

AP BIOLOGY SUMMER PACKET 2026-2027

This packet is intended to be used as a way to introduce some of the necessary science skills that you will need for the duration of AP Biology, and as a way for you to gain practice with said skills. These skills align with several of the "Science Practices" that are provided in the AP Biology Course and Exam Description manual.

Download and complete this packet to notability

Please re-write the following statement. Then sign and date.

"I pledge on my honor to uphold academic integrity and will not give or receive any unauthorized assistance on this assignment."

Print your full Name: _____

Signature: _____

Date: _____

Part 1 - CER Practice

Develop explanation for phenomena based on scientific evidence (data)

Claim: statement about results of investigation (can support or refute hypothesis)

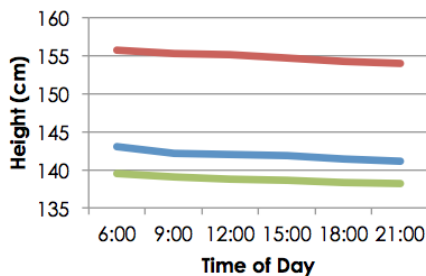
Evidence: scientific data from the lab investigation, previous experiments, published literature, models, etc.

Reasoning: ties together claim and evidence; includes scientific principles

QUESTION: Does a person's height change throughout the day?

CLAIM: A person's height decreases throughout the day as gravity pulls down on their body.

EVIDENCE: Data



Interpretation: The height of the students decreased by an average of 1.7 cm throughout the day.

REASONING:

- We saw an avg 1.7 cm decrease in height across a 15 hour day.
- We took measurements at the same time for each person.
- Students measured spent roughly the same amount of time sitting and standing.



Watch the following video to understand further:
<https://youtu.be/15aWaGYheJs?si=He23XC8juzMTg44->

Now, watch the video <https://youtu.be/BIFSUCcNuUU?si=Z8QPn9rubhbyl-oi> on Carl's Conspiracies and write down the TWO CER's made in the video

CLAIM 1: _____

EVIDENCE: _____

REASONING: _____

CLAIM 2: _____

EVIDENCE: _____

REASONING: _____

Part 2- FRQ Practice

Study each Task verb for the FRQ, you will take a quiz on them during your first week

The following **task verbs** are commonly used in the free-response questions:

Calculate: Perform mathematical steps to arrive at a final answer, including algebraic expressions, properly substituted numbers, and correct labeling of units and significant figures.

Construct/Draw: Create a diagram, graph, representation, or model that illustrates or explains relationships or phenomena. Labels may or may not be required.

Describe: Provide relevant characteristics of a specified topic.

Determine: Decide or conclude after reasoning, observation, or applying mathematical routines (calculations).

Evaluate: Judge or determine the significance or importance of information, or the quality or accuracy of a claim.

Explain: Provide information about how or why a relationship, process, pattern, position, situation, or outcome occurs, using evidence and/or reasoning to support or qualify a claim. Explain "how" typically requires analyzing the relationship, process, pattern, position, situation, or outcome; whereas explain "why" typically requires analysis of motivations or reasons for the relationship, process, pattern, position, situation, or outcome.

Identify: Indicate or provide information about a specified topic, without elaboration or explanation.

Justify: Provide evidence to support, qualify, or defend a claim, and/or provide reasoning to explain how that evidence supports or qualifies the claim.

Make a claim: Make an assertion that is based on evidence or knowledge.

Predict/Make a prediction: Predict the causes or effects of a change in, or disruption to, one or more components in a relationship, pattern, process, or system.

Represent: Use appropriate graphs, symbols, words, illustrations, and/or tables of numerical values to describe biological concepts, characteristics, and/or relationships.

State (the null/alternative hypothesis): Indicate or provide a hypothesis to support or defend a claim about a scientifically testable question.

Support a claim: Provide reasoning to explain how evidence supports or qualifies a claim.

Part 3- Lab Safety

To ensure a safe and productive laboratory environment, it is crucial to follow proper safety protocols. By familiarizing yourself with lab safety guidelines, you can protect yourself and others while conducting experiments.

Create an account using your school account on: <https://www.flinnpavo.com/>

□ When it asks you "What is your interest in science" select "student"

Once you're on the main page, you'll see icons on the left, select "My Courses" then on the top drop down under "Select Learning Path" select "FLINNsafety"

Then scroll down to look for this training course:



Go through and watch all the videos and take the end of lesson assessments. At the end they will provide you with a certificate of completion with your name on it. You will need to print this out and submit this to me on the first day of school.

Part 4- Data Analysis

For this class, you will also need to be adept at analyzing data. This means that you will need to be able to interpret the data that you or others have gathered from an experiment by searching for trends and/or patterns in the data, by identifying specific data points of significance, and/or by describing relationships between variables. You will also need to be able to determine how to best present your own data in an experiment (as a bar graph, line graph, pie chart, etc.).

One of the best ways to communicate the results of a scientific investigation is graphing or creating an effective visual representation (a graph) of the data that have been counted, measured, and calculated. Investigators often can easily see patterns in a carefully crafted visual display that may not be as readily apparent in a data table of numbers. Visual displays also can clarify how two measured variables affect each other.

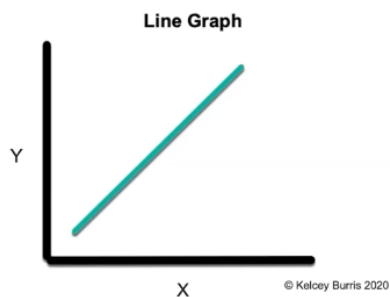
The AP Biology laboratory manual is designed to encourage students to ask their own questions by designing and carrying out investigations. This process of inquiry requires data analysis and communication of results. The data collected to answer questions generated by students will generally fall into three categories: (1) normal or parametric data, (2) nonparametric data, and (3) frequency or count data. Normal or parametric data are measurement data that fit a normal curve or distribution. Generally, these data are in decimal form. Examples include plant height, body temperature, and response rate. Nonparametric data do not fit a normal distribution, may include large outliers, or may be count data that can be ordered. A scale such as big, medium, small (qualitative) may be assigned to nonparametric data. Frequency or count data are generated by counting how many of an item fit into a category. For example, the results of a genetic cross fit this type of data as do data that are collected as percentages.

You should know the different types of graphs and when to use the appropriate graph to represent your data.

Types of graphs

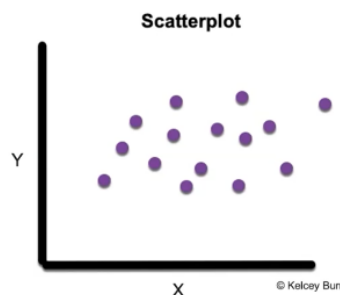
- Line Graph

- Reveals trends or progress over time for multiple groups or treatments
- Track changes over time, concentrations, etc.



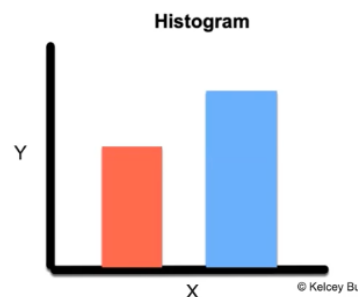
- X Y Graph

- Scatterplot
- To determine relationships between two different things
- Compare two variables that may or may not have a linear relationship



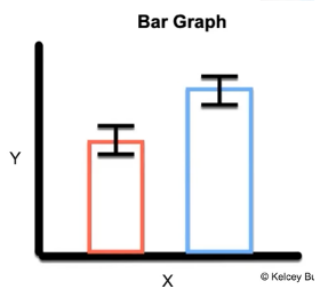
- Histogram

- Show how values in a data set are distributed across evenly spaced or equal intervals
- Explore the relationship between two or more variables



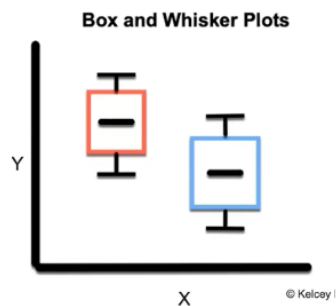
- Bar graph

- Compare multiple groups or treatments to each other



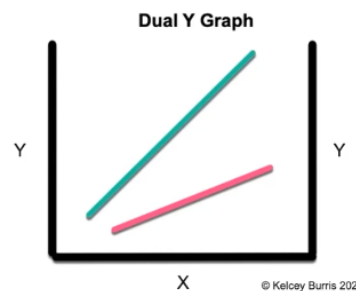
- Box and Whisker Plots

- Show the variability in a sample
- Ideal for comparing distributions in relation to the mean



- Dual Y

- Illustrate the relationship between two dependent variables



The components of an effective graph

- 1) **Title:** Experiment details and what is being measured.

2) **Labeled axes with units:** Axes must be clearly labeled with units

- The X-axis is the independent variable
- The Y-axis is the dependent variable
- Intervals must be uniform
- It is not necessary to label every interval
- Labels, including units, should allow the reader to easily see the information

3) **Scaling-** Uniform intervals

- Scale is large enough to analyze data
- Scale numbers on the grid lines

4) **Identifiable lines or bars-** legend or label each line or bar

- Multiple conditions: more than one condition can be present in a graph, however, they need to be clearly labeled and a key must be present. This is the preferable method for comparing multiple experiments that differ by only a single variable.

5) **Origin:** the origin of the graph must be clearly labeled whether it is at (0,0) or not.

6) **Trend line-** line of best fit that shows the general pattern or overall direction of the data

7) **Standard error:** you may include standard error bars to inform the reader of the accuracy of your data collection.

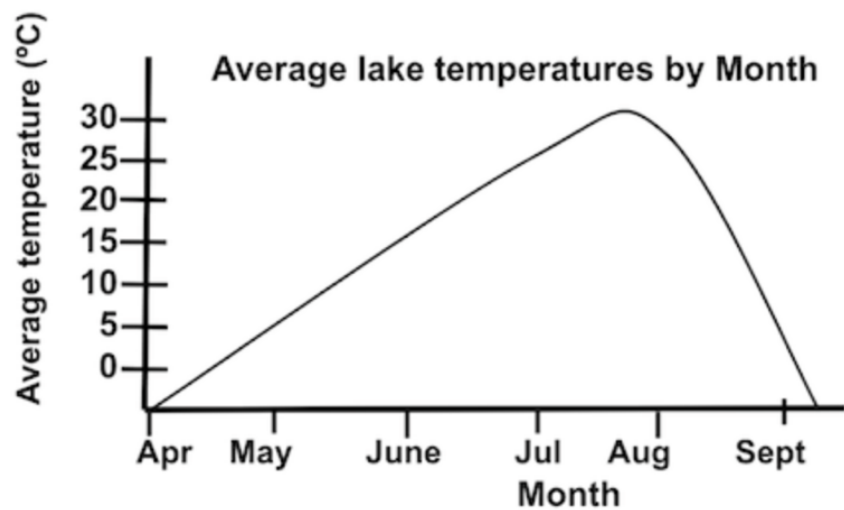
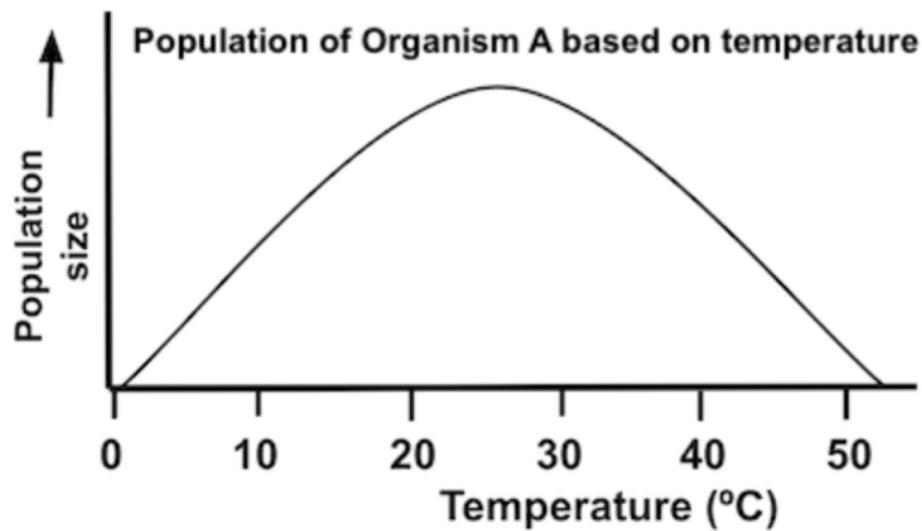
Below are some questions for you to practice analyzing data:

A biology student wanted to determine if there is a relationship between resting heart rate and body height. She gathered information from 12 classmates and constructed the table below.

Student height (cm)	Resting heart rate (beats per minute)
155	60
156	65
156	78
165	72
170	67
175	62
175	80
180	64
180	73
190	68
194	78
195	63

1. Which of the following is best supported by the data in the table? (*Circle one.*)
 - a. The taller the student, the higher the resting heart rate.
 - b. The shorter the students, the higher the resting heart rate.
 - c. A higher resting heart rate results in student growth.
 - d. There is no direct correlation between height and resting heart rate.
2. Which type of graph/chart would you use to show the trends in this data? (*Note: Multiple answers accepted here.*)

The graphs below show the population size of Organism A in a local lake, and the average temperatures of the lake by month.



3. What type of graphs or charts are shown in the figure above? (*Circle one.*)

- a. bar graphs
- b. pie charts
- c. line graphs
- d. histograms

4. During which month would you expect the Organism A population to be the greatest? (*Circle one.*)

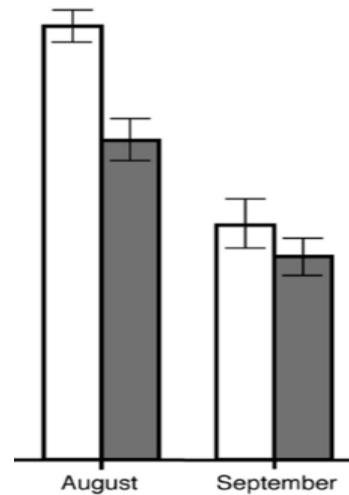
- | | |
|-----------|---------|
| a. August | c. June |
| b. May | d. July |

Interpreting Data

In any data table that you are asked to graph, you see the SEM (Standard Error of Mean).

- Make sure that you plot the SEM times 2 and that with brackets that are +2SEM above the mean and -2SEM below the mean.

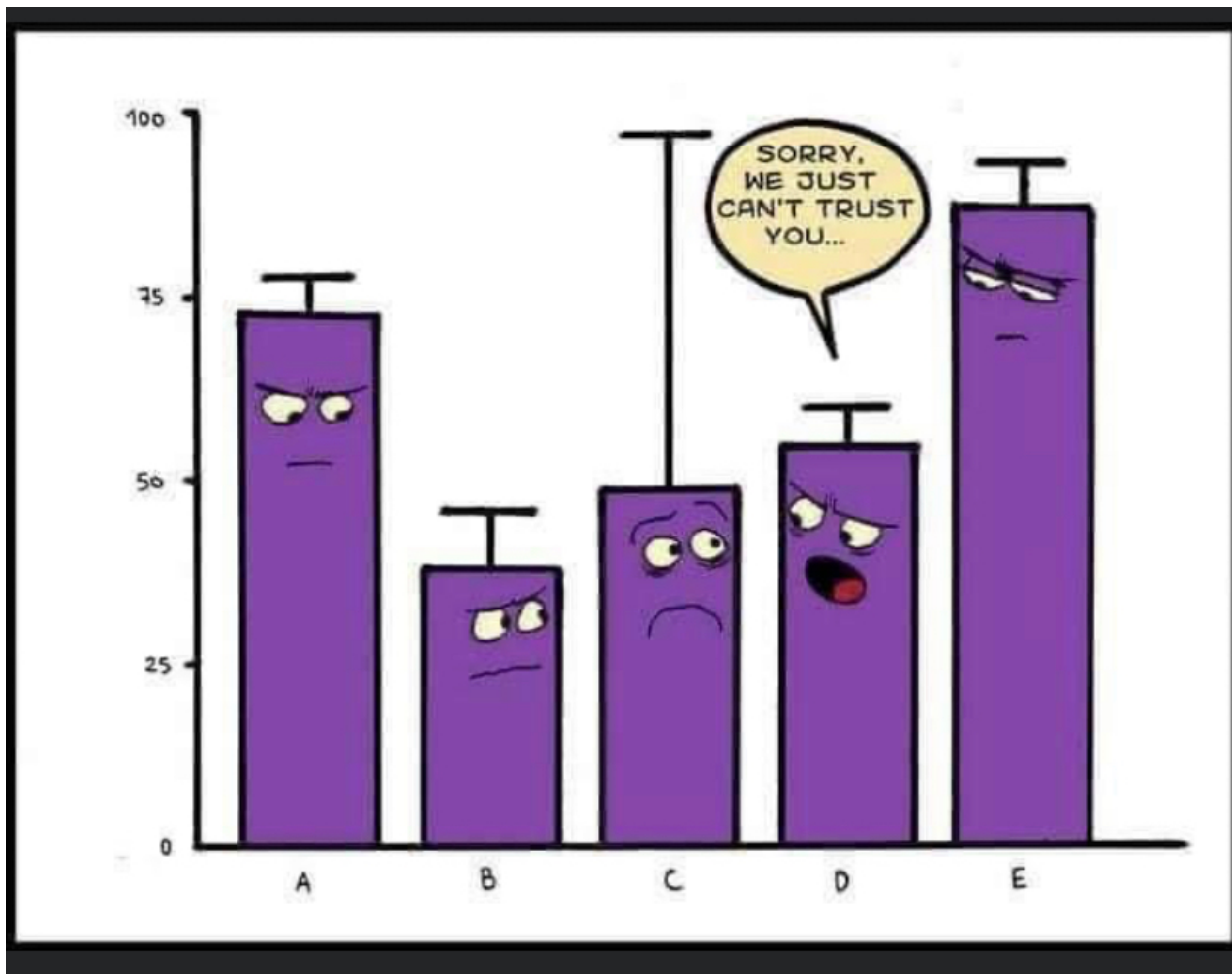
If the SEM bars are overlapping, take this to mean data sets have **no statistical significant** difference. Example: In August, the SEM brackets are not overlapping. In September, the SEM brackets are overlapping



might

depict
mean

that two

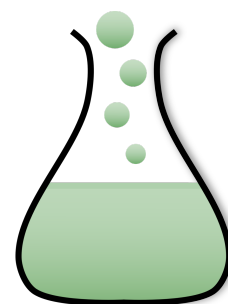


Part 5- Starting the AP Bio Curriculum

There is **A LOT** of information to go through in AP Biology, so you will need to learn a few concepts independently throughout the year that I think that you will be able to handle. To allow us to get through everything we need to and properly prepare you for the AP Bio exam you will need to first pre-read **Unit 1: Chemistry of Life Reading Guide**. We will go through this unit QUICKLY at the beginning of the year.

Topics:

1. Scientific Method Review
2. Statistics
3. Chemistry Review
4. Properties of Water
5. Elements of Life
6. Biological Macromolecules



Annotation Key

All students are expected to complete annotations for the readings below.

- ❖ **Pink highlighter** → Vocabulary words
- ❖ **Yellow highlighter** → Key equations/formulas
- ❖ **Underline** → Definitions
- ❖ **Circle** → Unfamiliar words
- ❖ **Star** → Key ideas/facts
- ❖ **Write a question mark (?)** → Next to anything that is confusing you
- ❖ **Write down notes in the margins or under the paragraphs** → Any questions you have or thoughts/comments you have about what you read

Topic #1: Scientific Method Review

WHAT IS SCIENCE?

Science is a systematic endeavor aimed at understanding the natural world through observation, experimentation, and logical reasoning. Central to the scientific method are processes such as inquiry, hypothesis formation, and rigorous testing of ideas.

Inquiry in Science

At the heart of scientific exploration is **inquiry**, which involves posing questions and seeking answers through systematic investigation. This process begins with making careful observations and gathering relevant data.

Observations: Qualitative and Quantitative

Observations in science can be **qualitative**, describing qualities or characteristics, or **quantitative**, involving numerical measurements.

Reasoning: Inductive and Deductive

Scientists employ two primary forms of reasoning: inductive and deductive. **Inductive reasoning** involves making generalizations based on specific observations, while **deductive reasoning** uses logical inference to predict specific outcomes from general principles.

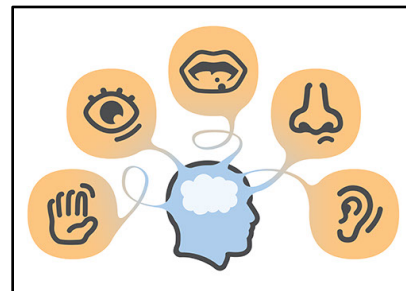
Hypothesis: Definition and Formulation

A **hypothesis** is a proposed explanation for a phenomenon or a prediction that can be tested through experimentation. It serves as a tentative answer to a scientific question and is formulated based on prior knowledge and observations.

How do you write a hypothesis?

To construct a hypothesis, one typically follows a structured format: "If [cause], then [effect], because [rationale]."

- For example, "If plants are exposed to sunlight, then their growth rate will increase, because sunlight is essential for photosynthesis."



Null and Alternative Hypotheses

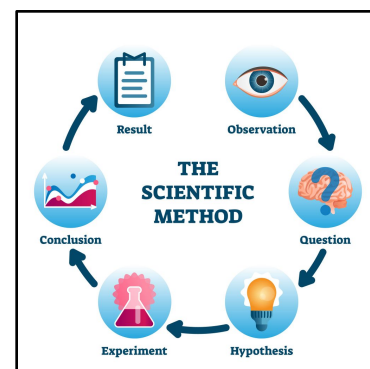
In experimental research, hypotheses are categorized into null and alternative hypotheses. The **null hypothesis (H_0)** states that there is no significant relationship between variables being studied, whereas the **alternative hypothesis** proposes that there is a significant relationship.

- For example, if a scientist wants to test whether a new fertilizer affects plant growth, the hypotheses would be:
 - **Null Hypothesis (H_0):** The new fertilizer has no effect on plant growth. This means any observed differences in growth are due to random variation or other factors, not the fertilizer.
 - **Alternative Hypothesis (H_1):** The new fertilizer has an effect on plant growth. This implies that any observed differences in growth are due to the application of the fertilizer.

HOW DO YOU DESIGN AN EXPERIMENT?

In scientific inquiry, a hypothesis, law, and theory represent different levels of understanding.

- A **hypothesis** is an educated guess based on prior knowledge and observations, which can be tested through experiments. For instance, you might hypothesize that a specific nutrient enhances plant growth.
- A **scientific law** describes an observable phenomenon that occurs consistently under specific conditions, often expressed mathematically, like Newton's Law of Gravity.
- A **scientific theory** is a well-substantiated explanation supported by extensive evidence, explaining the reasons behind a wide range of observations, such as the theory of evolution by natural selection.



Key Components of a Well-Designed Experiment

1. Independent and Dependent Variables:

- The **independent variable** is the factor that is deliberately manipulated by the researcher. It is the presumed cause in an experiment. For example, in an experiment testing the effect of fertilizer on plant growth, the type or amount of fertilizer used would be the independent variable.
- The **dependent variable** is the factor that is measured or observed to assess the effect of the independent variable. Continuing the example, the plant growth (measured by height, biomass, etc.) would be the dependent variable.

2. Controls:

- **Positive Control:** This group is exposed to a treatment known to produce a positive result. It helps confirm that the experimental setup is capable of producing results. For instance, if testing a new drug, a positive control could be a drug already known to be effective.
- **Negative Control:** This group is not exposed to the treatment and should not produce a result. It helps identify any external factors that might influence the outcome. In the plant growth example, a negative control might be a group of plants that receive no fertilizer at all.

3. Constants:

- **Constants** are all the factors that must be kept the same throughout the experiment for all groups (experimental, positive control, and negative control). This ensures that any observed effect on the dependent variable is due to the independent variable alone.
 - i. In our example, constants might include the type of plants used, the amount of water and sunlight each plant receives, the soil type, and the temperature.

4. Number of Trials:

- Repetition is essential in experiments to ensure that the results are reliable and not due to random chance. The greater the number of trials, the more robust and statistically significant the results will be.
 - i. For example, if testing the fertilizer, it would be beneficial to have multiple plants in each group and repeat the experiment several times.

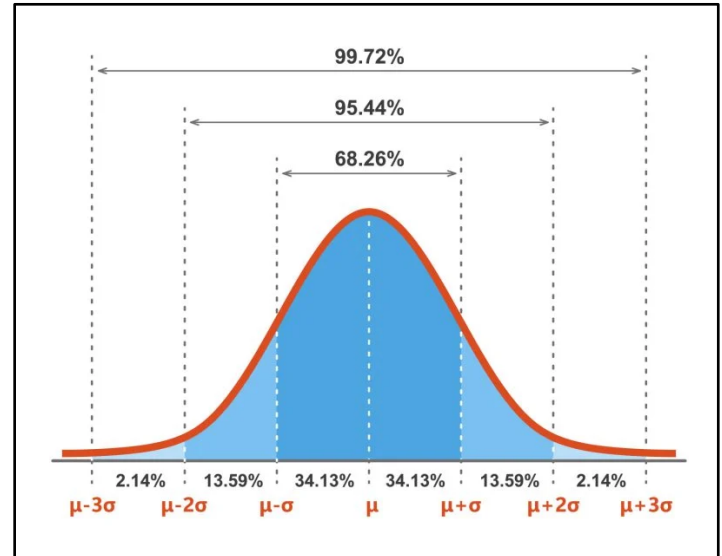
Topic #2: Statistics

What is Statistics?

Statistics is a branch of mathematics that helps us understand and interpret data. In biology, statistics are used to summarize, describe, and analyze experimental data, helping scientists draw conclusions about biological phenomena.

The Bell-Shaped Curve and Normal Distributions

A **bell-shaped curve** represents a **normal distribution**, a common pattern where most data points are concentrated around the middle (mean) value, with fewer data points appearing as you move away from the mean. This curve is symmetric, meaning it looks the same on both sides of the center.



Central Tendencies: Mean, Median, and Mode

Central tendencies are measures that summarize a set of data by identifying the center point. There are three measures that we will be concerned with:

- **Mean (Average):** The sum of all data points divided by the number of data points. It tells us the overall average.
 - For example, if five plants grow 10, 12, 14, 16, and 18 cm tall, the mean height is $(10 + 12 + 14 + 16 + 18) / 5 = 14$ cm.
- **Median:** The middle value when the data points are ordered from least to greatest. It shows the central point of the data.
 - Using the same plant heights, the median is 14 cm because it is the third number in the ordered list.
- **Mode:** The most frequently occurring value in a data set.
 - If you had plant heights of 10, 12, 12, 14, and 16 cm, the mode is 12 cm because it appears most often.

Variability: Range and Standard Deviation

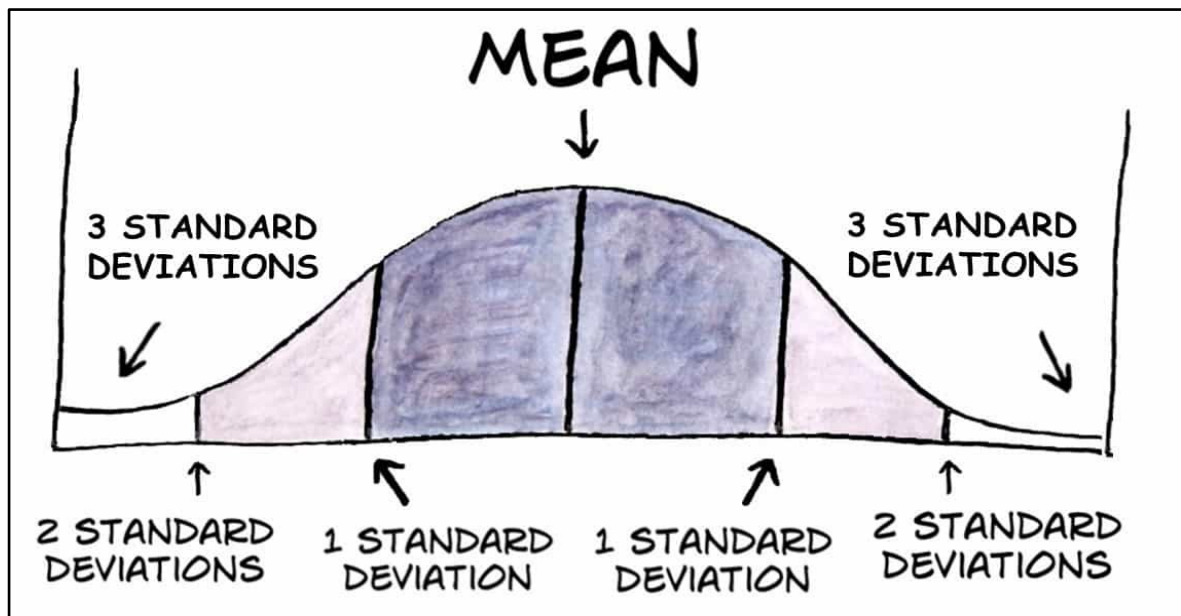
Variability measures how spread out the data points are.

Range: The difference between the highest and lowest values. It gives a simple measure of variability.

- **Example:** If plant heights range from 10 cm to 18 cm, the range is $18 - 10 = 8$ cm.
- **Large Range:** Indicates *high* variability; data points are spread out.
- **Small Range:** Indicates *low* variability; data points are close together.

Standard Deviation (SD): Shows how much the data points differ from the mean. A higher SD means more spread out data, while a lower SD means data points are closer to the mean. In general, if the standard deviation is low, it is more likely that the independent variable is causing the changes; if the standard deviation is high, it is likely that factors other than the independent variable are causing the changes.

- **Example:** If the average height of plants is 14 cm, but most plants are between 13 and 15 cm, the SD is small. If plant heights vary widely from 10 to 18 cm, the SD is large.
- In a normal distribution:
 - **68%** of data falls within **1 SD** of the mean.
 - **95%** of data falls within **2 SDs** of the mean.
 - **99.7%** of data falls within **3 SDs** of the mean.



The formula for standard deviation is shown to the right. Here are 4 steps for calculating the standard deviation:

1. Find the mean.
2. Determine the deviation from the mean for each point and square it.
3. Calculate the degrees of freedom (n-1), n is the # of data values.
4. Plug it into the formula and calculate "s."

Sample
$s = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$ X - The Value in the data distribution $\bar{X}$ - The Sample Mean n - Total Number of Observations

See this example:

Five people took a test. Their scores were 85, 92, 64, 99, 56. Find the population standard deviation.

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{n}}$$

$$\mu = \frac{85 + 92 + 64 + 99 + 56}{5}$$

$$\mu = 79.2$$

$$\sigma = \sqrt{\frac{1358.8}{5}}$$

$$= \sqrt{271.76}$$

$$\sigma = 16.485$$

x_i	$x_i - \mu$	$(x_i - \mu)^2$
85	5.8	33.64
92	12.8	163.84
64	-15.2	231.04
99	19.8	392.04
56	-23.2	538.24
		1358.8

↑

Standard Error

- **Standard Error (SE):** Measures how accurately the sample mean estimates the population mean. It decreases as the sample size increases.

$SE = \frac{\sigma}{\sqrt{n}}$	← Standard deviation ← Number of samples
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- **Example:** If you measure the height of 10 plants and find an average height, SE tells you how close this average is likely to be to the true average height of all plants of that type.

Error Bars and Analysis

Error Bars: Graphical representations of the variability of data on charts and graphs. They can represent the range, standard deviation, or standard error.

Creating Error Bars:

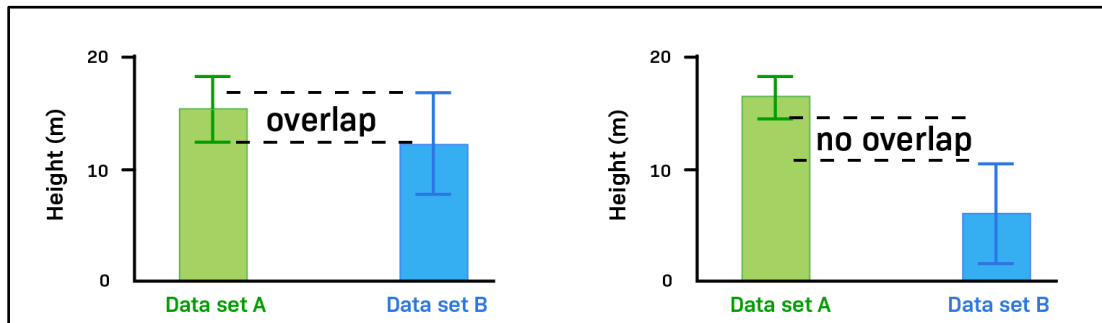
1. **Draw Your Bar Graph:** Create your bar graph as usual, using the mean value for each data set.
2. **Add Error Bars:** Draw error bars above and below each bar to represent the standard error.

For example: If the mean height of a group of plants is 20 cm and the standard error is 1 cm:

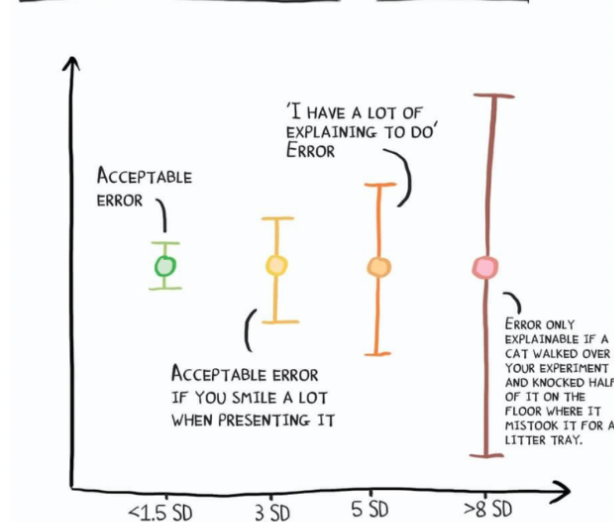
- I. Draw the bar at 20 cm.
- II. The error bar should extend from 19 cm to 21 cm ($20 \text{ cm} \pm 1 \text{ cm}$).

Analyzing Error Bars:

- a. **Overlapping Error Bars:** Suggest that the difference between data sets may not be statistically significant.
- b. **Non-overlapping Error Bars:** Suggest a significant difference between data sets.



SCALE OF ERROR BARS, EXPLAINED



Understanding Chi-Square in Biology

Chi-square (χ^2) is a statistical test used to determine if there is a significant difference between observed and expected values in categorical data. Chi-square compares the observed data to what we would expect to find if there were no difference. It helps us understand whether the deviations we see are due to chance or if there is another factor at play.

Steps to Perform a Chi-Square Test:

1. State the Hypothesis:

- **Null Hypothesis (H_0):** There is no significant difference between the observed and expected frequencies. Any deviation is due to random chance.
- **Alternative Hypothesis (H_1):** There is a significant difference between the observed and expected frequencies.

2. Calculate Expected Frequencies:

- Determine the expected frequencies based on your hypothesis.

3. Calculate Chi-Square Value:

- Use the formula:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Key:

χ^2 = Chi-square, the test statistic

Σ = Sum

O = Number of Observed frequencies recorded

E = Expected frequencies

4. Determine Degrees of Freedom (df):

- Degrees of freedom is the number of categories minus one.

5. Compare to Chi-Square Distribution:

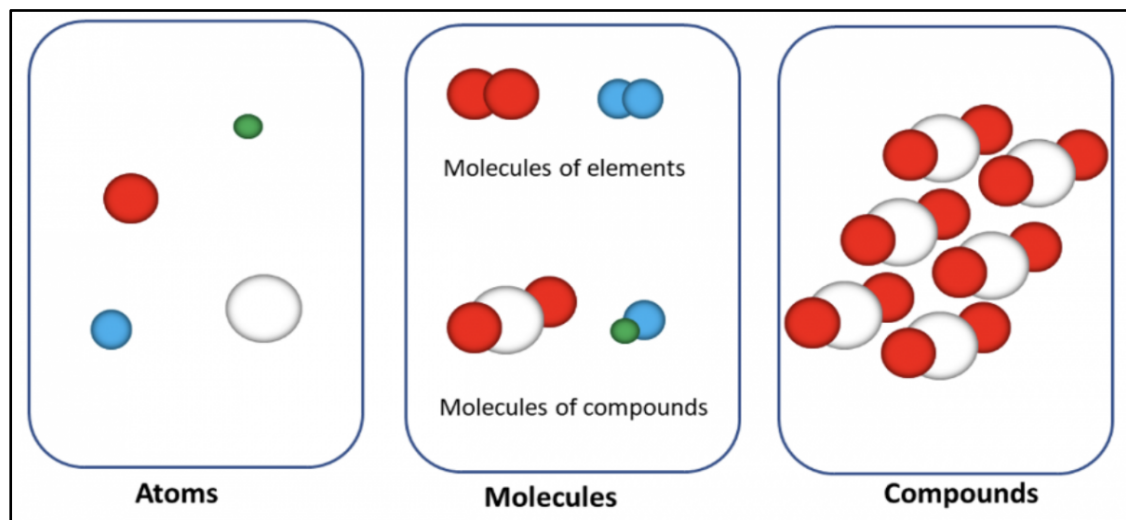
- Use a chi-square distribution table to find the critical value for your degrees of freedom and desired significance level (commonly 0.05).
- If your calculated chi-square value is greater than the critical value from the table, you reject the null hypothesis.

Topic #3: Chemistry Review

Chemistry Review

Matter, Elements, and Compounds

- **Matter:** Anything that takes up space and has mass. All living and nonliving things are made of matter.
- **Element:** A pure substance that cannot be broken down into simpler substances by chemical means. Each element is made up of one kind of atom.
- **Compound:** A substance formed when two or more different elements combine in a fixed ratio. Compounds have properties different from the individual elements that make them up.



Essential vs. Trace Elements

- **Essential Elements:** Elements that organisms need in large amounts to survive. Examples include carbon (C), hydrogen (H), oxygen (O), and nitrogen (N), which make up 96% of living matter.
- **Trace Elements:** Elements required by organisms in minute quantities. Examples include iron (Fe), iodine (I), and zinc (Zn).

Reading the Periodic Table

The periodic table organizes elements based on their properties.

- **Atomic Number:** The number of protons in the nucleus of an atom. It defines the element.
- **Atomic Mass:** The average mass of an element's atoms, usually expressed in atomic mass units (amu).
- **Groups:** Vertical columns that indicate elements with similar chemical properties.
- **Periods:** Horizontal rows that indicate the number of electron shells in the atoms of the elements.

Atomic number → 8

→ Element symbol O

Element name → Oxygen

15.999 → Atomic weight

1

H

Hydrogen

Nonmetal

3

Li

Lithium

Alkali Metal

4

Be

Beryllium

Alkaline E...

11

Na

Sodium

Alkali Metal

12

Mg

Magnesium

Alkaline E...

19

K

Potassium

Alkali Metal

20

Ca

Calcium

Alkaline E...

21

Sc

Scandium

Transition ...

22

Ti

Titanium

Transition ...

23

V

Vanadium

Transition ...

24

Cr

Chromium

Transition ...

25

Mn

Manganese

Transition ...

26

Fe

Iron

Transition ...

27

Co

Cobalt

Transition ...

28

Ni

Nickel

Transition ...

29

Cu

Copper

Transition ...

30

Zn

Zinc

Transition ...

31

Ga

Gallium

Post-Tran...

32

Ge

Germanium

Metalloid

33

As

Arsenic

Metalloid

34

Se

Selenium

Nonmetal

35

Br

Bromine

Halogen

36

Kr

Krypton

Noble Gas

37

Rb

Rubidium

Alkali Metal

38

Sr

Strontium

Alkaline E...

39

Y

Yttrium

Transition ...

40

Zr

Zirconium

Transition ...

41

Nb

Niobium

Transition ...

42

Mo

Molybden...

Transition ...

43

Tc

Technetium

Transition ...

44

Ru

Ruthenium

Transition ...

45

Rh

Rhodium

Transition ...

46

Pd

Palladium

Transition ...

47

Ag

Silver

Transition ...

48

Cd

Cadmium

Transition ...

49

In

Indium

Post-Tran...

50

Sn

Tin

Post-Tran...

51

Sb

Antimony

Metalloid

52

Te

Tellurium

Metalloid

53

I

Iodine

Halogen

54

Xe

Xenon

Noble Gas

55

Cs

Cesium

Alkali Metal

56

Ba

Barium

Alkaline E...

72

Hf

Hafnium

Transition ...

73

Ta

Tantalum

Transition ...

74

W

Tungsten

Transition ...

75

Re

Rhenium

Transition ...

76

Os

Osmium

Transition ...

77

Ir

Iridium

Transition ...

78

Pt

Platinum

Transition ...

79

Au

Gold

Transition ...

80

Hg

Mercury

Transition ...

81

Tl

Thallium

Post-Tran...

82

Pb

Lead

Post-Tran...

83

Bi

Bismuth

Post-Tran...

84

Po

Polonium

Metalloid

85

At

Astatine

Halogen

86

Rn

Radon

Noble Gas

87

Fr

Francium

Alkali Metal

88

Ra

Radium

Alkaline E...

104

Rf

Rutherford...

Transition ...

105

Db

Dubnium

Transition ...

106

Sg

Seaborgium

Transition ...

107

Bh

Bohrium

Transition ...

108

Hs

Hassium

Transition ...

109

Mt

Meitnerium

Transition ...

110

Ds

Darmstadt...

Transition ...

111

Rg

Roentgeni...

Transition ...

112

Cn

Copernici...

Transition ...

113

Nh

Nihonium

Post-Tran...

114

Fl

Flerovium

Post-Tran...

115

Mc

Moscovium

Post-Tran...

116

Lv

Livermorium

Post-Tran...

117

Ts

Tennessee

Halogen

118

Og

Oganesson

Noble Gas

57

La

Lanthanum

Lanthanide

58

Ce

Cerium

Lanthanide

59

Pr

Praseody...

Lanthanide

60

Nd

Neodymium

Lanthanide

61

Pm

Promethium

Lanthanide

62

Sm

Samarium

Lanthanide

63

Eu

Europium

Lanthanide

64

Gd

Gadolinium

Lanthanide

65

Tb

Terbium

Lanthanide

66

Dy

Dysprosium

Lanthanide

67

Ho

Holmium

Lanthanide

68

Er

Erbium

Lanthanide

69

Tm

Thulium

Lanthanide

70

Yb

Ytterbium

Lanthanide

71

Lu

Lutetium

Lanthanide

89

Ac

Actinium

Actinide

90

Th

Thorium

Actinide

91

Pa

Protactini...

Actinide

92

U

Uranium

Actinide

93

Np

Neptunium

Actinide

94

Pu

Plutonium

Actinide

95

Am

Americium

Actinide

96

Cm

Curium

Actinide

97

Bk

Berkelium

Actinide

98

Cf

Californium

Actinide

99

Es

Einsteinium

Actinide

100

Fm

Fermium

Actinide

101

Md

Mendelevi...

Actinide

102

No

Nobelium

Actinide

103

Lr

Lawrencium

Actinide

Chemical Property/Group

Chemical Group Block

1

H

Hydrogen

Nonmetal

Atomic Number

Symbol

Name

Chemical Group Block

5

B

Boron

Metalloid

6

C

Carbon

Nonmetal

7

N

Nitrogen

Nonmetal

8

O

Oxygen

Nonmetal

9

F

Fluorine

Halogen

10

Ne

Neon

Noble Gas

13

Al

Aluminum

Post-Tran...

14

Si

Silicon

Metalloid

15

P

Phosphorus

Nonmetal

16

S

Sulfur

Nonmetal

17

Cl

Chlorine

Halogen

18

Ar

Argon

Noble Gas

19

K

Potassium

Alkali Metal

20

Ca

Calcium

Alkaline E...

21

Sc

Scandium

Transition ...

22

Ti

Titanium

Transition ...

23

V

Vanadium

Transition ...

24

Cr

Chromium

Transition ...

25

Mn

Manganese

Transition ...

26

Fe

Iron

Transition ...

27

Co

Cobalt

Transition ...

28

Ni

Nickel

Transition ...

29

Cu

Copper

Transition ...

30

Zn

Zinc

Transition ...

31

Ga

Gallium

Post-Tran...

32

Ge

Germanium

Metalloid

33

As

Arsenic

Metalloid

34

Se

Selenium

Nonmetal

35

Br

Bromine

Halogen

36

Kr

Krypton

Noble Gas

37

Rb

Rubidium

Alkali Metal

38

Sr

Strontium

Alkaline E...

39

Y

Yttrium

Transition ...

40

Zr

Zirconium

Transition ...

41

Nb

Niobium

Transition ...

42

Mo

Molybden...

Transition ...

43

Tc

Technetium

Transition ...

44

Ru

Ruthenium

Transition ...

45

Rh

Rhodium

Transition ...

46

Pd

Palladium

Transition ...

47

Ag

Silver

Transition ...

48

Cd

Cadmium

Transition ...

49

In

Indium

Post-Tran...

50

Sn

Tin

Post-Tran...

51

Sb

Antimony

Metalloid

52

Te

Tellurium

Metalloid

53

I

Iodine

Halogen

54

Xe

Xenon

Noble Gas

55

Cs

Cesium

Alkali Metal

56

Ba

Barium

Alkaline E...

72

Hf

Hafnium

Transition ...

73

Ta

Tantalum

Transition ...

74

W

Tungsten

Transition ...

75

Re

Rhenium

Transition ...

76

Os

Osmium

Transition ...

77

Ir

Iridium

Transition ...

78

Pt

Platinum

Transition ...

79

Au

Gold

Transition ...

80

Hg

Mercury

Transition ...

81

Tl

Thallium

Post-Tran...

82

Pb

Lead

Post-Tran...

83

Bi

Bismuth

Post-Tran...

84

Po

Polonium

Metalloid

85

At

Astatine

Halogen

86

Rn

Radon

Noble Gas

87

Fr

Francium

Alkali Metal

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Rutherford...

Transition ...

105

Db

Dubnium

Transition ...

106

Sg

Seaborgium

Transition ...

107

Bh

Bohrium

Transition ...

108

Hs

Hassium

Transition ...

109

Mt

Meitnerium

Transition ...

110

Ds

Darmstadt...

Transition ...

111

Rg

Roentgeni...

Transition ...

112

Cn

Copernici...

Transition ...

113

Nh

Nihonium

Post-Tran...

114

Fl

Flerovium

Post-Tran...

115

Mc

Moscovium

Post-Tran...

116

Lv

Livermorium

Post-Tran...

117

Ts

Tennessee

Halogen

118

Og

Oganesson

Noble Gas

57

La

Lanthanum

Lanthanide

58

Ce

Cerium

Lanthanide

59

Pr

Praseody...

Lanthanide

60

Nd

Neodymium

Lanthanide

61

Pm

Promethium

Lanthanide

62

Sm

Samarium

Lanthanide

63

Eu

Europium

Lanthanide

64

Gd

Gadolinium

Lanthanide

65

Tb

Terbium

Lanthanide

66

Dy

Dysprosium

Lanthanide

67

Ho

Holmium

Lanthanide

68

Er

Erbium

Lanthanide

69

Tm

Thulium

Lanthanide

70

Yb

Ytterbium

Lanthanide

71

Lu

Lutetium

Lanthanide

89

Ac

Actinium

Actinide

90

Th

Thorium

Actinide

91

Pa

Protactini...

Actinide

92

U

Uranium

Actinide

93

Np

Neptunium

Actinide

94

Pu

Plutonium

Actinide

95

Am

Americium

Actinide

96

Cm

Curium

Actinide

97

Bk

Berkelium

Actinide

98

Cf

Californium

Actinide

99

Es

Einsteinium

Actinide

100

Fm

Fermium

Actinide

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Md

Mendelevi...

Actinide

102

No

Nobelium

Actinide

103

Lr

Lawrencium

Actinide

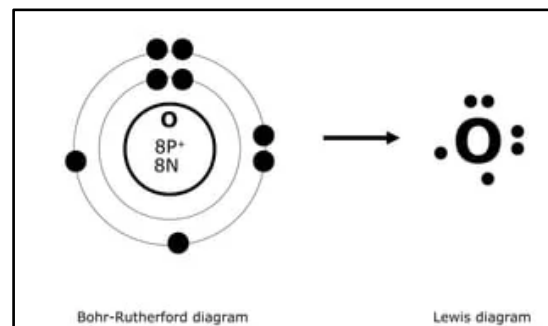
LIST OF ELEMENTS W/CHEMICAL GROUP BLOCK

PRINTABLE IMAGE (PNG) OR PDF OF THE PERIODIC TABLE

Atomic Models

Bohr Model

- Represents electrons orbiting the nucleus in fixed energy levels or shells.
- Useful for understanding the arrangement of electrons in atoms and predicting how atoms interact in chemical reactions.

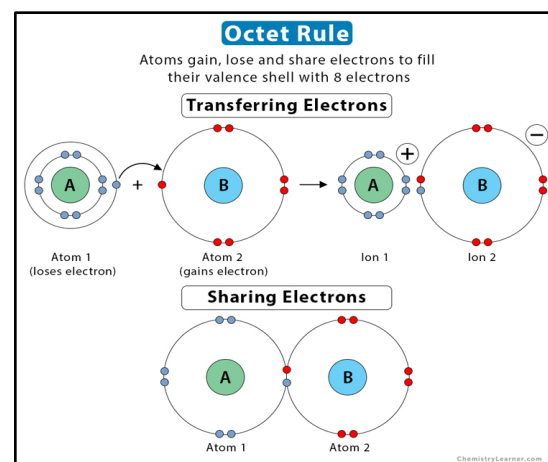


Lewis Dot Model

- Represents valence electrons as dots around the chemical symbol of an element.
- Useful for visualizing bonding between atoms and the formation of molecules.

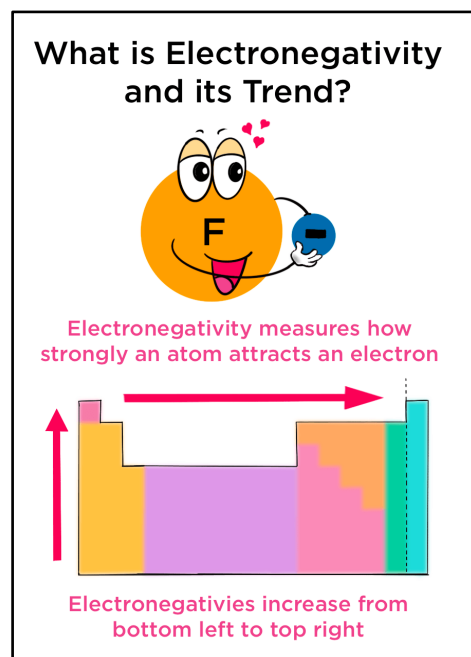
The Octet Rule

- Atoms tend to gain, lose, or share electrons to have a full outer shell of 8 electrons, achieving stability similar to the noble gases.



Electronegativity

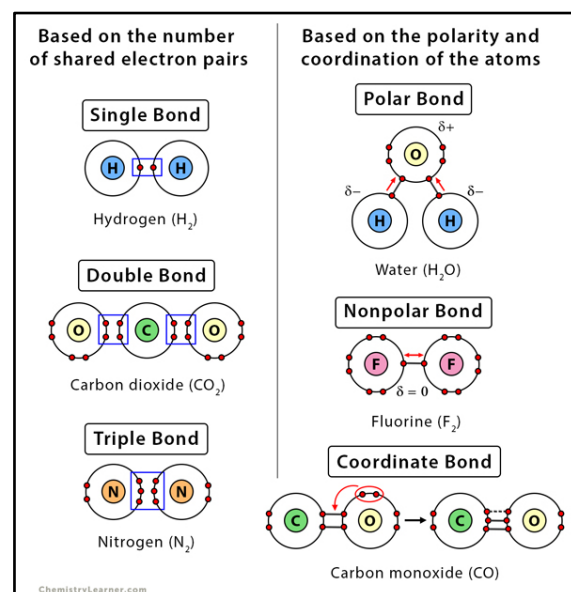
- A measure of an atom's ability to attract and hold electrons in a chemical bond.
- Elements with high electronegativity, like fluorine, attract electrons more strongly.
- Electronegativity increases moving from left to right on the periodic table.



Types of Chemical Bonds

Covalent Bonds

- **Nonpolar Covalent Bonds:** Electrons are shared equally between atoms (e.g., H_2 , O_2).
- **Polar Covalent Bonds:** Electrons are shared unequally (due to one of the atoms being more electronegative), leading to partial charges on atoms (e.g., H_2O).
- **Single Bonds:** One pair of electrons shared (e.g., $\text{H}-\text{H}$).
- **Double Bonds:** Two pairs of electrons shared (e.g., $\text{O}=\text{O}$).
- **Triple Bonds:** Three pairs of electrons shared (e.g., $\text{N}\equiv\text{N}$).

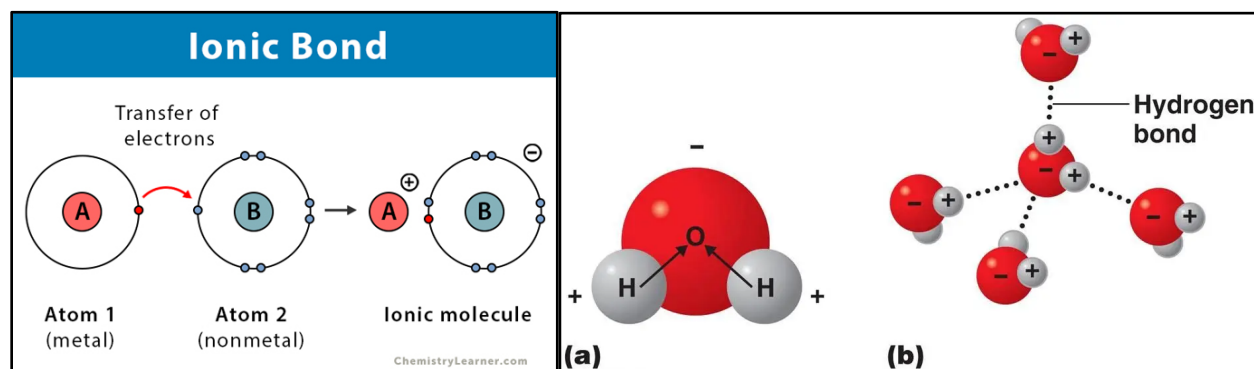


Ionic Bonds

- Formed when one atom donates an electron to another atom, creating positively charged cations and negatively charged anions that attract each other (e.g., NaCl).

Hydrogen Bonds

- Weak bonds between a hydrogen atom in one molecule and an electronegative atom (like oxygen or nitrogen) in another molecule (e.g., the bonds between water molecules).



Acids, Bases, and pH

Understanding acids, bases, and pH is fundamental to many processes in biology. From enzyme function to cellular respiration, the concepts of acidity and alkalinity play crucial roles in the chemistry of life.

What are Acids and Bases?

Acids are substances that increase the concentration of hydrogen ions (H^+) in a solution. They donate protons (H^+ ions) when dissolved in water.

- Examples: Hydrochloric acid (HCl), sulfuric acid (H_2SO_4), citric acid (found in citrus fruits).

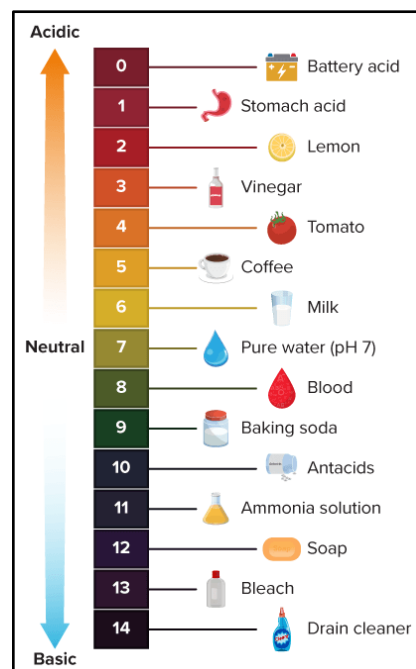
Bases are substances that reduce the concentration of hydrogen ions in a solution. They accept protons or produce hydroxide ions (OH^-) when dissolved in water.

- Examples: Sodium hydroxide ($NaOH$), ammonia (NH_3), baking soda (sodium bicarbonate, $NaHCO_3$).

The pH Scale

The pH scale measures the acidity or alkalinity of a solution. It ranges from 0 to 14:

- **pH 7:** Neutral (pure water)
- **pH < 7:** Acidic (more H^+ ions)
- **pH > 7:** Basic (more OH^- ions)



Importance of pH in Biology

- **Enzyme Activity:** Enzymes, which are proteins that catalyze biochemical reactions, have an optimal pH range in which they function most efficiently. Deviations from this range can denature enzymes, reducing their activity.
- **Cellular Processes:** Cellular respiration and photosynthesis involve reactions that are pH dependent.
- **Homeostasis:** Organisms maintain a stable internal pH through buffers, which are substances that minimize changes in pH by absorbing or releasing H^+ or OH^- ions.

Buffers

Buffers are crucial in biological systems to maintain a stable pH. They are mixtures of weak acids and their corresponding bases (or weak bases and their corresponding acids).

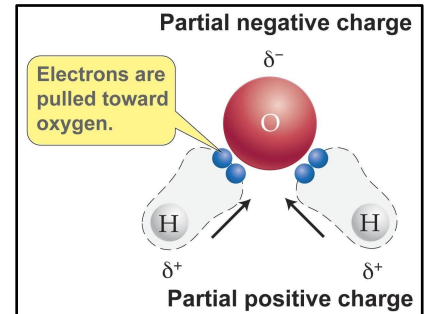
- Example: The bicarbonate buffer system in human blood helps maintain a pH around 7.4.

Topic #4: Properties of Water

Water is a vital molecule for all life forms due to its unique properties that arise from its molecular structure and hydrogen bonding. Understanding these properties helps explain how water supports life and biological processes.

Property #1: Polarity

Water (H_2O) is a polar molecule. This means it has a partial positive charge on the hydrogen atoms and a partial negative charge on the oxygen atom. The polarity of water is due to the difference in electronegativity between oxygen and hydrogen. This polarity allows water molecules to form hydrogen bonds with each other and with other polar substances, giving rise to many of its unique properties.

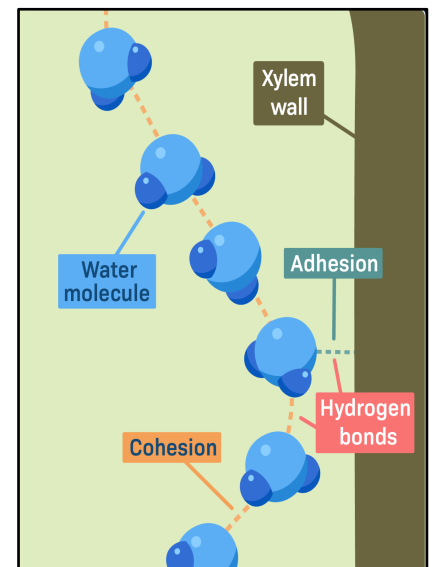


Property #2: Cohesion and Adhesion

- **Cohesion:** The attraction between water molecules due to hydrogen bonding. This property causes water molecules to stick together, leading to phenomena such as surface tension. Surface tension allows small insects to walk on water and drops of water to form beads on surfaces.
- **Adhesion:** The attraction between water molecules and other types of molecules. This property helps water cling to plant cell walls, which is crucial for water transport in plants.

Function in Plants

Cohesion and adhesion work together to facilitate water transport from the roots to the leaves through the xylem in a process known as transpiration. Water molecules stick together (cohesion) and to the walls of the xylem (adhesion), creating a continuous column of water that moves upward against gravity.

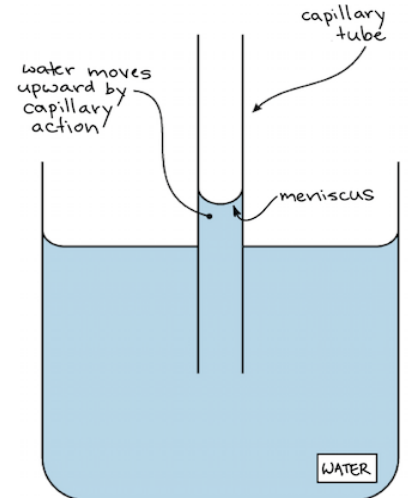


Property #3: Capillary Action

Capillary action is the ability of water to flow in narrow spaces without the assistance of external forces. This is due to the combined effects of cohesion and adhesion.

Function in Plants

Capillary action helps draw water up from the roots through the tiny vessels in the plant stem and into the leaves. It is essential for transporting water and dissolved nutrients from the soil to the entire plant.



Property #4: Temperature Control

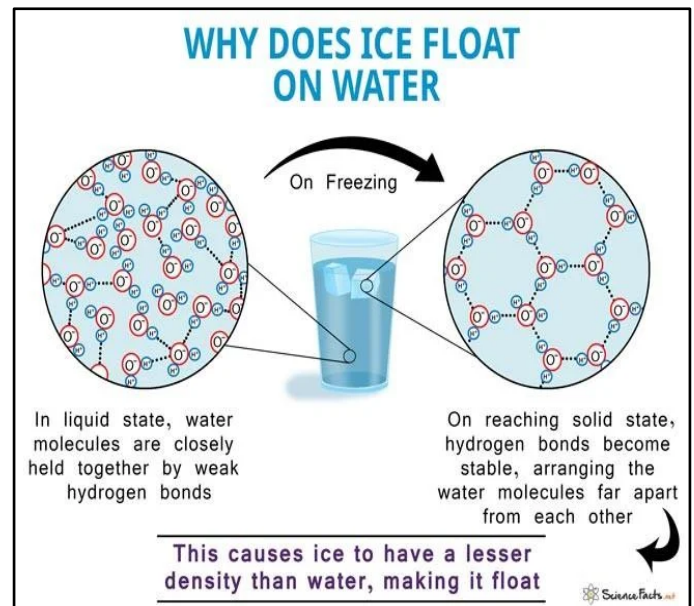
Water has a high specific heat, which means it can absorb a lot of heat without a significant increase in temperature. This property helps moderate Earth's climate and maintain stable temperatures in organisms.

- **High Specific Heat:** Water can absorb or release large amounts of heat with only a slight change in its own temperature. This property is important for maintaining homeostasis in living organisms.
- **Evaporative Cooling:** When water evaporates, it takes heat away from the surface, cooling the organism. This process helps regulate temperature in animals and humans through sweating and in plants through transpiration.

Property #5: Density

Water is unique because its solid form (ice) is less dense than its liquid form. This is due to the hydrogen bonds forming a crystalline structure in ice, keeping the molecules further apart than in liquid water.

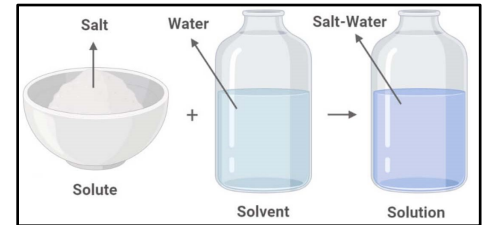
- **Importance:** The lower density of ice causes it to float on liquid water, insulating the water below and providing a habitat for aquatic life during cold seasons.



Property #6: Water as a Solvent

Water is often called the "universal solvent" because it can dissolve a wide variety of substances. This property is crucial for many biological processes.

- **Solvent:** The substance that dissolves other substances (solute) to form a solution.
- **Solute:** The substance that is dissolved in a solvent.
- **Solution:** A homogeneous mixture of solvent and solute.



Water's polarity allows it to dissolve ionic compounds (like salt) and polar molecules (like sugar). This capability is essential for transporting nutrients, gases, and waste products in biological organisms.

Topic #5: Elements of Life

Life on Earth is fundamentally built from a variety of chemical compounds, broadly classified into **organic** and **inorganic** compounds. The study of these compounds, particularly the role of carbon, is essential for understanding the molecular basis of life.

Organic vs. Inorganic Compounds

Organic Compounds

- **Definition:** Organic compounds are primarily composed of carbon atoms bonded to hydrogen, oxygen, nitrogen, and other elements.
- **Characteristics:** They are typically found in living organisms and include carbohydrates, lipids, proteins, and nucleic acids.
- **Examples:** Glucose ($C_6H_{12}O_6$), DNA, proteins, and fats.

Inorganic Compounds

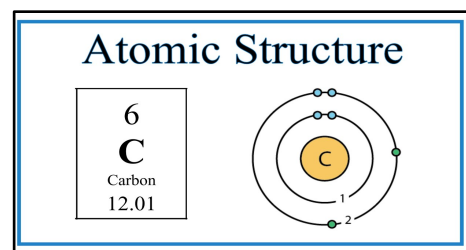
- **Definition:** Inorganic compounds do not primarily consist of carbon-hydrogen bonds. They include minerals, salts, and water.
- **Characteristics:** They are usually found in non-living systems but are also vital to life processes.
- **Examples:** Water (H_2O), carbon dioxide (CO_2), and sodium chloride ($NaCl$).

The Versatility of Carbon

Carbon's Unique Properties

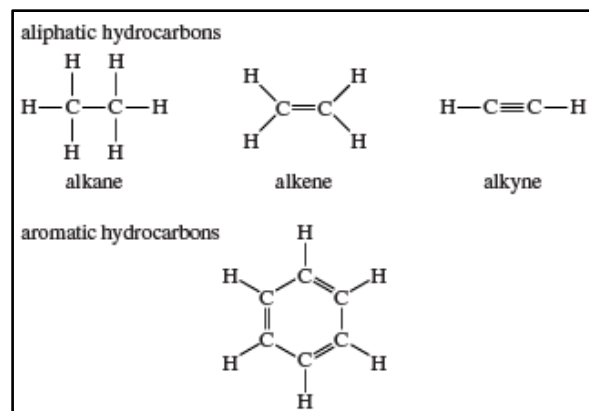
Carbon is unparalleled in its ability to form diverse and stable compounds, making it the backbone of organic chemistry.

- **Tetravalency:** Carbon has four valence electrons, allowing it to form four covalent bonds with other atoms, leading to a variety of complex molecules.
- **Bonding Capacity:** Carbon can form single, double, and triple bonds, creating a range of molecular structures.
- **Catenation:** Carbon can bond with other carbon atoms to form long chains and rings, essential for creating complex organic molecules.



Hydrocarbon Chains

- **Definition:** Hydrocarbons are organic molecules consisting entirely of carbon and hydrogen.
- **Types of hydrocarbon chains:** Carbon can form single, double, or triple bonds. The length of the hydrocarbon chain affects the shape of the molecule.
- **Importance:** Hydrocarbons serve as the foundation for more complex molecules and are major components of lipids and fuels.



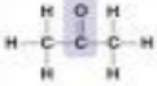
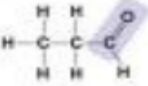
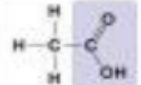
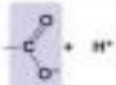
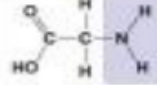
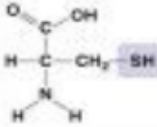
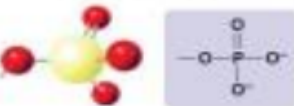
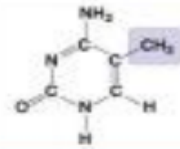
Importance of Carbon in Living Systems

- **Biological Molecules:** Carbon's versatility allows it to form the diverse array of molecules necessary for life, including carbohydrates, lipids, proteins, and nucleic acids.
- **Energy Storage:** Carbon-based compounds like glucose and fatty acids store and provide energy for cellular processes.
- **Structural Roles:** Carbon compounds form the structural framework of cells and tissues, such as cellulose in plants and collagen in animals.

Functional Groups

Functional groups are specific groups of atoms within molecules that have characteristic properties and chemical reactivity. They are responsible for the diverse chemical behaviors of organic molecules.

Memorize these functional groups:

Chemical Group	Compound Name	Examples
Hydroxyl group (—OH) 	Alcohol	 Ethanol
Carbonyl group ($>\text{C=O}$) 	Ketone Aldehyde	 Acetone  Propanal
Carboxyl group (—COOH) 	Carboxylic acid, or organic acid	 Acetic acid $\rightleftharpoons$  $+ \text{H}^+$
Amino group (—NH_2) 	Amine	 $+ \text{H}^+ \rightleftharpoons$  Glycine
Sulfhydryl group (—SH) 	Thiol	 Cysteine
Phosphate group (—OPO_3^{2-}) 	Organic phosphate	 Glycerol phosphate
Methyl group (—CH_3) 	Methylated compound	 5-Methyl cytosine

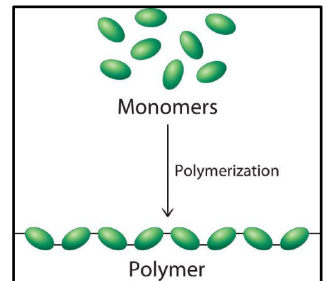
Topic #6: Biological Macromolecules

Biological **macromolecules** are large, complex molecules essential for life. They are involved in virtually every cellular process and are critical for structure, function, and regulation of the body's tissues and organs. The four main classes of biological macromolecules are *carbohydrates*, *proteins*, *nucleic acids*, and *lipids*. Each class has unique structures and functions, playing vital roles in biological systems.

Monomers and Polymers

Monomers

Monomers (mono = one) are small, basic molecular units that can join together to form polymers. Examples include glucose (a monomer of carbohydrates), amino acids (monomers of proteins), nucleotides (monomers of nucleic acids), and fatty acids (components of lipids).

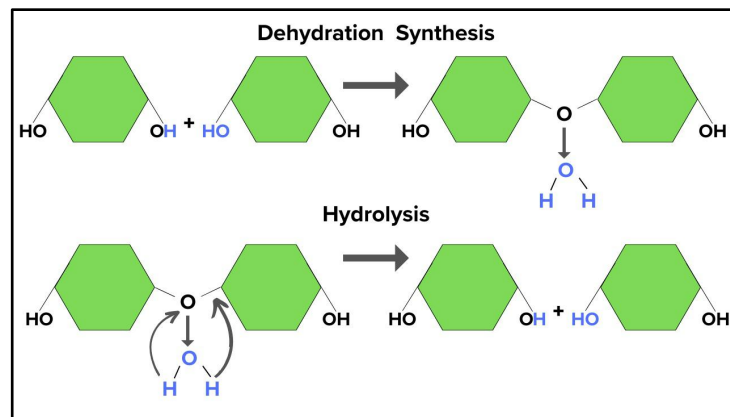


Polymers

Polymers (poly = many) are large molecules composed of repeating monomer units. These macromolecules are formed through dehydration synthesis reactions, where monomers are bonded together by the removal of water.

Dehydration Reaction vs. Hydrolysis

- **Dehydration Reaction:** A chemical reaction where two molecules are covalently bonded with the loss of a water molecule. This process forms polymers from monomers.
- **Hydrolysis:** The reverse of dehydration synthesis, where water is added to break the bonds between monomers, breaking down polymers into monomers.

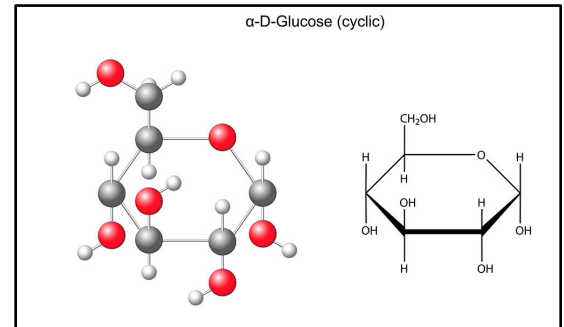


Carbohydrates

Carbohydrates are organic molecules composed of carbon, hydrogen, and oxygen, usually in a 1:2:1 ratio. They function as the body's main source of energy and fuel and also make up structural materials. When you eat carbohydrates, your body breaks them down into simple sugars, which are absorbed into your bloodstream as glucose (blood sugar). Eventually, that glucose can be used by cells as energy, or stored away for later use. Depending on how big the carbohydrates are, they can be classified as monosaccharides, disaccharides, or polysaccharides, and have various functions.

Monosaccharides (*mono-* = one)

- **Definition:** The simplest form of carbohydrates, consisting of single sugar molecules.
- **Examples:** Glucose, fructose, and galactose.

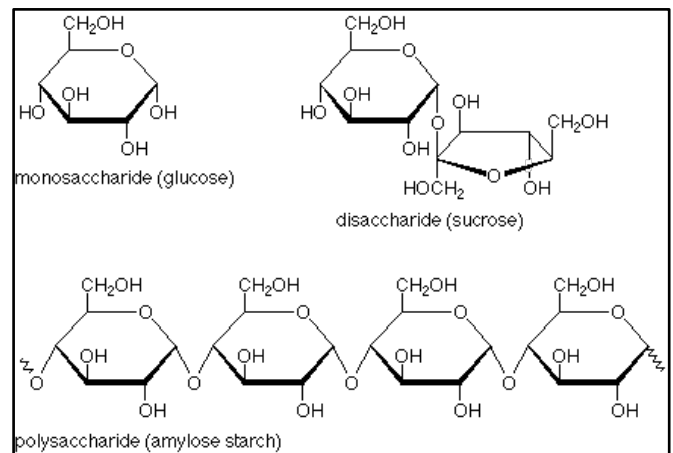


Disaccharides (*di-* = two)

- **Definition:** Formed by the joining of two monosaccharides through a dehydration reaction.
- **Examples:** Sucrose (glucose + fructose), lactose (glucose + galactose), and maltose (glucose + glucose).

Polysaccharides (*poly-* = many)

- **Definition:** Long chains of monosaccharide units bonded together.
- **Types:**
 - **Storage Polysaccharides:**
 - **Starch:** The storage form of glucose in plants.
 - **Glycogen:** The storage form of glucose in animals.
 - **Structural Polysaccharides:**
 - **Cellulose:** A major component of plant cell walls, providing structural support.
 - **Chitin:** Found in the exoskeletons of arthropods and the cell walls of fungi.

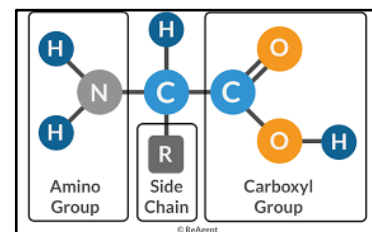


Proteins

Proteins are complex molecules made up of amino acids linked by peptide bonds. They perform a vast array of functions within organisms.

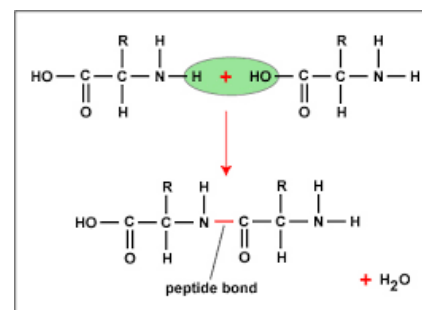
Amino Acids

- **What are amino acids?** Amino acids are the building blocks of proteins. There are 20 different amino acids commonly found in proteins.
 - **Essential** amino acids cannot be synthesized by the human body and must be obtained through the diet. There are 9 essential amino acids.
 - **Nonessential** amino acids, on the other hand, can be synthesized by the body.
- **General Structure:** An amino group (NH_2), a carboxyl group (COOH), a hydrogen atom, and an R group (side chain) attached to a central carbon atom.
- **Side Chains:** Determine the properties and functions of amino acids.
 - **Nonpolar:** Hydrophobic (water-fearing; think of what "phobia" means), found in the interior of proteins, where they don't have to interact with water.
 - **Polar:** Hydrophilic (water-loving), found on the exterior of proteins, where they can interact with water.
 - **Charged:** Can be positively or negatively charged, important for protein interactions.



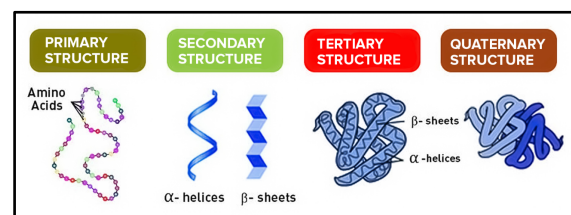
Peptide Bonds and Polypeptides

- **Peptide Bonds:** Formed by dehydration reactions between the amino group of one amino acid and the carboxyl group of another.
- **Polypeptides:** Long chains of amino acids. Proteins are made of one or more polypeptides.



Protein Structure

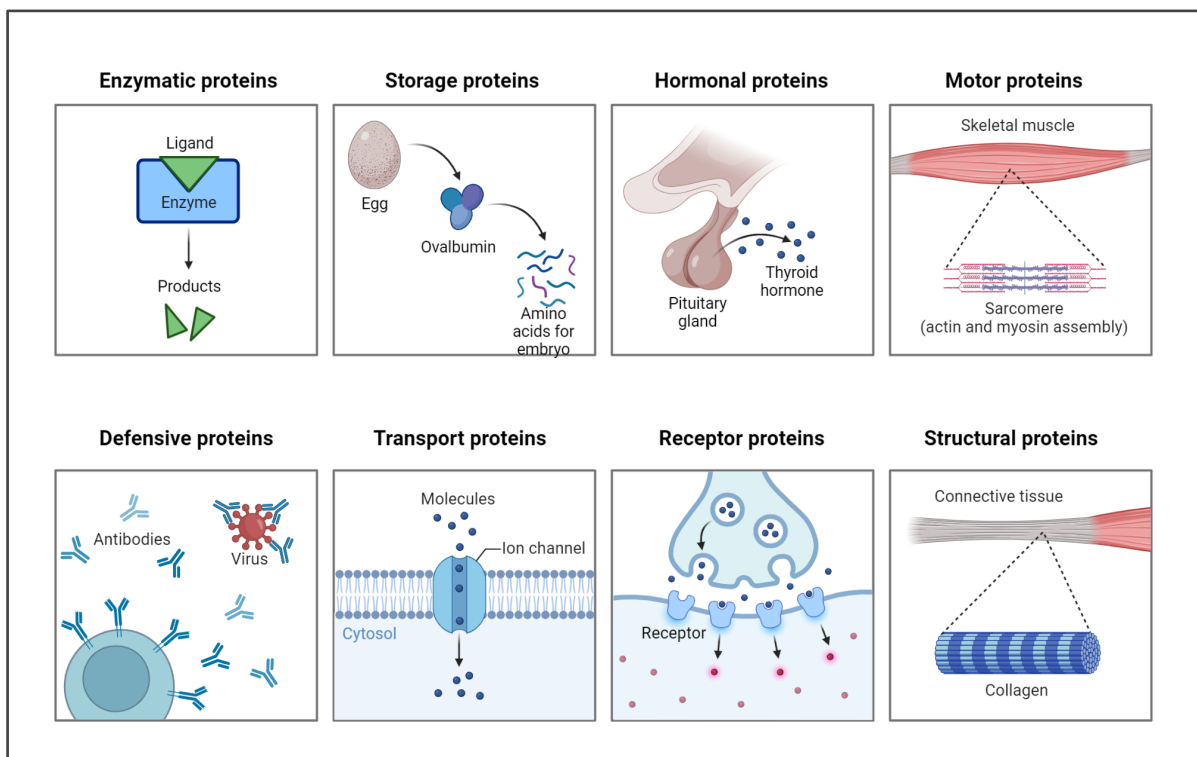
1. **Primary Structure:** The sequence of amino acids in a polypeptide chain.



2. **Secondary Structure:** Local folding into alpha-helices and beta-sheets stabilized by hydrogen bonds.
3. **Tertiary Structure:** The overall 3D shape of a polypeptide, determined by interactions between R groups.
4. **Quaternary Structure:** The arrangement of multiple polypeptide chains into a functional protein.

Functions of Proteins

- **Antibody:** Defense against pathogens.
- **Enzyme:** Catalysts for biochemical reactions.
- **Messenger:** Hormones and signaling molecules.
- **Structural:** Provide support and shape (e.g., collagen).
- **Transport:** Carry substances (e.g., hemoglobin).

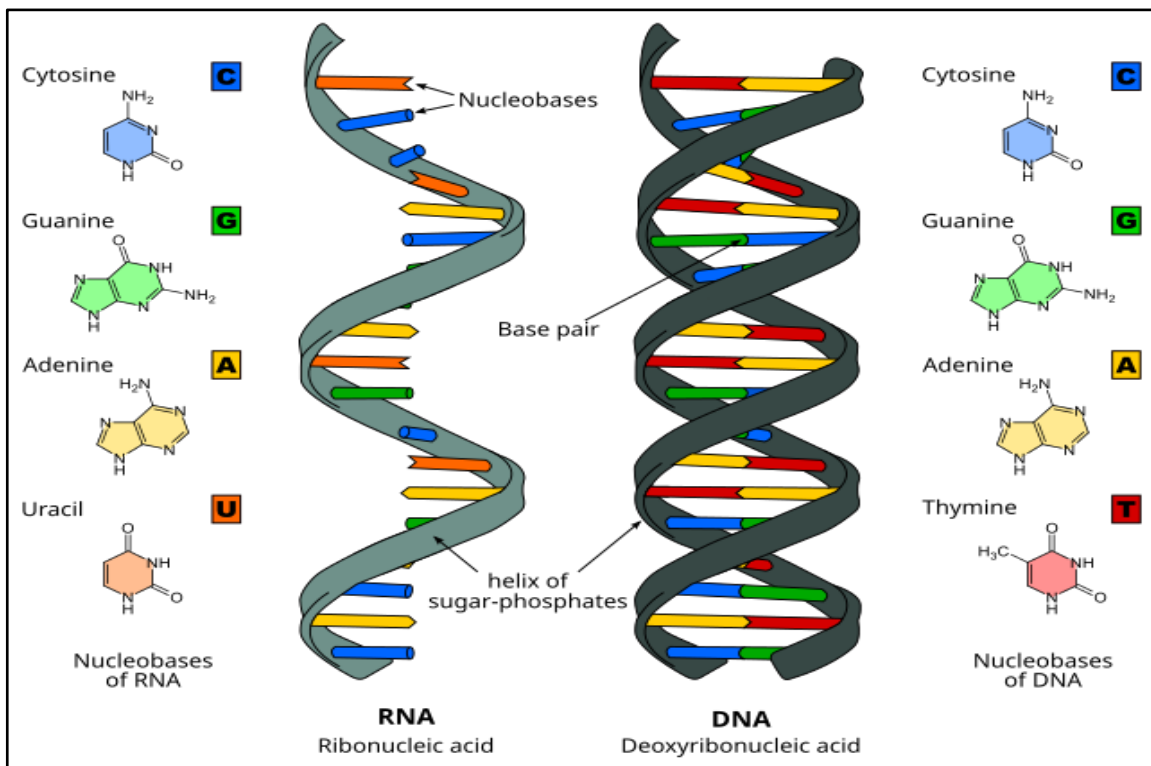


Nucleic Acids

Nucleic acids are macromolecules that store and transmit genetic information. There are two types of nucleic acids: *DNA* and *RNA*. Both of these nucleic acids are made up of monomers called **nucleotides**.

Functions

- **DNA (deoxyribonucleic acid):** Stores genetic information for all living things. Its form is a double-stranded helix.
- **RNA (ribonucleic acid):** Transmits genetic information and helps in protein

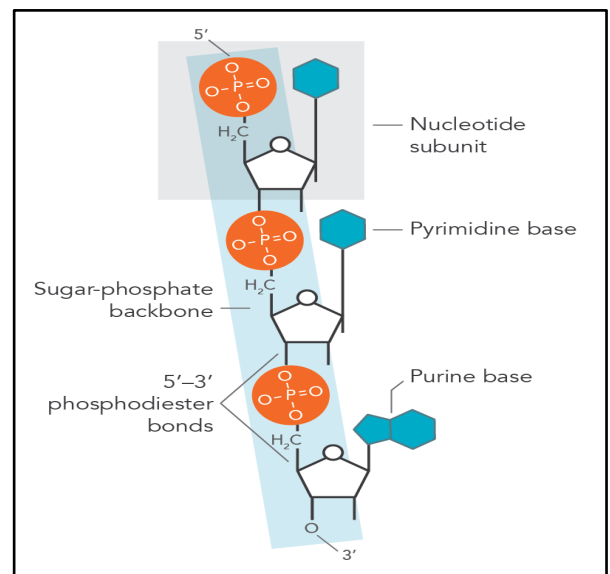
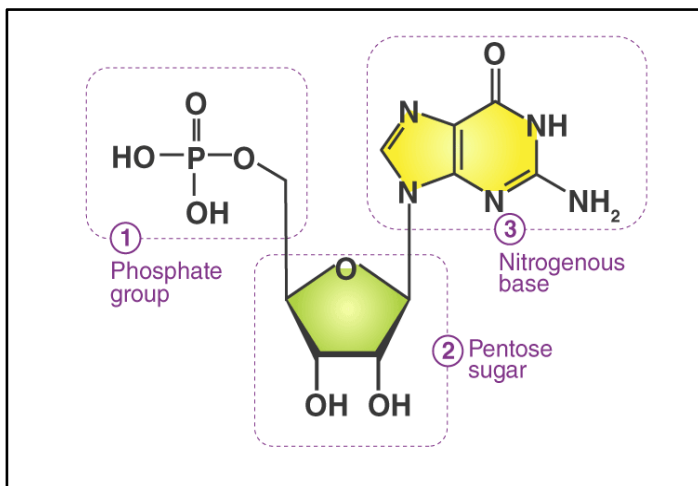


synthesis. Its structure is single-stranded.

Monomers: Nucleotides

- **Parts of a Nucleotide:**

- **Sugar:** Deoxyribose in DNA, ribose in RNA.
- **Phosphate Group:** Links nucleotides together.
- **Nitrogenous Base:** Adenine (A), thymine (T), cytosine (C), guanine (G) in DNA; uracil (U) replaces thymine in RNA. There are two types of nitrogenous bases, pyrimidines and purines.
 - **Pyrimidines:** Single-ring bases (C, T, U).
 - **Purines:** Double-ring bases (A, G).



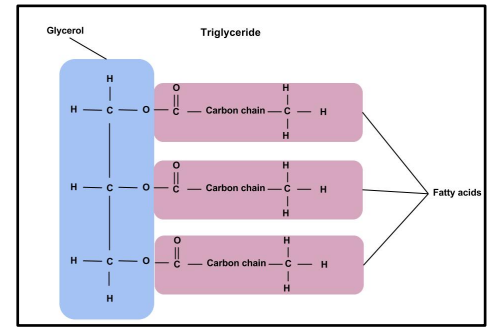
Formation and Structure

- **Phosphodiester Linkages:** Bonds between the phosphate group of one nucleotide and the sugar of another.
- **Directionality:** Nucleic acids have a 5' to 3' direction, important for replication and transcription.
- **Sequence:** The order of nucleotides determines the genetic information.

Lipids

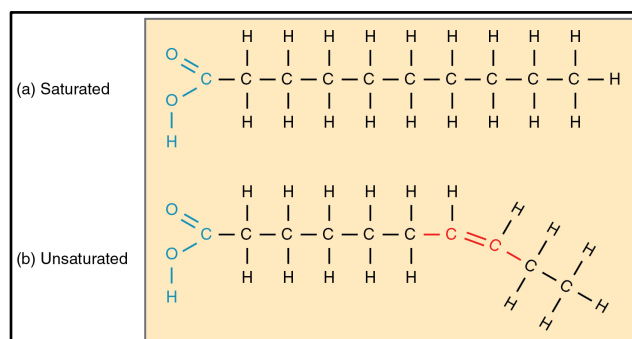
Lipids are *hydrophobic* molecules that play roles in energy storage, membrane structure, and signaling. While there are no true monomers, lipids are made up of two components:

- **Glycerol:** A three-carbon alcohol.
- **Fatty Acids:** Long hydrocarbon chains with a carboxyl group.



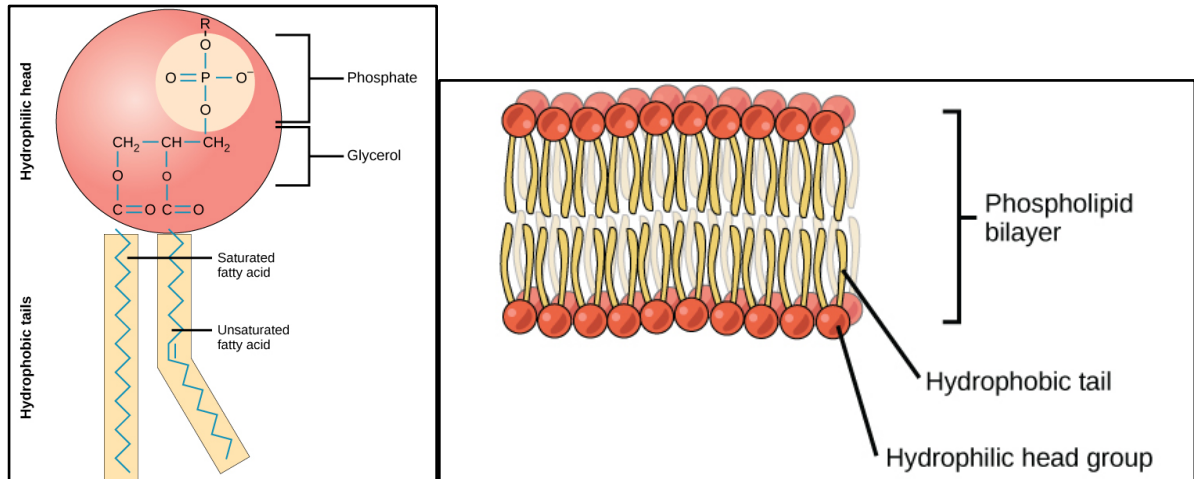
Types of Lipids

- **Fats (Triglycerides):**
 - **Structure:** One glycerol and three fatty acids linked by ester bonds.
 - **Saturated Fats:** No double bonds, solid at room temperature. Found in foods such as butter and coconut oil.
 - **Unsaturated Fats:** One or more double bonds, liquid at room temperature. Found a lot in foods such as olive oil, avocado, nuts/seeds, etc.
 - Sometimes you may hear fats classified as “good” or “bad” fats. Typically, this is what that means:
 - “Good” Fats
 - **Monounsaturated Fats:** Found in olive oil, avocados, and nuts; help reduce bad cholesterol (LDL) and lower heart disease risk.
 - **Polyunsaturated Fats:** Includes omega-3s in fatty fish and flaxseeds; beneficial for heart health and reducing inflammation.
 - “Bad” Fats
 - **Saturated Fats:** Found in animal products and some plant oils; can raise bad cholesterol and increase heart disease risk.
 - **Trans Fats:** Created by hydrogenating oils; found in processed and fried foods; raise bad cholesterol (LDL) and lower good cholesterol (HDL), increasing heart disease risk.



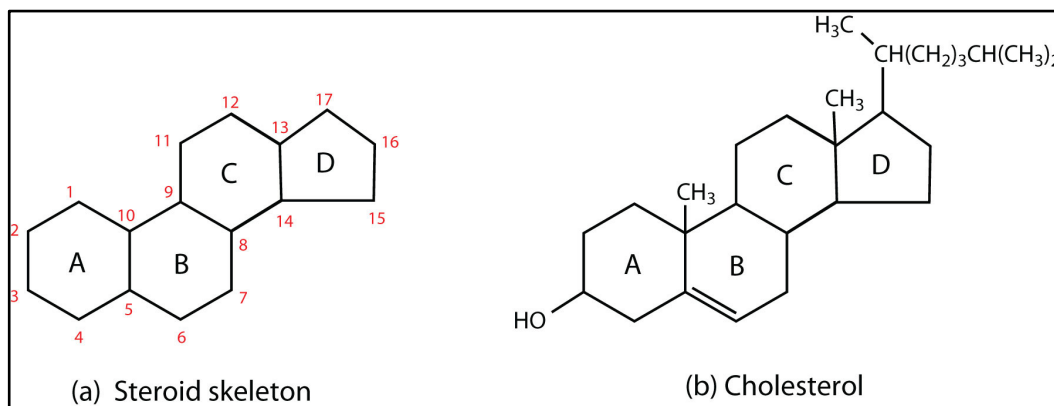
- **Phospholipids:**

- **Structure:** Glycerol, two fatty acids, and a phosphate group.
- **Function:** Form cell membranes with hydrophilic heads facing the exterior and hydrophobic tails facing the interior.



- **Steroids:**

- **Structure:** Four fused carbon rings.
- **Function:** Include hormones like testosterone and cholesterol, a component of cell membranes. Steroids are able to diffuse through the cell membrane, bind to DNA and regulate gene expression.



OPTIONAL: Below is the Unit 1 Study Guide- This is for you to complete if you choose to do so to prepare you for your Unit 1 Test. You are getting this ahead of time.

Topic 1.1: Structure of Water and Hydrogen Bonding

Learning Objective	SYI-1.A Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.
I can...	☐ I can describe a hydrogen bond. ☐ I can explain how two strands of DNA bind to create the double helix. ☐ I can explain ways that R groups affect the structure of a protein. ☐ I can identify the properties of water caused by hydrogen bonds. ☐ I can explain what makes water polar. ☐ I can explain what moves water against gravity up a capillary tube. ☐ I can explain what allows a water strider to walk on water.

1. What is a hydrogen bond?
2. Where are hydrogen bonds found in water?
3. Where are hydrogen bonds found in DNA?
 - a. How many hydrogen bonds are found between each complementary base pairing?
4. What is the structure of an amino acid?
 - a. What are the three options for the R group?
 - b. For each R group option, describe the polarity and justify your response.
5. What are three properties of water?
 - a. How did hydrogen bonding allow for each property?
6. Describe why water is considered a polar molecule?
7. Using the properties of water, describe how water can move up a capillary tube to move from the roots to the leaves in a plant.
8. Using the properties of water, describe how a water strider can walk on water.

Topic 1.2: Elements of Life

Learning Objective	ENE-1.A Describe the composition of macromolecules required by living organisms.
I can...	☐ I can identify the macromolecules required by living organisms. ☐ I can describe the function of proteins in living organisms. ☐ I can describe the function of lipids in living organisms. ☐ I can describe the function of carbohydrates in living organisms. ☐ I can describe the function of nucleic acids in living organisms. ☐ I can describe how the R group affects the folding of a protein. ☐ I can identify the elements found in carbohydrates. ☐ I can identify the elements found in proteins. ☐ I can identify the elements found in nucleic acids. ☐ I can identify the elements found in lipids. ☐ I can describe how macromolecules are formed. ☐ I can describe how macromolecules are broken down. ☐ I can identify which macromolecules contain nitrogen. ☐ I can identify which macromolecules contain phosphorus. ☐ I can identify which macromolecules contain sulfur.

1. What are the four macromolecules?
2. What are the elements found in a carbohydrate?
3. What are three functions of carbohydrates in living organisms?
4. What are the elements found in a protein?
 - a. What are the functional groups found in all amino acids?
5. What are three functions of proteins in living organisms?
6. What are the elements found in nucleic acids?
 - a. What are parts found in all nucleotides?
7. What are three functions of nucleic acids in living organisms?
8. What are the elements found in a lipid?
 - a. How are the three different types of lipids different?
9. What are three functions of lipids in living organisms?
10. Which macromolecule(s) contain nitrogen?
11. Which macromolecule(s) contain phosphorus?
12. Which macromolecule(s) contain sulfur?
13. How does the R group affect the folding of the protein? (include polar and nonpolar R groups)
14. What is dehydration?
 - a. Provide an example of dehydration.
15. What is hydrolysis?
 - a. Provide an example of hydrolysis.

Topic 1.3: Introduction to Biological Macromolecules

Learning Objective	SYI-1.B Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.
I can...	☐ I can describe the process of hydrolysis. ☐ I can describe the process of dehydration. ☐ I can identify the bond between carbohydrate monomers. ☐ I can identify the bond between protein monomers. ☐ I can identify the bond between nucleic acid monomers.

1. What is the hydrolysis?
 - a. Identify inputs and outputs using a specific example.
2. What is the dehydration?
 - a. Identify inputs and outputs using a specific example.
3. What type of bond is found in carbohydrates?
 - a. Specifically, where is this bond located?
4. What type of bond is found between protein monomers?
 - a. Specifically, where is this bond located?
5. What type of bond is found between nucleic acid monomers?
 - a. Specifically, where is this bond located?

Topic 1.4: Properties of Biological Macromolecules

Learning Objective	SY1-1.B Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.
I can...	☐ I can describe the structural components of the monomer of a carbohydrate. ☐ I can describe the structural components of the monomer of a protein. ☐ I can describe the structural components of the monomer of a nucleic acid. ☐ I can describe the structural components of a phospholipid. ☐ I can describe the difference between the bonds of starch and cellulose. ☐ I can describe the structural differences between DNA and RNA. ☐ I can identify an R group as hydrophobic, hydrophilic, or ionic. ☐ I can describe the effect of level of saturation on function of lipids.

- What is the monomer of a carbohydrate?
 - Identify the components of the monomer.
- What is the monomer of a protein?
 - Identify the components of the monomer.
- What is the monomer of a nucleic acid?
 - Identify the components of the monomer.
- Identify the components of a phospholipid.
- Starch vs. Cellulose
 - What type of bond is found in starch?
 - What type of bond is found in cellulose?
 - Which bond can be broken by animals?
- Compare and contrast DNA and RNA using the following chart:

	DNA	RNA
Pentose Sugar		
Nitrogenous Bases		
Strandedness (traditionally)		

- Identify the group as hydrophobic, hydrophilic, or charged?

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- How does a saturated and unsaturated fatty acid differ?
 - How does the level of saturation affect the function of the lipid?

Topic 1.5: Structure and Function of Biological Macromolecules

Learning Objective	SYI-1.C Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.
I can...	☐ I can explain how changes in the subunits of a protein may lead to changes in structure. ☐ I can explain how changes in the subunits of a protein may lead to changes in function. ☐ I can explain how changes in the subunits of a nucleic acid may lead to changes in structure. ☐ I can explain how changes in the subunits of a nucleic acid may lead to changes in function. ☐ I can describe the directionality of a nucleic acid. ☐ I can describe the directionality of a protein. ☐ I can identify the appropriate base pairing based on Chargaff's rules. ☐ I can identify the location of a growing nucleic acid strand. ☐ I can describe the levels of folding found in a protein. ☐ I can describe the structure of carbohydrate polymers. ☐ I can describe the structure of nucleic acid polymers. ☐ I can describe the structure of protein polymers. ☐ I can describe the structure of a fat. ☐ I can describe the structure of a phospholipid. ☐ I can describe the structure of a steroid.

- Describe how a nonpolar to polar R group substitution changes the structure and function of a protein.
- Describe how a cytosine to thymine substitution changes the structure and function of DNA.
 - Note this is a pyrimidine-to-pyrimidine substitution
- Describe how a cytosine to guanine substitution changes the structure and function of DNA.
 - Note this is a pyrimidine-to-purine substitution
- Describe how a deoxyribose to ribose changes the structure and function of a nucleic acid.
- Describe the structure of the nucleic acid polymer.
 - What are the ends called and what is found at each end?
 - Which end is the location of the growing nucleic acid strand?
- What are the complementary base pairings found in nucleic acids?
 - Identify the number of hydrogen bonds found between these two nitrogenous bases.
- Use the following chart to describe the levels of folding found in proteins.

Level of Folding	Description	Types of Bonds
Primary		
Secondary		
Tertiary		
Quaternary		

- What are the ends of a protein called and what is found at each end?
 - Which end is the location of the growing polypeptide strand?
- Describe the structure of a carbohydrate polymer.
- What are the components of a fat molecule?
- What are the components of a phospholipid?
- Describe the structure of a steroid.

Topic 1.6: Nucleic Acid

Learning Objective	IST-1.A Describe the structural similarities and differences between DNA and RNA.
I can...	☐ I can describe the structure of DNA ☐ I can describe the structure of RNA ☐ I can describe the structural similarities between DNA and RNA ☐ I can describe the sugar differences between DNA and RNA ☐ I can describe the nitrogenous base differences between DNA and RNA ☐ I can describe the structural differences between polymers of DNA and RNA ☐ I can describe the structural differences between directionality of DNA and RNA

1. What are the three components of a DNA or RNA molecule?
2. Identify differences between DNA and RNA using the following chart:

	DNA	RNA
Pentose Sugar		
Nitrogenous Base Difference		
Strandedness (traditionally)		
Directionality		