What Is Science?
The Work of Scientists
MVMS Life Science 7A
Lab Manual

RLH 2016

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WHAT IS SCIENCE? https://youtu.be/YwYEy5AXwlQ

Thinking Like a Scientist

Basic Skills

Observing:

Using **five senses**:

seeing, hearing, touching, tasting, and smelling.

Quantitative Observations:

number, amount

Qualitative Observations: **descriptions**

Inferring:

Explaining or **interpreting** the things you observe.

Predicting:

Forecasting what will happen **based on** past **experience** or **evidence**.

Classifying:

Process of **grouping** together **items** that are **alike** in some way.

Making Models:

Creating **representations** of complex **objects** or **processes**.

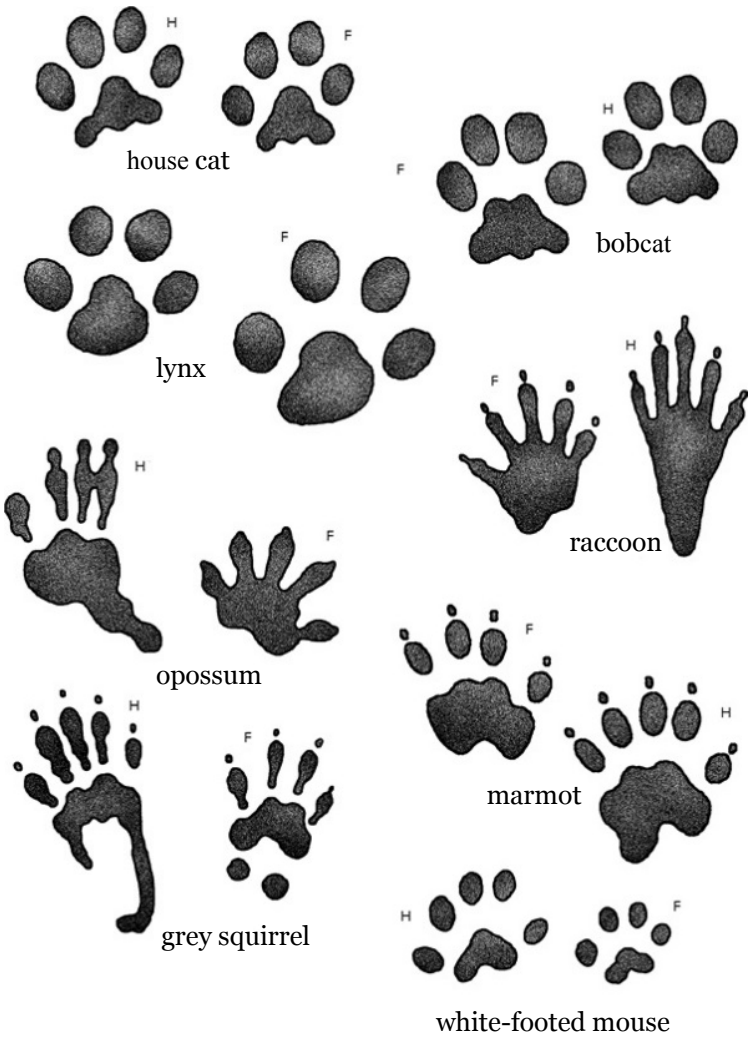
Scientist: Person who **uses these skills to learn** more about the world.
Life Science (Biology): **The study of living things**.
Biologist: Scientist who studies living things.

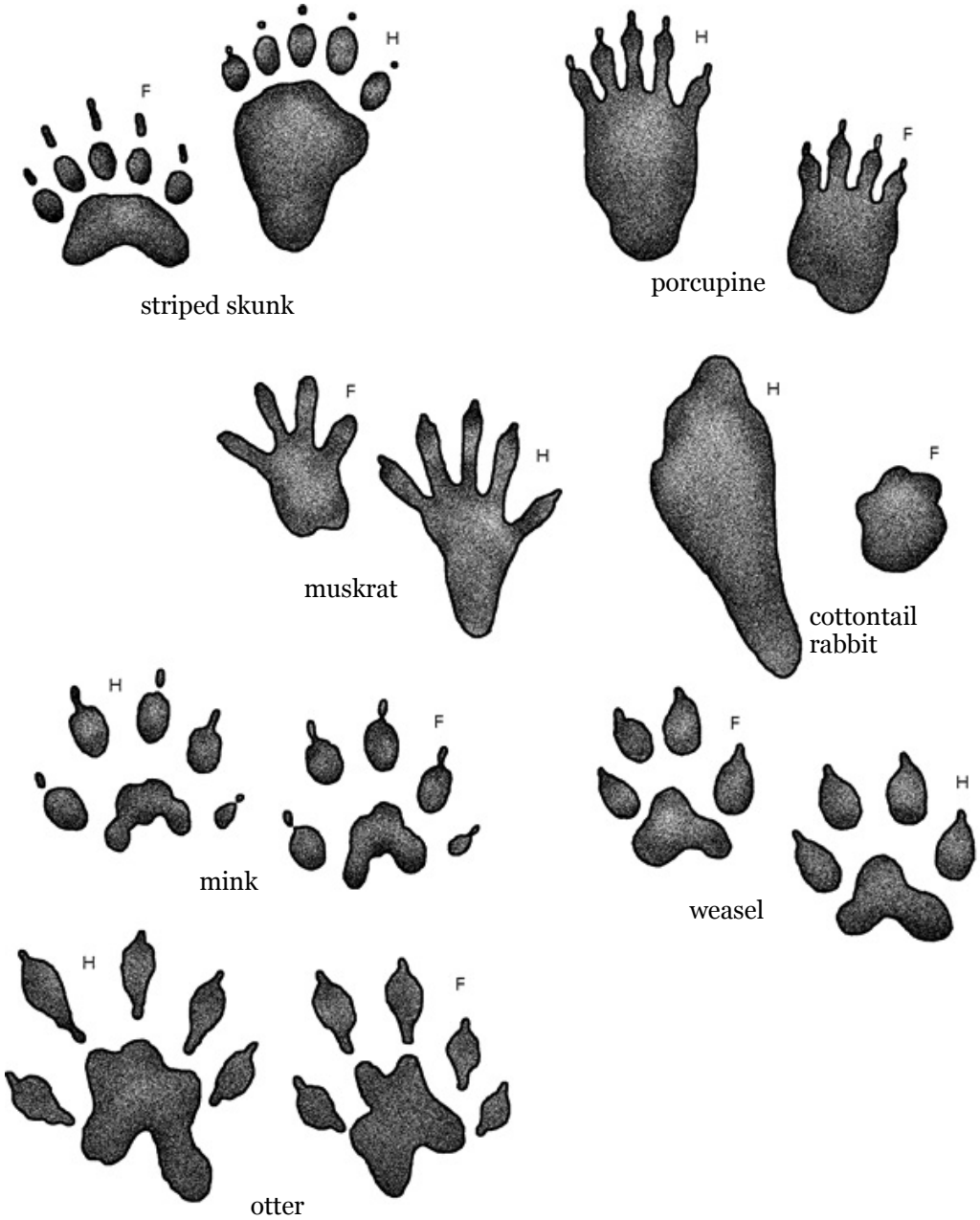
OBSERVATIONS AND INFERENCES

In a snow-covered meadow on a chilly winter day, you see mysterious animal tracks in the snow. You look at these tracks carefully.

Make a list of your observations. Be as detailed as you possibly can be including qualitative observations and quantitative observations.

ANIMAL TRACKS GUIDE





Based on your observations of the meadow and the Animal Tracks Guide, what inferences can you reasonably make?

OBSERVING, PREDICTING, AND INFERRING

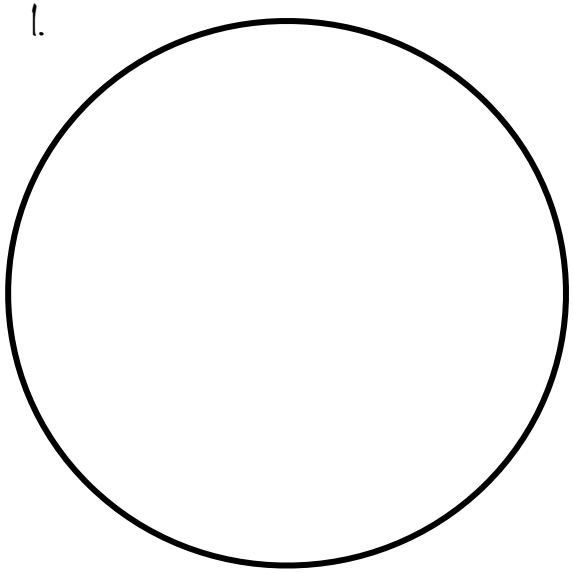
Can you predict what will happen with the colors when you place four chocolate M&Ms in a dish of water?

Gather Materials Required:
Food coloring
1 Small round dish
5 different colored chocolate M&Ms (1 Brown, 1 Red, 1 Blue, 1 Yellow, 1 Green)
Water

1. OBSERVATION – Food Coloring in Water

Instructions:
Pour water into the round container, about 1cm deep.
Wait twenty seconds for the water to settle – don't rush.
Carefully add a single drop of food coloring to the water in the center of the container.
Color in the diagram and use the space provided to describe your observations:
When you have finished, pour the water into the sink.
Clean your container for the next observation.

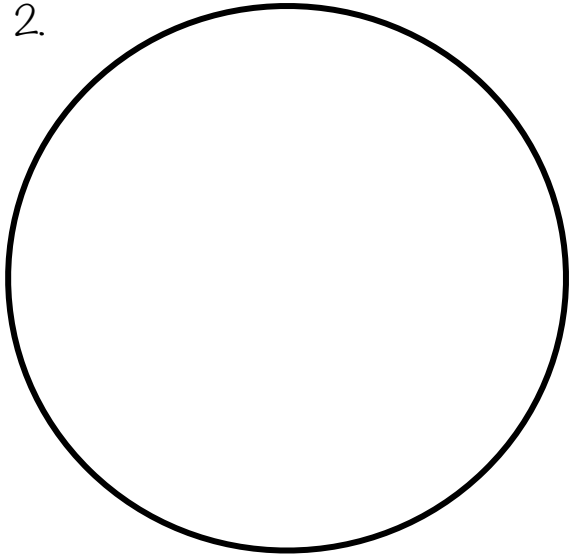
1.



2. OBSERVATION – Chocolate M&M in Water

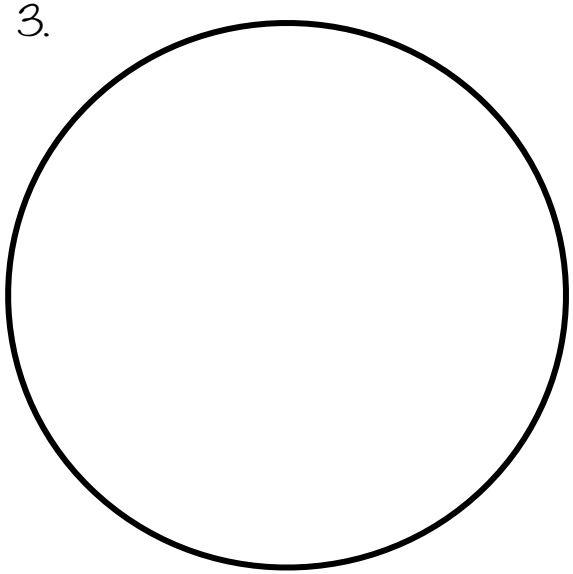
Instructions:
Pour the same amount of water into your container.
This time, place a single brown chocolate M&M in the center of the container and watch carefully. Wait at least 90 seconds before recording your observations.
Color in the picture and use the space provided to describe your observations:
When you have finished, pour the water into the sink.
Clean your container for the next observation.

2.



3. PREDICTIONS – Four Different M&Ms in Water

3.



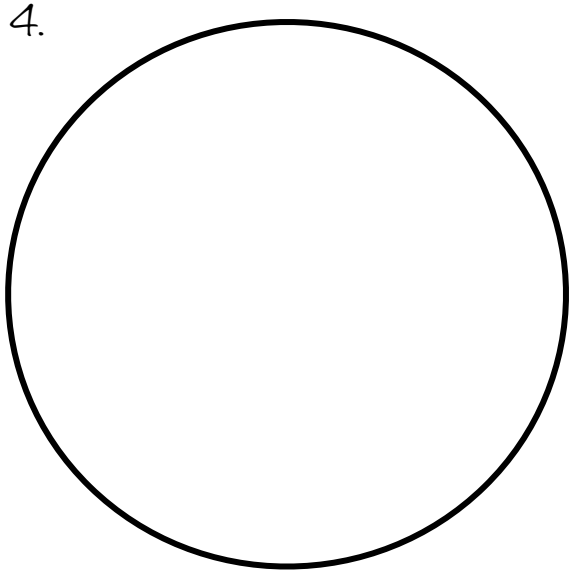
Instructions:
Color in the four chocolate M&Ms in the picture.
Use your observations and knowledge of colors to predict what will happen when you
place four chocolate M&Ms in your dish as illustrated.
Color in the dish to
demonstrate and use the space provided to describe what you think it will look like
after the M&Ms have been in the water for at least 90 seconds.

4. RESULTS

What actually happened when you placed four chocolate M&Ms in the water? Did your observations match your predictions? Can you explain why there were differences between your prediction and observations?

Color in your observations.

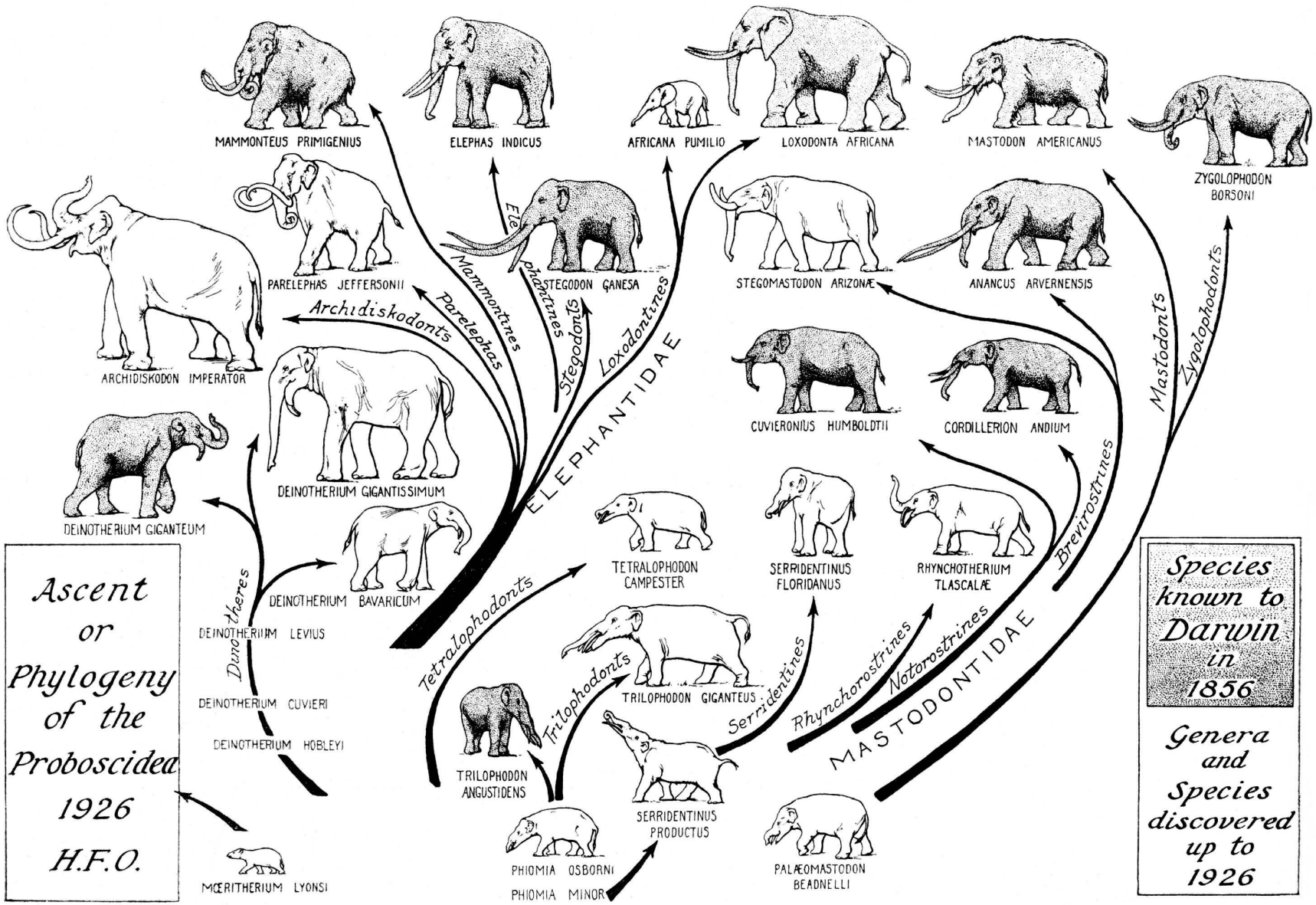
4.



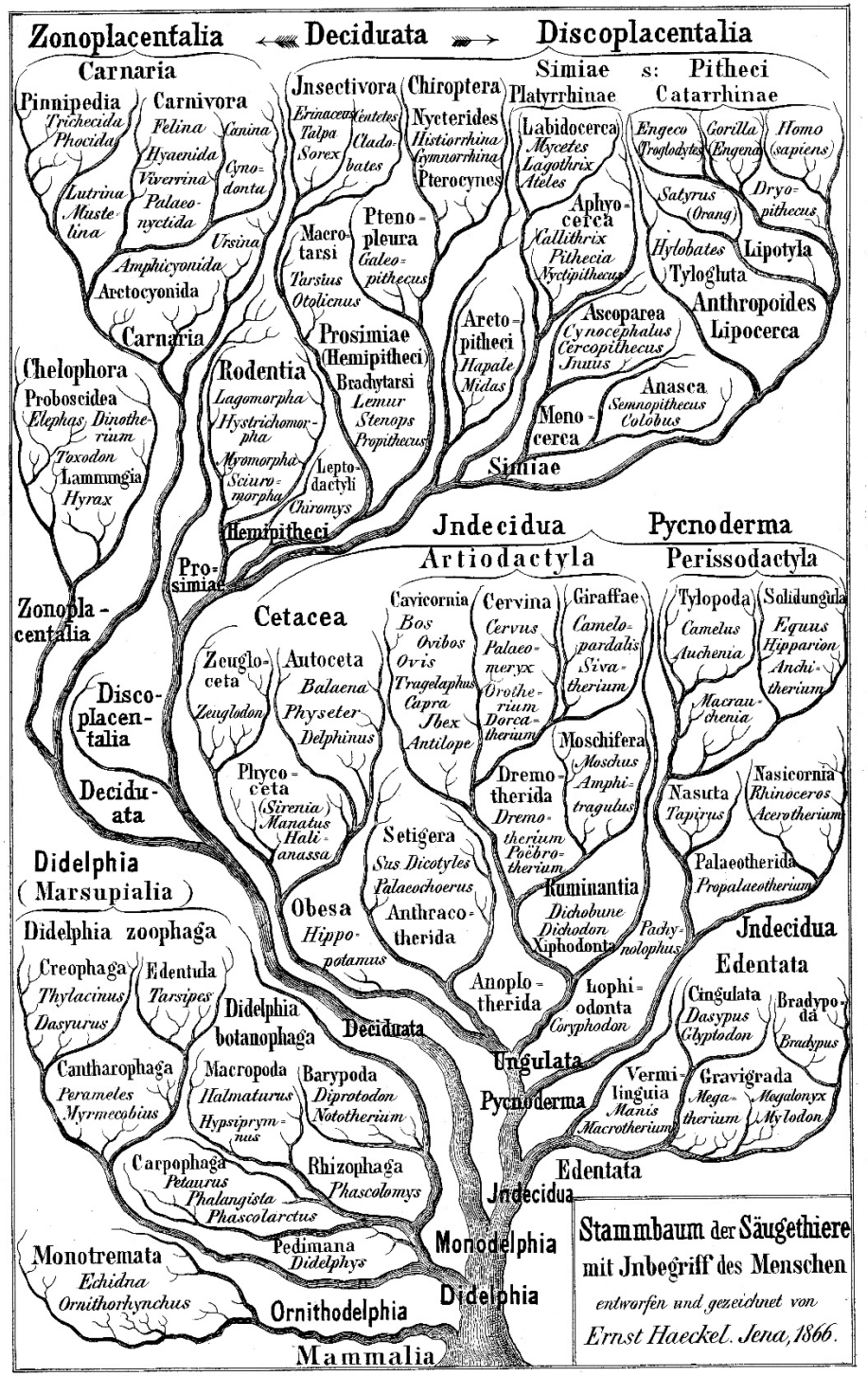
5. REFLECTION

Were you surprised by your observations? What can you say about making predictions?

Did your classmates make the same predictions?



Ascent phyla of Elephants and Mastodonts. After Osborn in the year 1926


Zonoplacentalia
Deciduata
Discoplacentalia
Carnaria
Pinnipedia
Trichecida
Phocida
Carnivora
Felina
Hyaenida
Viverrina
Palaeonyctida
Canina
Cynodonta
Lutrina
Mustelina
Ursina
Amphicyonida
Arctocyonida
Carnaria
Chelophora
Proboscidea
Elephas
Dinotherium
Toxodon
Lamnungia
Hyrax
Zonoplacentalia
Discoplacentalia
Deciduata
Didelphia
(Marsupialia)
Didelphia zoophaga
Creophaga
Thylacinus
Dasyurus
Edentula
Tarsipes
Cantharophaga
Perameles
Myrmecobius
Didelphia botanophaga
Macropoda
Halmaturus
Hypsiprymnus
Barypoda
Diprotodon
Nototherium
Carpophaga
Petaurus
Phalangista
Phascolarctus
Rhizophaga
Phascolomys
Monotremata
Echidna
Ornithorhynchus
Pedimana
Didelphys
Ornithodelphia
Mammalia
Insectivora
Erinaceus
Talpa
Sorex
Centetes
Cladobates
Chiroptera
Nycteridae
Histiorrhina
Gymnorrhina
Pterocynes
Macrotarsi
Tarsius
Otolicnus
Pteno-pleura
Galeopithecus
Prosimiae
(Hemipitheci)
Brachytarsi
Lemur
Stenops
Propithecus
Rodentia
Lagomorpha
Hystrichomorpha
Myomorpha
Sciuromorpha
Leptodactyli
Chiromys
Hemipitheci
Prosimiae
Simiae s: Pitheci
Platyrrhinae
Catarrhinae
Labidocerca
Mycetes
Lagothrix
Ateles
Engeco
Troglodytes
Gorilla
Engeno
Homo
(sapiens)
Satyrus
(Orang)
Dryopithecus
Aphyocerca
Callithrix
Pithecia
Nyctipithecus
Hylobates
Lipotyla
Tylogluta
Anthropoides
Lipocerca
Ascoparea
Cynocephalus
Cercopithecus
Inuus
Arctopitheci
Hapale
Midas
Anasca
Semnopithecus
Colobus
Menocerca
Simiae
Jndecidua
Pycnoderma
Artiodactyla
Perissodactyla
Cetacea
Zeuglodon
Autoceta
Balaena
Physeter
Delphinus
Phyco-ceta
(Sirenia)
Manatus
Halianassa
Cavicornia
Bos
Ovibos
Ovis
Tragelaphus
Capra
Ibex
Antilope
Cervina
Cervus
Palaeomeryx
Orotherium
Dorcatherium
Giraffae
Camelopardalis
Sivatherium
Moschifera
Moschus
Amphitragulus
Dremotherida
Dremotherium
Poebrotherium
Setigera
Sus Dicotyles
Palaeochoerus
Anthracotherida
Obesa
Hippopotamus
Ruminantia
Dichobune
Dichodon
Xiphodonta
Pachynolophus
Anoplotherida
Lophiodonta
Coryphodon
Ungulata
Pycnoderma
Jndecidua
Tylopoda
Camelus
Auchenia
Solidungula
Equus
Hipparion
Anchitherium
Macrauchenia
Nasuta
Tapirus
Nasicornia
Rhinoceros
Acerotherium
Palaeotherida
Propalaeotherium
Jndecidua
Edentata
Cingulata
Dasypus
Glyptodon
Bradypoda
Bradypus
Vermilinguia
Manis
Macrotherium
Gravigrada
Megatherium
Megalonyx
Mylodon
Edentata
Jndecidua
Monodelphia
Didelphia
Stammbaum der Säugethiere
mit Jnbegriff des Menschen
entworfen und gezeichnet von
Ernst Haeckel. Jena, 1866.

Making Models: Origami Maple Seed

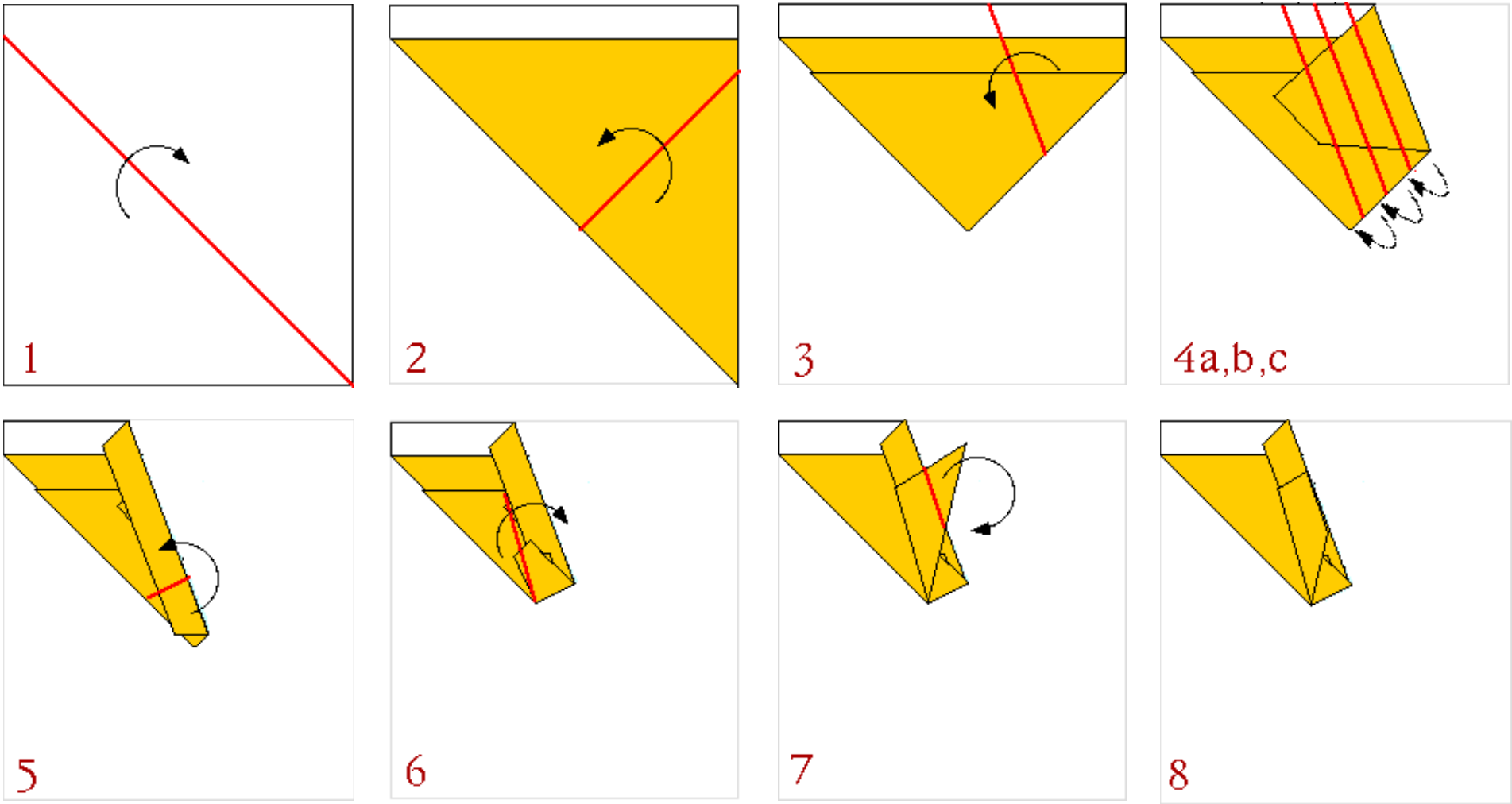
This origami (folded paper) model of a maple seed can be used to demonstrate seed dispersal. It can be assembled with a minimum number of tools and supplies, and will autorotate reliably.

It is best built out of an Andes® mint wrapper. The thin foil holds the shape of the folds. It can also be built using aluminum foil, origami paper, regular paper (with a glue stick to ensure that the last fold sticks), or thin paper. Thick paper doesn't work very well.

Note that all the fold lines indicated by arrows are "valley" folds, with the paper on either side of the line folded upward.

For those who want to make one the size of the Andes® mint wrappers, but who can't get them, the wrapper measures 55mm wide x 62mm tall.

Instructions:



What physical characteristics do you observe in the finished "seeds"?

In what ways does each characteristic affect the performance of the "seed"?

How did making these models help you to understand real maple seeds?

WHAT IS SCIENCE?

Scientific Inquiry Process

Ways in which **scientists study** the natural **world** and **propose explanations** based on **evidence** they gather.

1) **Posing Questions**:
   Can **answer by** making **observations** and gathering **evidence**.
   Questioning continues **throughout the process**.
2) **Developing a Hypothesis** (hypotheses: plural):
   A **possible answer** to a scientific question. It **must be testable**.
3) **Designing an Experiment**:
   Used to **test your hypothesis**.
   Variables: Factors that **can change**.
   Controlled Experiment: Only **one variable manipulated** at a time.
   - **Manipulated (Independent) Variable**: **Purposely changed to test** the hypothesis.
   - **Responding (Dependent) Variable**: **May change in response** to the manipulated variable.

- **Operational Definition**: Statement that **describes how to measure a variable** or define a term.

4) **Collecting and Interpreting Data**:

Data is the **facts**, **figures**, and **other evidence gathered through observations**.

Table to record

Graph to interpret

5) **Drawing Conclusions**:

Conclusion is a **summary of what you have learned** from an experiment. Does the **data support the hypothesis?** Was **enough data collected?** The process **often raises new questions**.

6) **Communicating**:

Sharing of ideas and experimental **findings with others** through writing and speaking.

Scientific Theory:

A well-tested explanation for a **wide range of observations** or experimental results. **https://youtu.be/gklQ3GbmufI**

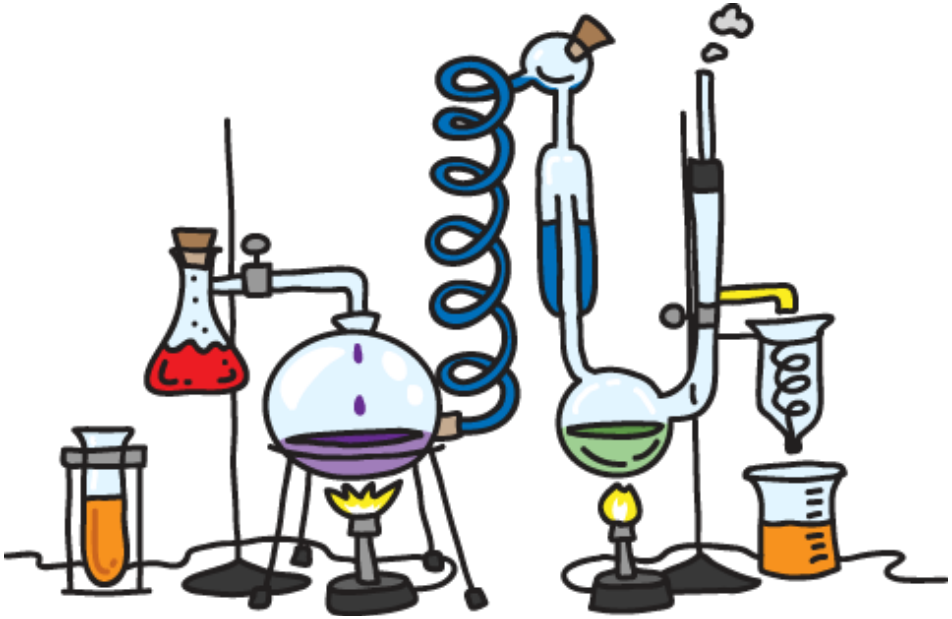
In what ways is your understanding of scientific theory different after viewing this video?

Scientific Law:

Describes an observed pattern in nature without attempting to explain it.

Scientific Attitudes (habits of the mind)

Curiosity, Honesty, Open-Mindedness, Skepticism, Creativity.



THE WORK OF SCIENTISTS

Measurement – A Common Language

A Standard System of Measurement: **Metric System**: A system of measurement **based on** the number **10**.
The International System of Units (SI): Modern scientists all over the world use the SI version of the metric system to make all kinds of measurements. **Using SI allows scientists to compare data and communicate** about **results**.
https://youtu.be/SYn5UJ76h1Y

Common SI Prefixes		
Prefix	Symbol	Meaning
kilo-	k	1,000
hecto-	h	100
deka-	da	10
deci-	d	0.1
centi-	c	0.01
milli-	m	0.001

How does this commemorative stamp relate to what you learned about the metric system while watching the video?

Length: The **distance** between one point and another.

Units of Length: The **meter** is the basic unit of length.

Measuring Length

1. Line one end of the object up exactly with the zero mark on the metric ruler.
2. Read the number at the other end of the object.

Common Conversions for Length
1 km = 1,000 m
1 m = 100 cm
1 m = 1,000 mm
1 cm = 10 mm

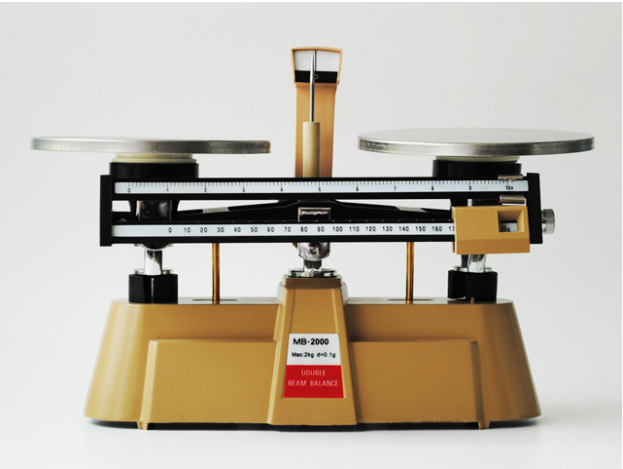
Mass: The **amount of matter** an object contains.

Units of Mass: The basic unit of mass for smaller objects is the **gram**.

Measuring Mass

1. **Use a balance**.
2. Place the object on the pan.
3. Shift the riders on the beams until they balance the mass of the object.
4. The mass of the object is equal to the sum of the readings on the beams.

Common Conversions for Mass		
1 kg	=	1,000 g
1 g	=	1,000 mg



The Difference Between Mass and Weight

Weight is **a measure of** the force of **gravity** acting on an object.

Mass measures the amount of **matter** an object contains.

Volume: The **amount of space** an object takes up.

Volume of Liquids: The basic unit is the **liter**.

Scientist commonly **use a graduated cylinder** to measure liquid volumes.

Meniscus is the **curve of liquid** at the surface in a graduated cylinder.

Read the bottom of the curve.

Volume of Rectangular Objects: The basic unit is cubic **centimeters (cm^3)**.

A cubic centimeter is exactly **equal to one milliliter**.

For **larger** volumes, **cubic meters (m^3)** are used.

Volume = Length x Width x Height

Volume of Irregular Solids

Immerse the object in water, measure how much the water level rises.

Common Conversions for Volume		
1 L	=	1,000 mL
1 L	=	1,000 cm^3
1 mL	=	1 cm^3

Density: Measure of how much **mass** is contained **in a given volume**.

Units of Density: Expressed as a **combination of two units**. **Grams per cubic centimeters (g/cm³) or grams per milliliter (g/mL)**

$$\textbf{Density} = \frac{\textbf{Mass}}{\textbf{Volume}}$$

Time

Units of Time: The **second (s)** is the basic unit used to measure time. The second is **divided by multiples of 10** like other units such as the millisecond (ms). 60 seconds in a minute, 60 minutes in an hour.

Measuring Time: **Clocks and watches** are used to measure time.

Common Conversions for Time		
1 s	=	1,000 ms
1 min	=	60 s
1 h	=	60 min

Temperature

Units of Temperature: Scientists commonly use the **Celsius (C) scale**. Water freezes at 0°C and boils at 100°C.

Kelvin (K) is the official SI unit for temperature. **Units** on the **Kelvin** scale are the **same size as** those on the **Celsius** scale. Zero on the Kelvin scale **(absolute zero)** is the coldest possible temperature. **The Kelvin scale has no negative numbers**.

Common Conversions for Temperature		
0°C	=	273 K
100°C	=	373 K

What is the story behind this commemorative stamp in relation to the measurement of temperature?

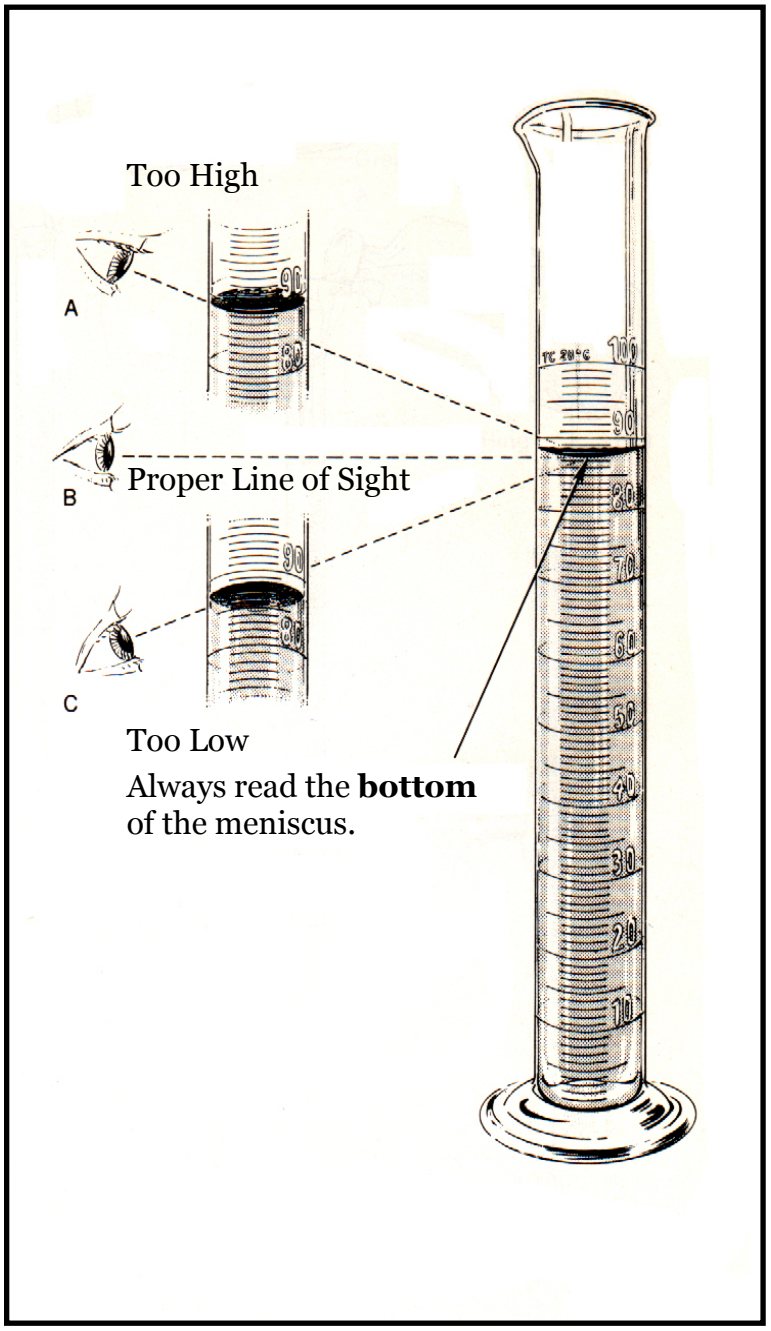
Converting Between Units

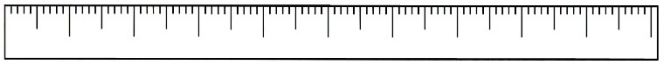
Know the appropriate **conversion factor**

1. Write down the measurement you want to convert.
2. Find a conversion factor that relates the two units.
3. Write the conversion factor as a fraction. Units you are converting from is the denominator (bottom).
4. Multiply the measurement by the fraction.

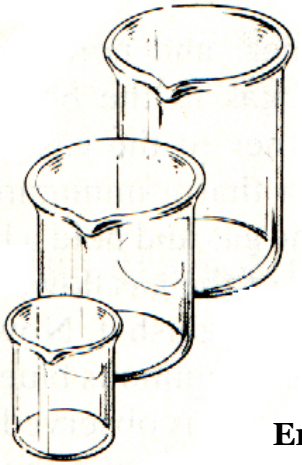
(**Move the decimal** to the right the **same number of prefixes** larger or to the left the same number of prefixes smaller.)

BASIC LAB EQUIPMENT



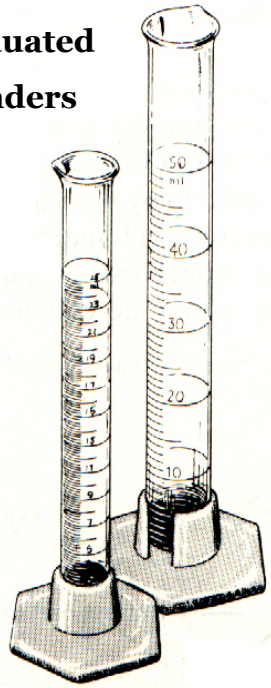


Metric Ruler or Meter Stick

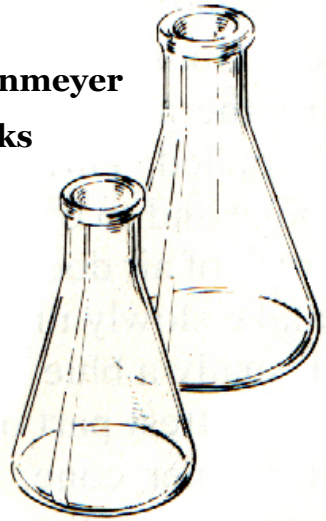


Beakers

Graduated Cylinders

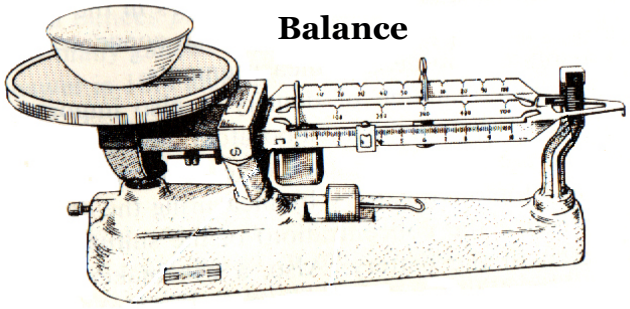


Erlenmeyer Flasks

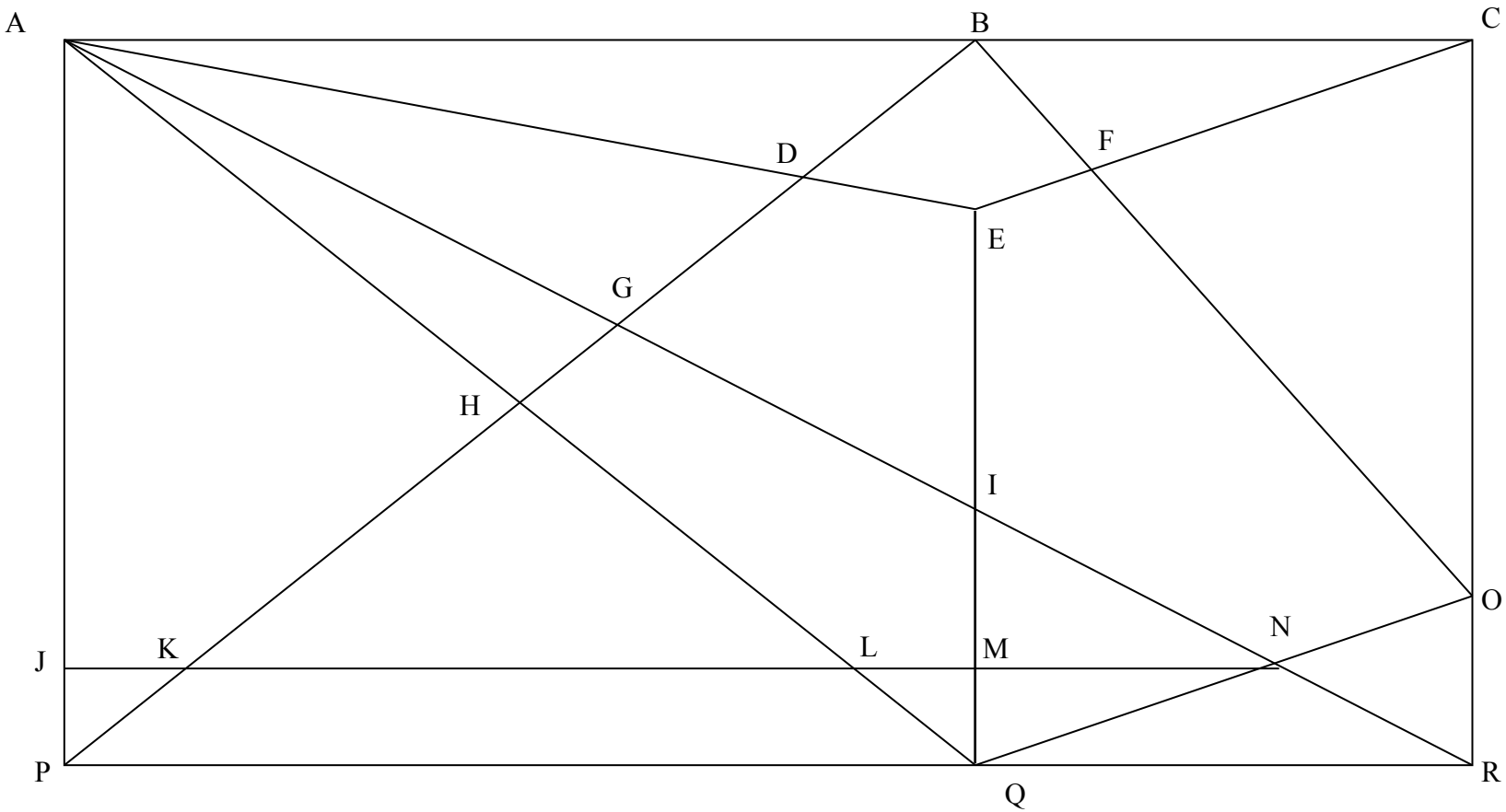


Medicine Dropper

Balance



LENGTH LAB



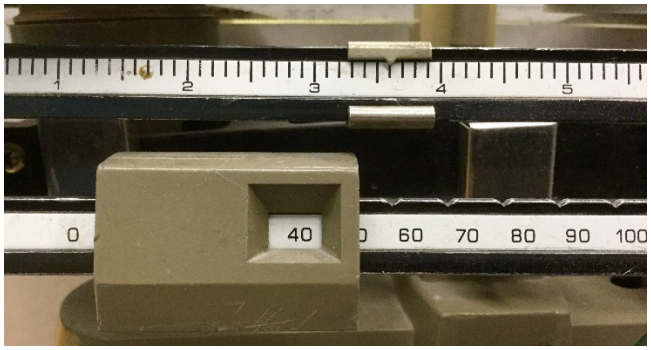
Use a metric ruler and the diagram to measure the lines listed below. Be sure to record both the number and unit. Measure each line to:

a) the nearest **0.1 cm**.
b) the nearest **whole mm**.

1. Line A-B _____ or _____
2. Line A-E _____ or _____
3. Line B-C _____ or _____
4. Line A-R _____ or _____
5. Line B-H _____ or _____
6. Line E-I _____ or _____
7. Line A-D _____ or _____
8. Line K-L _____ or _____
9. Line D-P _____ or _____
10. Line L-Q _____ or _____
11. Line N-O _____ or _____
12. Line C-R _____ or _____
13. Line K-N _____ or _____
14. Line P-B _____ or _____
15. Line P-R _____ or _____

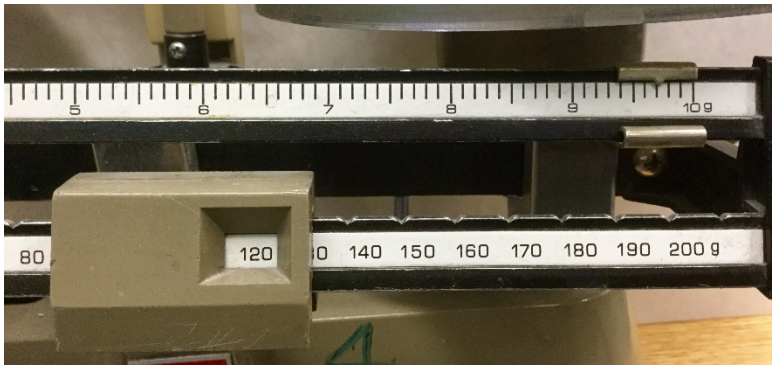
MASS LAB

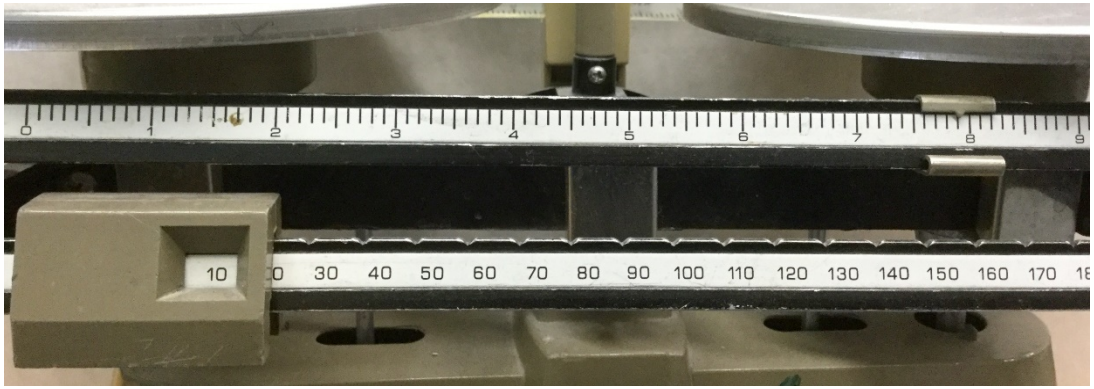
<u>Part 1</u>: Record the mass (to the **nearest 0.1 g**) shown by each photograph. Record both the **number and unit**.



1._____

2._____





3._____

Part 2: Use the balance to find the mass of the following items to the **nearest 0.1gram**. Record your answers in the blanks.

1. A glass funnel has a mass of _____.
2. A penny has a mass of _____.
3. A baby food jar has a mass of _____.
4. Scissors have a mass of _____.
5. A plastic funnel has a mass of _____.

Conclude:

1. How is a scale different from a balance? Explain examples of how these are used differently.

VOLUME LAB

Problem: To learn to use metric measuring equipment to measure volume.
Methods and Data:
Carefully follow steps a-l. The chart will be filled in at the end.
Mark off each step so that you do not skip or repeat any steps.

(a) The test tube rack is labeled A, B, C, D, E, and F helping keep the test tubes organized.
(b) Using the 100 mL graduate, measure these amounts:
-measure 19 mL of red water from the beaker and pour into test tube A.
-measure 18 mL of yellow water from the beaker and pour into test tube B.
-measure 18 mL of blue water from the beaker and pour into test tube C.
(c) Using the 25 mL graduate, measure 4 mL of blue water from the beaker and pour into test tube D.
(d) Using the 25 mL graduate, measure 7 mL of red water from the beaker and add to test tube D. Swirl the test tube gently to mix the colors.
(e) Using the 25 mL graduate, measure 8 mL **from the test tube A** and pour it into test tube E. Measure 3 mL **from test tube B** and add to test tube E. Swirl to mix.
(f) Using the 25 mL graduate, measure 4 mL **from test tube B** and pour it into test tube F. **From test tube C**, measure 7 mL and add it to test tube F. Swirl the test tube gently to mix.
(g) Record the color of the water in each test tube in your chart.

(h) Pour the colored water in test tube A into the 100 mL graduate and measure. Record its volume in your chart.
(i) Pour the water back into test tube A.
(j) Repeat steps h and I for the remaining 5 test tubes.
(k) Take all test tubes and graduates to the sink. Dump the colored water in each test tube into the sink and rinse out all the test tubes and graduates (Do not dry them.)
(l) Return all equipment and dry your table off with a sponge.

Test Tube	**A**	**B**	**C**	**D**	**E**	**F**
Color						
Volume						

Conclude

1. Why will it be important to be able to measure volume accurately? Give examples that apply to real life situations.

APPENDIX B: USING A MICROSCOPE

Microscope: An essential tool in the study of life science. Allows you to see things that are too small to be seen with the unaided eye.
Compound Microscope: Has more than one lens; one lens in the eyepiece (10X), and one lens in the objective. Our compound microscopes have three objectives – low-power (4X), medium-power (10X), and high-power (40X or 45X).

To calculate total magnification, multiply the magnification of the eyepiece lens by the magnification of the objective lens you are using.

Total Magnification = Eyepiece X Objective

Using the Microscope

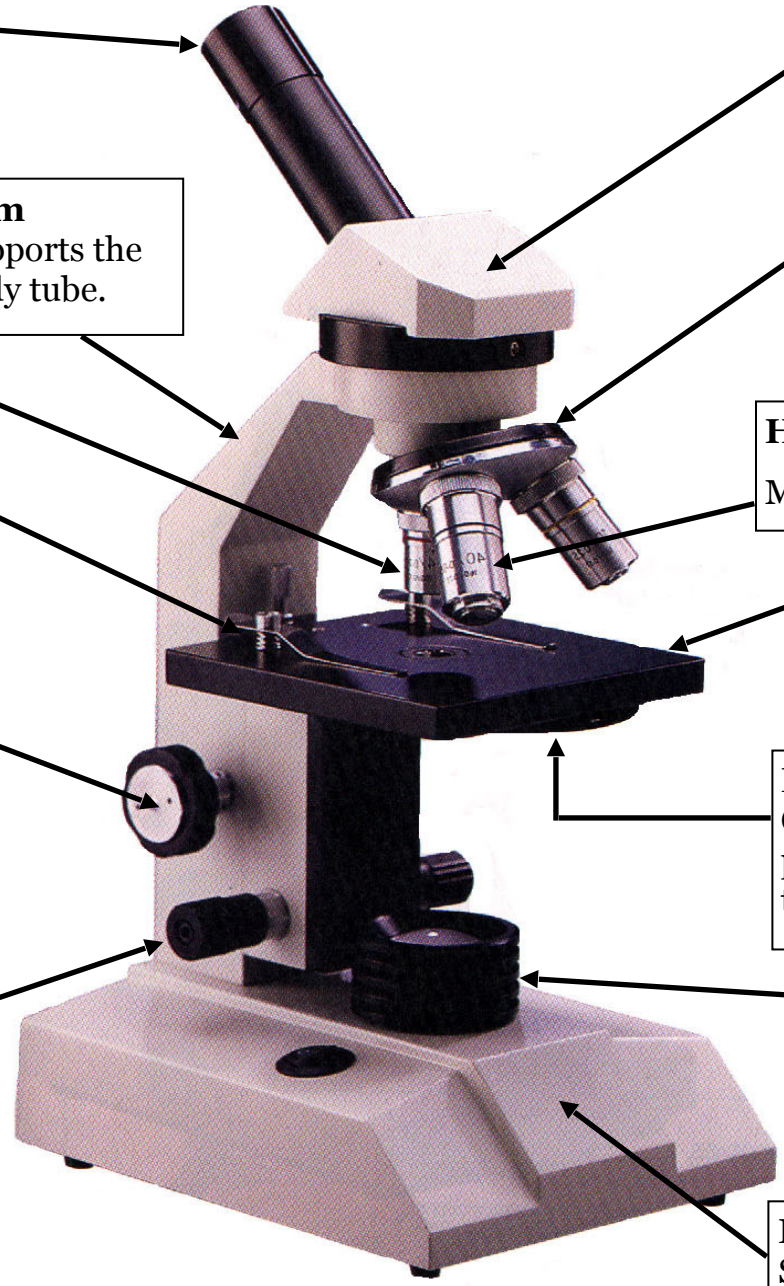
1. To carry the microscope, grasp the microscope's arm with one hand. Place your other hand under the base.
2. Place the microscope on a table with the arm toward you.
3. Turn the coarse adjustment knob to raise the body tube.
4. Revolve the nosepiece until the low-power objective lens clicks into place.
5. Adjust the diaphragm.
6. Place a slide on the stage. Center the specimen over the opening on the stage. Use the stage clips to hold the slide in place.

7. Look at the stage from the side. Carefully turn the coarse adjustment knob to lower the body tube until the low-power objective almost touches the slide.
8. Looking through the eyepiece, very slowly turn the coarse adjustment knob until the specimen comes into focus.
9. To switch to the medium or high-power objective lens, look at the microscope from the side. Carefully revolve the nosepiece until the desired objective lens clicks into place. Make sure the lens does not hit the slide.
10. Looking through the eyepiece, turn the fine adjustment knob until the specimen comes into focus.

Making a Wet-Mount Slide

1. Obtain a clean microscope slide and coverslip.
2. Place the specimen on the slide. The specimen must be thin enough for light to pass through it.
3. Using a medicine dropper, place a drop of water on the specimen.
4. Gently place one edge of the coverslip against the slide so that it touches the edge of the water drop at a 45° angle. Slowly lower the coverslip over the specimen. If air bubbles are trapped beneath the coverslip, add water to the edge of the coverslip using the medicine dropper.
5. Remove any excess water at the edge of the coverslip with a corner of a paper towel.

PARTS OF A COMPOUND MICROSCOPE



Eyepiece
Contains a lens that magnifies about 10X.

Body Tube
Separates the eyepiece lens from the objective lenses.

Low-Power Objective Lens
Magnifies about 10X.

Arm
Supports the body tube.

Revolving Nosepiece
Holds the objective lenses: allows the lenses to rotate for viewing.

Stage Clip
Holds the slide in place.

High-Power Objective Lens
Magnifies about 40X.

Coarse Adjustment Knob
Moves the body tube or the stage for focusing with the low-power objective lens.

Stage
Supports the slide being used.

Diaphragm
Controls the amount of light passing through the opening of the stage.

Fine Adjustment Knob
Moves the body tube or the stage for focusing with the medium or high-power objective lenses.

Light Source
Shines light upward through the diaphragm.

Base
Supports the microscope.

MICROSCOPE LAB

I can:

learn to make wet mount slides.
successfully view objects through the microscope.

Hypothesis – What do I expect to see?

Draw a picture of what you think a typed letter "e" (lowercase) that you cut from the newspaper will look like magnified using the high-power objective lens of the microscope.

Methods and Data:

1. Get a microscope from the cabinet and properly carry it to your area.
2. Find the magnification power written on the eyepiece and on each objective. Record them in the chart below. Be sure to write an "X" after each number.
3. Calculate and record the total magnification for each objective when it is in use. (Total Magnification = Eyepiece X Objective)

	Eyepiece	Low-Power Objective	Medium-Power Objective	High-Power Objective
Magnification Power	10X			
Total Magnification				

4. Use your microscope to answer the following questions:
   a) When the diaphragm is turned clockwise, the light does what?

      _____

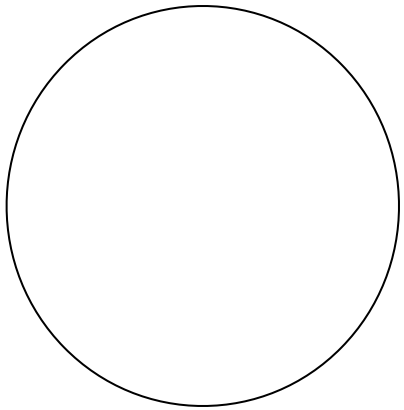
      When turned counter-clockwise, the light does what? _____
   b) Does your microscope have an inclination joint? _____
   c) When you turn the coarse adjustment, what part moves up and down?

      _____

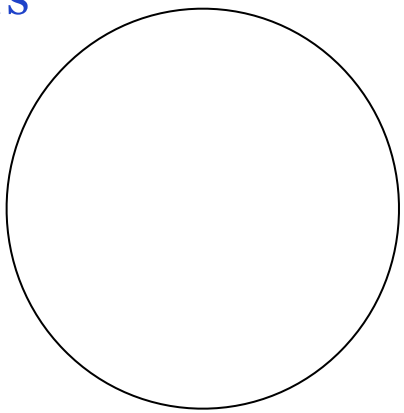
5. Cut a lowercase letter "e" from the newspaper.
6. Use the medicine dropper to put one drop of water on the center of the slide.
7. Place the letter on the drop of water.
8. Carefully lower the cover slip over the letter and water.
9. Focus using the low-power objective, following the directions in your notes.
10. Complete the following statements:
    a) When the slide is moved to the right, it appears to move

       _____.
    b) When the slide is moved to the left, it appears to move _____.

11. Draw in the circle the letter “e” as it appears using the low-power objective.
12. Write below your drawing the total magnification used for this picture.
13. Move the slide to center the letter in your field of view. Then change to the medium-power objective. Focus only with the fine adjustment.



14. Center the letter again, and turn to the high-power objective. Focus only with the fine adjustment.
15. Draw in the circle what you can see of the letter “e” as it appears using the high-power objective.
16. Write below your drawing the total magnification used for this picture.
17. Remove the cover slip and throw away the letter. Dry both slide and cover slip and throw away your used paper.
18. Put all your equipment away and complete the conclusions.



Conclusions

Your answers should be in complete sentences.

1. What are the black blobs you saw using the high-power objective?

2. Explain what else you are seeing in this view of the newspaper clipping.

3. What other objects would you be interested in viewing using the microscope? What do you think you could learn by viewing these objects?