Summer Assignment BIO 2026

Biology 9th grade

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The estimated time to complete each topic is around 1h (maximum 2h for Topic 4).

TOPIC 1: DETERMINING VARIABLES IN AN EXPERIMENT

The three main types of variables in an experiment are:

Variable Type	What it is	Example (Plant Growth Experiment)
Independent Variable	The factor that the scientist changes on purpose.	Amount of sunlight given to the plants.
Dependent Variable	The factor that is measured or observed; it changes in response to the independent variable.	Height of the plants after 4 weeks.
Constant (Controlled) Variables	Factors that are kept the same for all groups so the test is fair.	Type of plant, amount of water, soil type, pot size, temperature.

Simple way to remember:

- Independent variable = I change
- Dependent variable = I measure
- Constants = I keep the same

For the studies below, specify the <u>INDEPENDENT, DEPENDENT AND CONSTANT (ONE)</u> variables

1. A study was done to find if different tire treads affect the braking distance of a car.

I: _____ D: _____ C: _____

2. A student wanted to test how the mass of a paper airplane affected the distance it would fly. Paper clips were added before each test flight. As each paper clip was added, the plane was tested to determine how far it would fly.

I: _____ D: _____ C: _____

3. A conclusion of a study is that the height of bean plants depends on the amount of water they receive

I: _____ **D:** _____ **C:** _____

4. A study concludes that the higher the temperature of the air in the oven, the faster a cake will bake

I: _____ **D:** _____ **C:** _____

5. Lemon trees receiving the most water produced the most lemons.

I: _____ **D:** _____ **C:** _____

6. An investigation found that more bushels of potatoes were produced when the soil was fertilized more.

I: _____ **D:** _____ **C:** _____

7. Students measured the temperature of the water at different depths in Lake Skywalker and found that the temperature varied.

I: _____ **D:** _____ **C:** _____

8. The amount of pollution produced by cars was measured for cars using gasoline containing different amounts of lead.

I: _____ **D:** _____ **C:** _____

9. Four groups of rats are first massed and then fed identical diets except for the amount of vitamin A they receive. Each group gets a different amount. After 3 weeks on the diet, the rats' masses are measured again to see if there has been a decrease.

I: _____ **D:** _____ **C:** _____

10. The time it takes to run a mile depends on the person's running speed.

I: _____ **D:** _____ **C:** _____

TOPIC 2: SCIENTIFIC NOTATION

Scientific notation is a way of writing very large or very small numbers in the form: $\boldsymbol{a \times 10^n}$ where:

- a is a number with $1 \leq |a| < 10$ (the number a can be positive or negative, but its size must be between 1 and 10).
- n is an integer (positive, negative, or zero).

Examples

- $5{,}300{,}000 = 5.3 \times 10^6$
- $0.00042 = 4.2 \times 10^{-4}$
- $700 = 7 \times 10^2$

Converting to Scientific Notation:

1. Move the decimal point so the first number is between 1 and 10.
2. Count how many places you moved it.
3. If you moved it left, the exponent is positive.
4. If you moved it right, the exponent is negative.

Example: 0.000056. Move the decimal 5 places to the right: $0.000056 = 5.6 \times 10^{-5}$

Converting from scientific notation to standard form:

1. Look at the exponent.
2. If the exponent is positive, move the decimal to the right.
3. If the exponent is negative, move the decimal to the left.
4. Move it the number of places indicated by the exponent.

Examples: Positive exponent: 3.2×10^4

Move the decimal 4 places right: $3.2 \rightarrow 32000$

Negative exponent: 5.7×10^{-3}

Move the decimal 3 places left: $5.7 \rightarrow 0.0057$

Quick Practice:

1) 4.5×10^{3} 2) 7.2×10^{-4} 3) 1.09×10^{5} 4) 0.00000333

Answers: 1) 4,500 2) 0.00072 3) 109,000 4) 3.33×10^{-6}

A shortcut to remember:

- Positive exponent ⟶ big number
- Negative exponent ⟶ small decimal

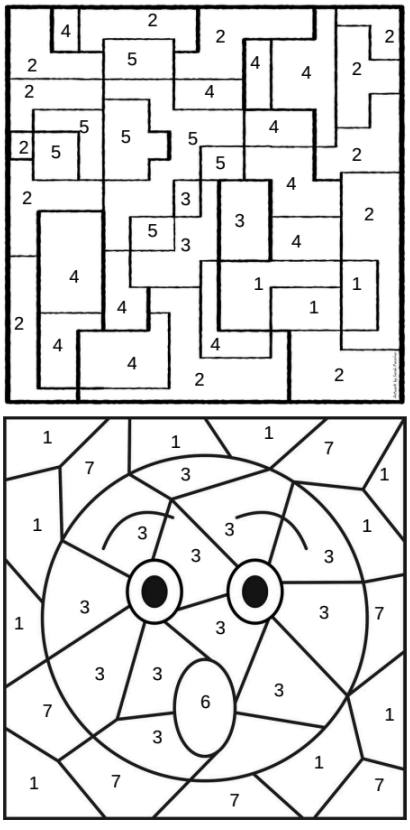
Watch this video if you need more explanation and practice.

YOUR TURN!! Print and Complete this activity.

Name:_____ Date:_____ MATH FOR CHEMISTRY COLOR-BY CODE

SCIENTIFIC NOTATION A

There is ONE correct answer for each question and a color associated with that answer. On the coloring page below, the number should be filled with that color.



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1. Write 4500 in scientific notation

4.5×10^{2}	45×10^{2}	4.5×10^{3}	0.45×10^{4}
RED	BROWN	GREEN	YELLOW

2. Write 0.0032 in scientific notation

3.2×10^{3}	3.2×10^{-3}	32×10^{-4}	0.32×10^{-2}
YELLOW	RED	GREEN	BLUE

3. Convert 6.1×10^{4} to standard form

6100	61,000	610,000	6,100,000
GREEN	YELLOW	PURPLE	ORANGE

4. Convert 2.5×10^{-2} to standard form

0.025	0.0025	0.25	2.5
ORANGE	YELLOW	RED	WHITE

5. Which is correctly written in scientific notation?

12.3×10^{2}	1.23×10^{3}	0.123×10^{4}	123×10^{1}
PURPLE	BLUE	GREEN	PINK

6. Which number is largest?

3.2×10^{3}	3.2×10^{4}	3.2×10^{2}	3.2×10^{1}
YELLOW	BLACK	ORANGE	RED

7. Which is equal to 5.0×10^{3}?

500	50,000	5000	0.005
PINK	WHITE	GREEN	BLUE

TOPIC 3: UNIT CONVERSIONS

Unit conversion is the process of changing a measurement from one unit to another without changing the actual amount being measured.

Example: Suppose you have **100 centimeters**.

Since **100 cm = 1 meter**, you can convert: **100 cm → 1 m**

The length stays the same; only the unit changes.

DIMENSIONAL ANALYSIS

Dimensional analysis is a method of solving unit conversion problems by using conversion factors and canceling units, just like you cancel numbers in fractions. The main idea is: Multiply by conversion factors until all unwanted units cancel and only the desired unit remains.

Example 1: Convert 250 cm to meters.

Start with what you have: 250 cm

Use a conversion factor that relates centimeters and meters:

$$\frac{1\ \text{m}}{100\ \text{cm}}$$

Multiply: $250\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}}$

The cm units cancel: $250 \times \frac{1\ \text{m}}{100}$

Answer: 2.5 m

Example 2: A multi-step conversion. Convert 60 miles/hour to meters/second.

$$60\ \frac{\text{mi}}{\text{hr}} \times \frac{1609\ \text{m}}{1\ \text{mi}} \times \frac{1\ \text{hr}}{3600\ \text{s}}$$

Notice how miles and hours cancel:

$$60 \times \frac{1609}{3600} \approx 26.8$$

Answer: 26.8 m/s

Steps for Dimensional Analysis

1. Write the given value.
2. Write a conversion factor as a fraction.
3. Arrange the fraction so the unwanted unit cancels.
4. Multiply.
5. Check that the final unit is the one you wanted.

Watch this video that explains dimensional analysis.

Watch this video for basic conversions in the metric system (kilo, centi, milli).

Here is the list of the main prefixes in the metric system:

Prefix	Symbol	Numerical Value	Exponential Value
tera	T	1,000,000,000,000	10^{12}
giga	G	1,000,000,000	10^{9}
mega	M	1,000,000	10^{6}
kilo	k	1,000	10^{3}
hecto	h	100	10^{2}
deka	da	10	10^{1}
no prefix		1	10^{0}
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}
pico	p	0.000000000001	10^{-12}

Meters (m)
Liters (L)
Grams (g)

Convert the following values using dimensions analysis:

1. 2 hL to L

$$2\ \text{hL} \times \frac{100\ \text{L}}{1\ \text{hL}} = 200\ \text{L}$$

2. 91 m to cm

3. 4,000 cL to daL

4. 5.3 dL to mL

5. 600 cL to L

6. 9 dag to g

7. 1,000 dg to hg

8. 3 kg to hg

9. 800 cm to m

10. 900 dm to dam

11. 7.8 megabytes to bytes

12. 16 milliseconds to seconds

13. 340,567,000 nanometer (nm) to meters (m)

MULTI STEP CONVERSIONS:

14. Convert 760 h to days

15. Convert 350 pesos to japanese yen
    1 dollar = 17.55 mxn
    1 dollar = 149.3 yen

TOPIC 4: DENSITY

INTRODUCTION TO DENSITY

The density is the mass per unit of volume of a substance. It essentially measures how much "stuff" is packed into a given space. The density can be calculated using the following equation:

Density = Mass / Volume

1. Match the following words to the correct definition: DENSITY | MASS | VOLUME | COMPACTNESS

a. _____: How much "stuff" (atoms) an item is made up of. (measured in grams)

b. _____: How much "space" an object takes up. (measured in mL or cubic cm)

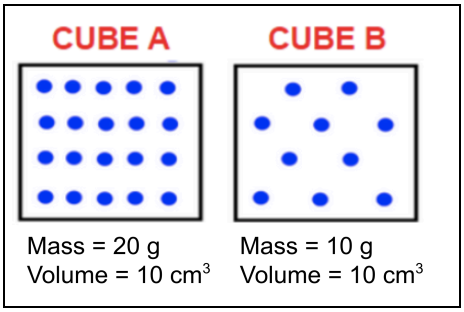
c. _____: Describes the relationship between a material's mass and volume.

d. _____: Another term to describe density

2. Determine the density of cube A (include unit: g/cm^3)? _____

Determine the density of cube B (include unit)? _____

Which cube is denser and why? (use a full sentence)



3. A block of aluminum occupies a volume of 15.0 mL and weighs 40.5 g.
Calculate its density in mg/mL (make sure you convert the g to mg). Write your answer in standard and scientific notations.

4. A bacteria sample grows 50% of the sample every hour. If it starts at 3/5 of a dish, how much of the dish will it cover in one hour?

If a bacteria is 2×10^5 nm wide and shrinks by a factor of 10^2, how wide is it now?

WHAT IS THE MASS OF A COPPER BLOCK?

You want to predict the mass of a copper block. The volume of any regular solid can be calculated using the following equation: **Volume = Length × Width × Height**. As seen in the previous exercise, the density is the mass per unit volume of a substance: **Density = Mass / Volume.** If the density of the solid is known, you can predict the mass by rearranging the previous equation to solve for mass. The density of copper is 9.3 g/cm^3.

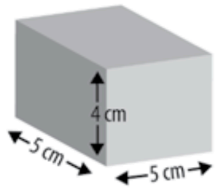


Figure 1. Copper Block dimensions

Calculate the mass of the copper block, using the passage above and Figure 1:

HOW DOES MASS AFFECT DENSITY?

You want to do an experiment to see if the mass of an object influences its density. In order to do so you will make sure your volume is kept constant by using four 300.0 mL plastic bottles (a bit smaller than a regular can of coke). You will be modifying the mass by putting marbles inside the bottles. All the marbles have the same mass: 12.0 g/ each. The bottle's mass is 10.0 g



1. **Identify** the variables of your experiment: Independent variable: _____

Dependent variable: _____

Constant variable: _____

2. You add 10 marbles to one of the empty bottles (Bottle 1). Calculate the density of the Bottle 1 with the 10 marbles. Remember the bottles also have a mass, not only the marbles. Show all the steps of your work. Include units in all the steps.

3. You take the other three bottles and you add 20 (Bottle 2), 30 (Bottle 3) and 40 marbles (Bottle 4), respectively. **Calculate** the densities of those bottles. *No need to show steps, but include units.*

Bottle 2 (with 20 marbles): _____ Bottle 3 (w/ 30 marbles): _____ Bottle 4 (w/ 40 marbles): ____

4. You put the four bottles in a tank of water (Density of water = 1 g/mL). **Predict** which ones would float and which ones would sink? Answer using complete sentences and explaining your reasoning.

DENSITY PRACTICE PROBLEMS

1) A block of aluminum occupies a volume of 15.0 mL and weighs 40.5 g. What is its density?

2) What is the mass of the ethyl alcohol that exactly fills a 200.0 mL container? The density of ethyl alcohol is 0.789 g/mL.

3) A rectangular block of copper metal weighs 1896 g. The dimensions of the block are 8.4 cm by 5.5 cm by 4.6 cm. From this data, what is the density of copper?

4) What volume of silver metal will weigh exactly 2500.0 g. The density of silver is 10.5 g/cm^3

5) A block of lead has dimensions of 4.50 cm by 5.20 cm by 6.00 cm. The block weighs 1587 g. From this information, calculate the density of lead.

6) A flask that weighs 345.8 g is filled with 225 mL of carbon tetrachloride. The weight of the flask and carbon tetrachloride is found to be 703.55 g. From this information, calculate the density of carbon tetrachloride.

7) A 28.5 g block of iron is added to a graduated cylinder containing 45.50 mL of water. The water level rises to the 49.10 mL mark. Calculate the density of iron in g/L. (make sure you convert mL to L!).

TOPIC 5: ATOMS

Build an atom simulation

1. Open the PhET "Build an Atom" Simulator and click on the "Atom" activity. Click on the **+** sign for each of the yellow boxes (element, net charge and mass number) to view changes as you change the number of particles in the atom.

2. NUCLEUS

What particle(s) are found in the center of the atom, the nucleus? _____

3. IDENTITY OF ELEMENTS

Add protons, neutrons and electrons to the atom. Which **particle(s)** determine(s) the name of the **element** you build? _____

What is the **name** of the following atoms?

a. An atom with 3 protons and 4 neutrons: _____
b. An atom with 2 protons and 4 neutrons: _____
c. An atom with 4 protons and 4 neutrons: _____

5. ATOMIC MASS

Add protons, neutrons and electrons to the atom. Which **particle(s)** determine(s) the **mass** number (atomic mass) of your atom and/or ion? _____

Write down the rule or equation for determining the mass number of an atom:

Mass number/atomic mass = _____ ____ _____
Subatomic particle operation subatomic particle

6. ELECTRIC CHARGE

Add protons, neutrons and electrons to an atom. Which particles affect the **charge** of the atom?

_____

When are atoms neutral? _____

Create a rule (in the form of a single sentence or equation) that can predict the charge of an atom (atomic charge) based on the number and types of particle.

Atomic charge = _____ ____ _____
Subatomic particle operation subatomic particle

9. Use the simulation to **create** atoms that fit the following descriptions/requirements. **Draw** your atom into the appropriate place and **complete** the "Details". In the bottom right part of the webpage, select the option "Stable/Unstable" so you can see if the nucleus is stable or unstable.

Important:

- Atoms are neutral.
- When an atom has a charge, we call it an **ION**.
- Positive atoms are called **CATIONS**
- Negative atoms are called **ANIONS**

Requirements	Drawing of the atom	Details
• **Neutral atom** • **Mass of 10 mass units** • **Stable nucleus**		Element name: Chemical Symbol: Protons: Neutrons: Electrons: Mass: Charge:
• **Cation** • **2+ charge** • **Stable nucleus** • **More than 3 electrons**		Element name: Chemical Symbol: Protons: Neutrons: Electrons: Mass: Charge:
• **Anion** • **1- charge** • **Unstable nucleus** • **At least 4 electrons**		Element name: Chemical Symbol: Protons: Neutrons: Electrons: Mass: Charge:

10. Practice your knowledge by going to the "Game" section of the simulation. Play the first two games. If you score less than 4/5 on either of the games, play again until you score at least 4/5 for both games.

TOPIC 6: BALANCING CHEMICAL EQUATIONS

A **chemical equation** is a shorthand way of showing a **chemical reaction** using chemical formulas and symbols.

It tells us:

- **What substances start the reaction** (reactants)
- **What substances are formed** (products)
- **How much of each substance is involved** (using coefficients)

Example: $2\ H_2 + O_2 \rightarrow 2\ H_2O_2$, read as: "Two molecules of hydrogen react with one molecule of oxygen to produce two molecules of water."

In a chemical equation, **coefficients** and **subscripts** both involve numbers, but they mean different things.

Term	Where it appears	What it tells you	Example
Coefficient	In front of a chemical formula	Number of molecules (or moles)	**2** H_2O = 2 water molecules
Subscript	Small number within a formula	Number of atoms of an element in one molecule	H_2O = 2 hydrogen atoms and 1 oxygen atom

Watch this video that explains how to balance chemical equations.

YOUR TURN!

1. Circle all the subscripts. Draw a square around all the coefficients. 

   H_2 **2 HCl** **4 O_2** **CH_4** **3 CO_3** **2 NaOH**

2. List the chemical symbols of each of the elements below the chemical formula. Then record how many of each element there. *The first one has been done for you.*

   C_2H_6 **2 MgO** **4 P_4O_{10}** **3 $Al(OH)_3$**

   C = 2
   H = 6

3. Balance the chemical equations.

$P + O_2 \rightarrow P_4O_{10}$

P =
O =

P =
O =

$Mg + O_2 \rightarrow MgO$

Mg =
O =

Mg =
O =

$HgO \rightarrow Hg + O_2$

Hg =
O =

Hg =
O =

$Al_2O_3 \rightarrow Al + O_2$

Al =
O =

Al =
O =

$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + HCl$

Ba =
Cl =
H =
S =
O =

Ba =
Cl =
H =
S =
O =

$Na + Br_2 \rightarrow NaBr$

$N_2O_5 + H_2O \rightarrow HNO_3$

$NaN_3 \rightarrow Na + N_2$

$KNO_3 \rightarrow KNO_2 + O_2$

$Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$

$Na + H_2O \rightarrow NaOH + H_2$

$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$

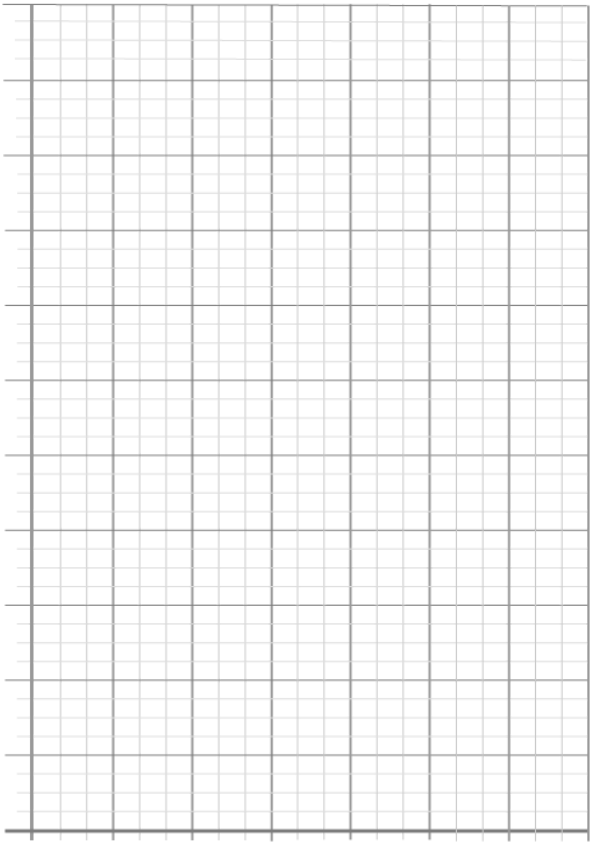
TOPIC 7: HOW DO BACTERIA GROW AND GET KILLED?

1. After watching this video, draw and/or summarize your observations to describe what you see a single bacterium doing that would cause the population of bacteria to increase in size over time.

2. Use the time it takes a single bacterium to reproduce into two bacteria (20 minutes) to do a quick calculation. How long would it take to end up with eight bacteria if you started with one bacterium? Support your answer with a model (drawing).

3. CREATING A MATHEMATICAL MODEL: Complete the table showing the growth of the bacteria population over 400 minutes. Then construct a graph of the number of bacteria vs. time in hours.

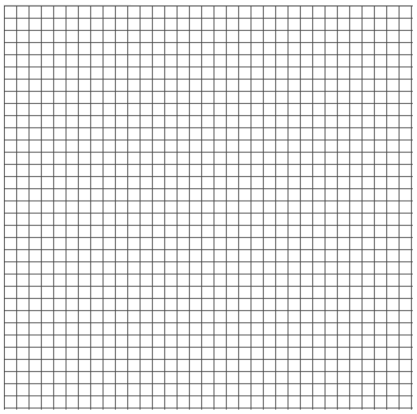
Time (in min)	Time (in hrs)	Number of bacteria
0	0	1
400	6 ⅔	



4. Describe the pattern of change of population growth in the table and graph: _____

5. Bacterial population:
The table shows a population of four types of bacteria (identified by a color) and their population after 4 hours of growth. Calculate the percentage of bacteria for each type of variation after 4h. Graph the final percentages. Percentage = (Number of bacteria of a specific variation / Total number of bacteria) x 100

VARIATION	TIME = 0 h		TIME = 4 h	
Color of the variation of bacteria	# of bacteria	% of the population made up of this variation	# of bacteria	% of the population made up of this variation
Purple	1	25%	123	
Green	1	25%	234	
Brown	1	25%	345	
Red	1	25%	678	
Total bacteria	4	100%		

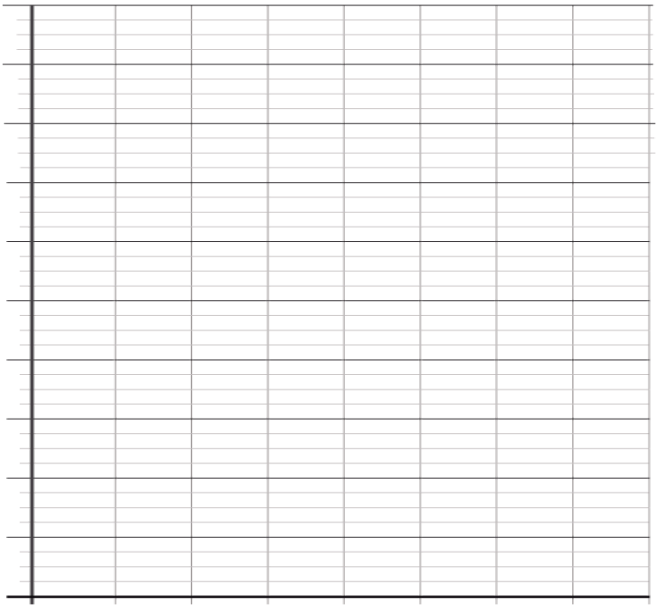


6. Antibiotic dosage: Watch this video about the interaction between bacteria and penicillin antibiotic. (Left: with antibiotic, Right: without)

a. Build a mathematical model to determine how many doses it would take to kill 1,000,000 bacteria if the antibiotic we were using was 90% (90/100) effective. Use the table to the right to help with this.
How many doses do you need to kill all the population of bacteria? _____

Dose	# of Bacteria Before Dose	# of Bacteria Killed	# of Bacteria Alive After Dose

b. Construct a graph of the data in the table of # of bacteria vs. # of antibiotic doses. Label your axes, and make sure to choose equal intervals for each axis. The independent variable goes in the x-axis and the dependent variable in the y-axis.



TOPIC 8: GRAPHING ACTIVITIES

In science, the type of graph you choose depends on the kind of data you have and what you want to show. In this activity we will work with Line Graphs and Bar Graphs.

1. Line Graph 📈

Use when: Showing how something changes over time or with a continuous variable.
It shows **trends and patterns** clearly. The points are connected because the data is continuous.

Examples:

- Temperature throughout the day
- Plant height over several weeks
- Distance traveled as time increases

2. Bar Graph 📊

Use when: Comparing different categories or groups.
It makes it easy to compare amounts. The bars do **not** touch because the categories are separate.

Examples:

- Number of students with different eye colors
- Average test scores for different classes
- Types of bacteria found in different locations

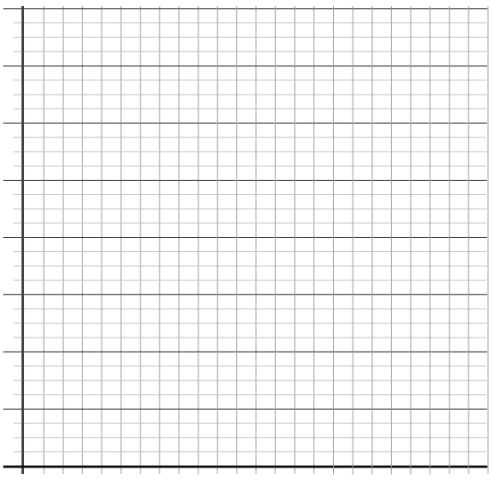
YOUR TURN!

I. ANTIBIOTIC PRESCRIPTION

Create a graph showing the number of prescriptions for each antibiotic, using the following data from the CDC (Center for Disease Control and Prevention). Make sure you choose the appropriate type of graph.

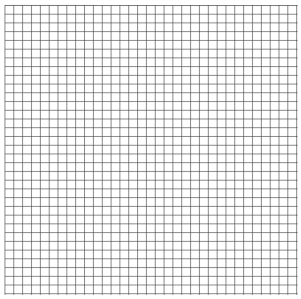
Name of antibiotic	# prescriptions
Amoxicillin	54.8 million
Azithromycin	49.4 million
Augmentin	25.3 million
Cephalexin	21.4 million
Ciprofloxacin	20.3 million

Figure 1. Top 5 most prescribed antibiotics. ⅝ most prescribed antibiotics are penicillin-derived (beta-lactams).



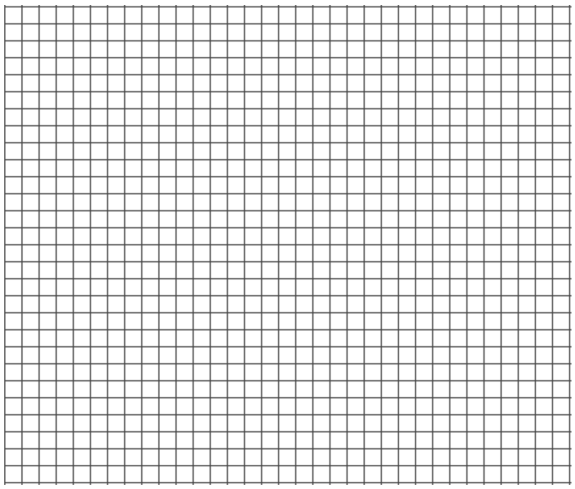
II. ATOMIC RADIUS

PREDICTION: Imagine what will happen to the atomic radius as the atomic number (number of protons) increases. **Sketch a graph** of the atomic radius vs the atomic number on the grid to the right. Be sure to label the x and y axes.



The following data table shows the atomic radii of 30 atoms, organized by increasing atomic number. Graph the data and **connect all the plotted points with a smooth curve** ("best fit curve").

Atomic Number	Atomic Radius (pm)	Atomic Number	Atomic Radius (pm)	Atomic Number	Atomic Radius (pm)
1	32	11	160	21	159
2	37	12	140	22	148
3	130	13	124	23	144
4	99	14	114	24	130
5	84	15	109	25	129
6	75	16	104	26	124
7	71	17	100	27	118
8	64	18	101	28	117
9	60	19	200	29	122
10	62	20	174	30	120



1. Using your Periodic Table (find it online), identify **the three elements** that do not seem to fit the pattern.

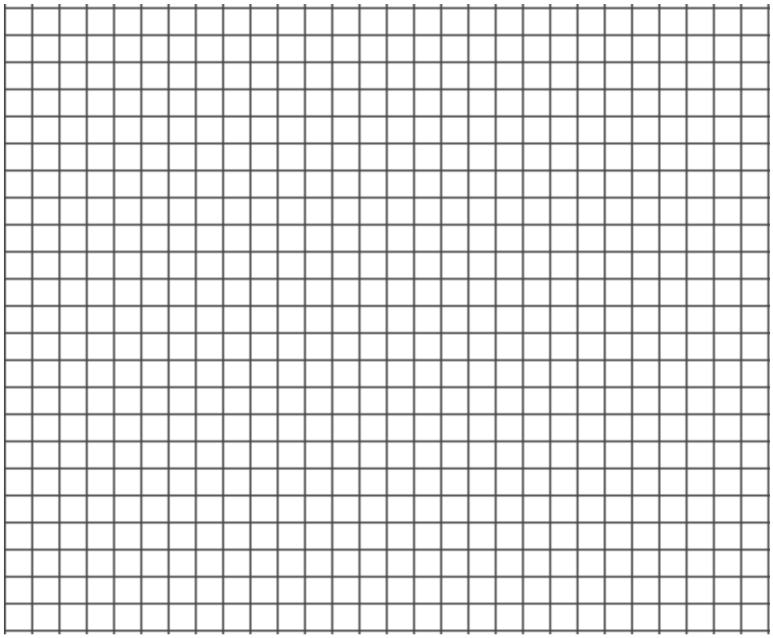
2. **Compare** this graph to your predicted graph. Is it similar? Why?

III. BACTERIAL GROWTH OVER TIME

Objective: Students will analyze bacterial growth data and create a **multi-series line graph** to observe patterns over time under different conditions.

A team of microbiologists is studying **how temperature affects bacterial growth**. They inoculate identical nutrient agar plates with the same bacterial strain: one single bacteria is added to each Petri dish. Once the colony in each Petri dish reaches 1mm, the microbiologists start the experiment and incubate them at different temperatures (10°C, 25°C, 37°C, and 50°C). Every 4 hours, they measure the bacterial colony size (in mm) for 24 hours. The collected data are shown in the data table. **Plot a multi-series line graph** showing bacterial growth over time under different temperature conditions. In the multiple series graph, you will have different lines and each line represents a different temperature. Make sure to add a key for each of the lines.

	Size of the colony (in mm) at a specific temperature			
Time (h)	**10°C**	**25°C**	**37°C**	**50°C**
0	1	1	1	1
4	1.5	1.5	2	1.5
8	2	2.8	4	2
12	2.5	4	5.7	2
16	2.8	5.2	7	2
20	3.2	5.9	8.5	2
24	3.4	6.5	9.5	2



Discussion Questions:

1. Which temperature led to the fastest bacterial growth? _____
2. What happened to the bacteria at 50°C and why?
3. If this experiment continued for 24 more hours, what do you predict would happen?