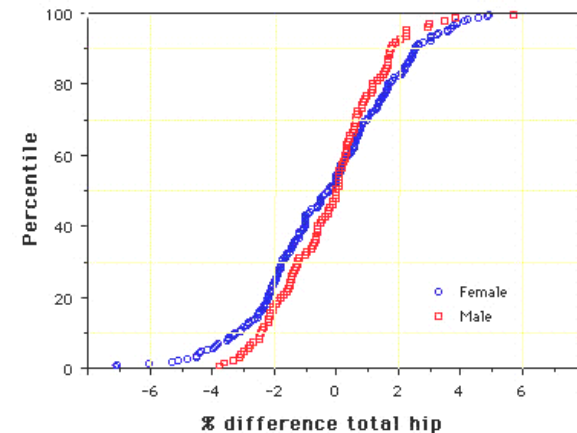
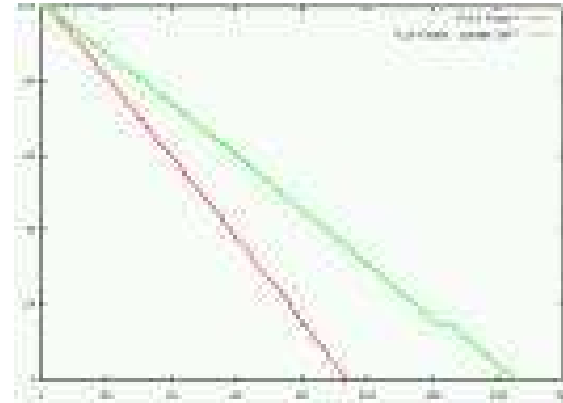
Data Trends

Direct
relationship
means as one
variable
changes, the
other changes
in the same
way.



Other Data Trends

- **Inverse** – when one goes up the other one goes down or as one goes down the other goes up.
- **Exponential** – typical of uncontrolled growth of a population, is a J-shaped curve

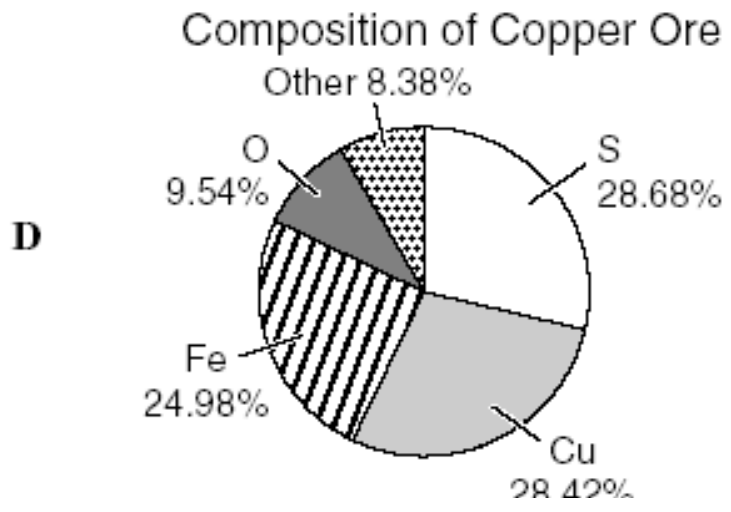
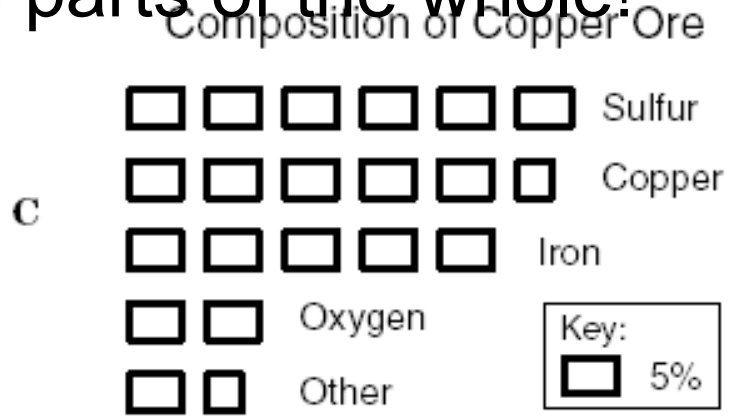
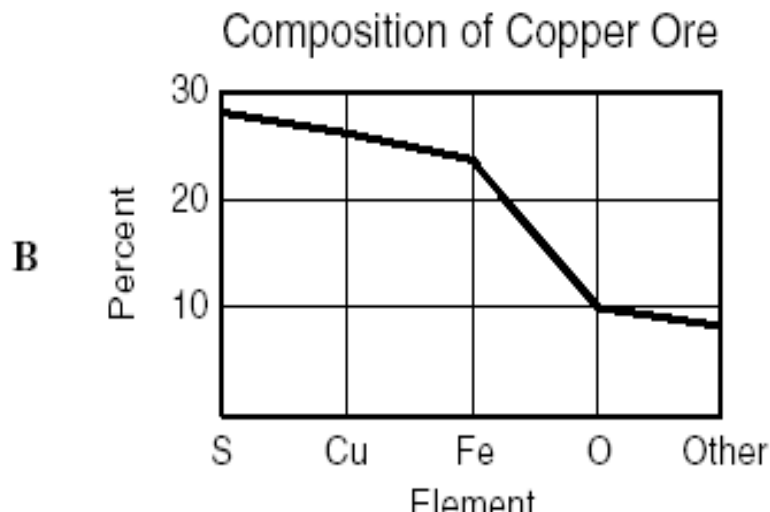
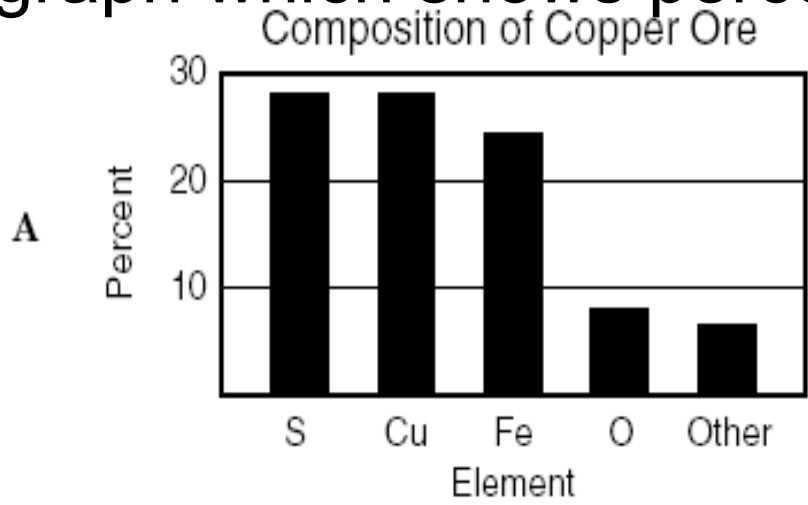


47 Which graph best shows the comparison of the elements to the total composition of the copper ore?

Composition of a Copper Ore

Element	Percent
Sulfur	28.68
Copper	28.42
Iron	24.98
Oxygen	9.54
Other	8.38
Total	100

This is noncontinuous data (not time or temperature or increasing forces) and it is in percentages. D is a pie graph which shows percentage parts of the whole!



Drawing conclusions

- Not getting the results expected, or predicted often provides more information than getting what you expected.
- Ernest Rutherford did not expect his light to go straight through the gold foil, but it showed him that atoms were mostly empty space. A very important discovery.

7 Many doctors recommend 800 µg of folate, 400 µg of vitamin B12, and 50 mg of vitamin B6 per day to improve cardiovascular health. Based on this information and the nutrition label, the cardiovascular health benefit of a 1-ounce serving of this cereal is —

CerealCo
presents **New**
Fantastic S
cereal with real fruit

A wholesome way to tantalize
your tongue and lower your
risk of heart attack!

Nutrition Information

Serving Size 1 oz (28 g)

Calories:	120
Protein:	5.8 g
Fat:	0.3 g
Carbohydrates	
—Total:	22 g
—Sugars:	5 g
Cholesterol:	0 mg
Dietary fiber:	1.5 g
Sodium:	75 mg
Thiamine:	0.29 mg
Riboflavin:	0.5 mg
Niacin:	2.6 mg
Vitamin B ₆ :	0.5 mg
Folate:	100 µg
Calcium:	300 mg
Iron:	1.5 mg

A doubtful because it provides insufficient folate and vitamin B6 and lacks vitamin B12

B superb because it contains only 22 g of carbohydrates and 75 mg of sodium

C excellent because it provides all needed vitamins and is low in fat and cholesterol

D poor because it raises blood cholesterol levels with its high fat and cholesterol content

Since the question asks about the nutritional value based on Folate and the B vitamins, evaluate the answers based on the same information.

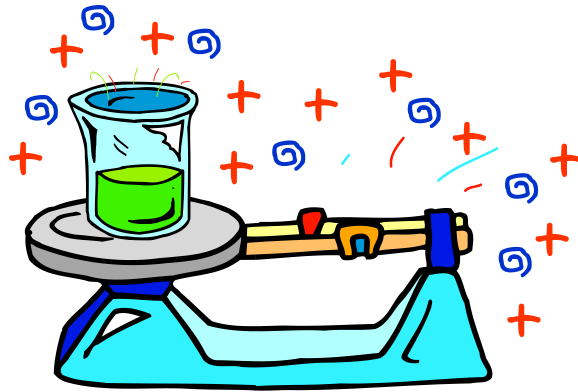
B is not valid since no information is given as to what are good levels.

C is not valid as it does not provide all the vitamins.

D is not a valid answer since it is very low in fat.

ANSWER: A

Tools for Measurement



Clocks and stopwatches measure time.

A balance is used to measure mass.

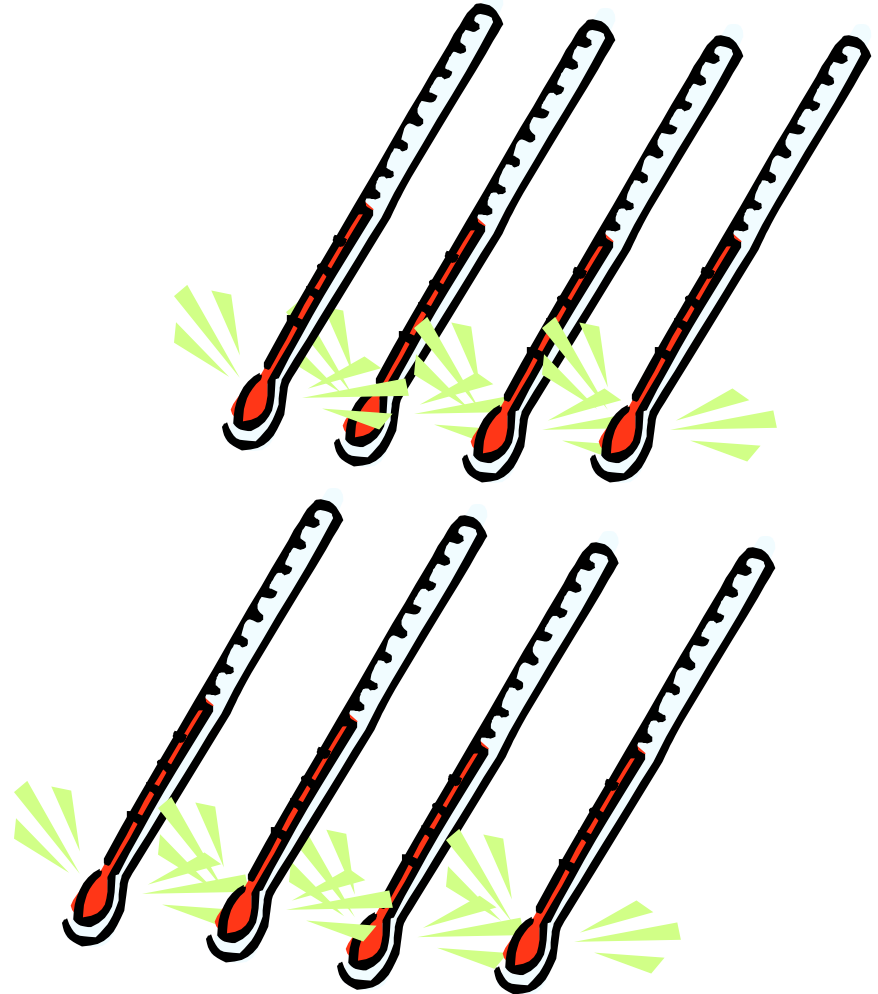
A graduated cylinder, dropper, or volumetric flask is used to measure volume.

Measuring Units – System Internationale

- Mass is in?
- Grams
- Volume in?
- Liters
- Length in?
- Meters

Accuracy

- This is when a measurement is closest to its true value.
- Several thermometers reading exactly the same temperature would indicate good accuracy.



Precision

- This is the repeatability of a measurement.
- It **may** or **may not** be accurate
- But everyone who does it gets the same answer



Accuracy vs. *Precision*

Which of the following will allow measurement of a liquid's volume with the greatest precision?

- A** 50 mL cylinder graduated in 1 mL increments
- B** 50 mL cylinder graduated in 0.5 mL increments
- C** 100 mL cylinder graduated in 1 mL increments
- D** 200 mL cylinder graduated in 5 mL increments

Answer:

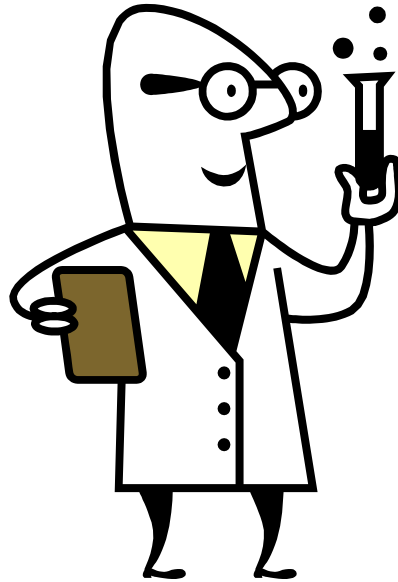
B

13 Four lab groups measured the volume of acid required to neutralize a standard solution of sodium hydroxide base. Which of the groups measured the volume with the highest precision?



What equipment is used to measure volume?

- In A, they are using two flasks. Not very precise markings!
- B is better, at least they are using a graduated cylinder.
- C is a bad choice, since most test tubes have no markings for volume.
- D is the best choice as the small volume markings on the burette gives the most precise measurement.



Now its your Turn!

If you have questions that you are unsure of the answer, please be sure to ask a science teacher before you take your test next Friday!!