

**CELL**

CENTER OF EXCELLENCE IN  
LEADERSHIP OF LEARNING

UNIVERSITY OF INDIANAPOLIS

# THE LOST ART OF THE PEN: A NOTEBOOK PROTOCOL

**Presenter:**

**Nicholas Boyd**

Secondary Science Educator

Bedford North Lawrence High School

**INDIANA EARLY  
COLLEGE SUMMIT**

## A question to begin:

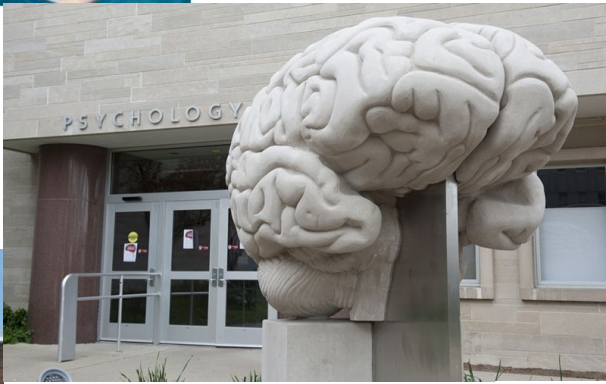
- 1) Get a sticky note (hopefully you have one already!)
- 2) Write down 1 good thing that happened to you this week.
- 3) Write down 1 good thing about students and their note taking.
- 4) Write down 1 thing students have difficulty with while note taking.

# Boyd Science and School Autobiography:



## Robert Goldstone

Distinguished Professor and Chancellor's Professor, Psychological and Brain Sciences  
Fellow, American Academy of Arts and Sciences  
**\*\*Not accepting graduate students for Fall, 2025\*\***



## Cooper Harriss

Associate Professor, Religious Studies  
Adjunct Professor, Folklore and Ethnomusicology  
Adjunct Professor, Comparative Literature





## Laboratory and Chemistry Experience

Teacher: Mr. Nicholas Boyd



# A couple disclosures to begin:

- 1) I don't think there's necessarily a "right" or "wrong" practice when it comes to how students take notes, but these are structures/protocols I use that I've seen really help students.
  - a) Certainly it is dependent on the class, but these are things I have found to help students build their note taking skills.
- 2) I've seen improvements in skills, which I think is just as important as performance. Ultimately, if performance stays level and skill acquisition improves, then it's worth it.

# Where this began:

I had this question that really bothered me in the winter of 2024-2025:

What have people been doing to learn for centuries?

# What I heard people consistently saying:

“Students don’t know how to take notes.”

# What I heard people consistently saying:

Students don't know how to take notes.

So I thought, well, that's probably right, and I agree, so how about I teach them?

# Part 1: What I was doing...

---

I don't think it was all bad, but I just thought...could this be better? How can I better equip students with note taking skills?

# Using things like graphic organizers for students to take reading notes

Thermochemistry: 17.1 Heat Flow

Lesson Vocabulary: *There's a TON of vocab, let's consider a few of them to get started:*

System:

Surroundings:

Open system

Closed system

Exothermic

Endothermic

Specific heat

**Chemical Energy and Heat:** *include 3 main points from this section. (be sure you explain the energy of bonds, also, where are these bonds?)*

# Using powerpoints/slideshows with embedded questions

## Enthalpy Change Case One

- $C_p$  is specific heat *usually* measured in  $\text{J/g}^\circ\text{C}$ .
- $q$  is heat; *usually* in Joules.
- $m$  is mass in grams.
- $\Delta T$  is the change in temperature measured

The specific heat of water is  $4.184 \text{ J/g}^\circ\text{C}$  or  
 $1.000 \text{ cal/g}^\circ\text{C}$ .

INDIANA UNIVERSITY  
Advance College Project

## Checkup 1

A nuclide with 47 protons and 62 neutrons has what nuclide symbol?

How many nucleons does this nuclide have?

# Where to put these?

All of these notes and graphic organizers, daily warm ups, everything would go into a binder.

There was specific organizational practices for the binder, but it wasn't super effective when it came time for students to prepare for tests, quizzes, and laboratories.



# What I wanted students to do:

---

Slow down. Think. Process. Generate their own notes, ideas, drawings, and summaries for in class work, discussions, and readings.

## These questions arose:

- How can I help students become better at actively generating their own work?
- At hand-writing in order to increase retention and information processing.
- Simply to slow down and take their time.

If they don't know how to take good notes, well, then my job needs to be to teach them how to do this over time.

What I had noticed about all the reading guides/graphic organizers:

Students are *really really good* at following the directions.

- So I thought, how can I leverage **directions** to improve their note taking.

# So, I just changed the structures and directions.

Instead of making a graphic organizer, I thought, why don't I give them the directions to generate their own graphic organizers?

AND IT WORKED

It's all about the set up.

---

# Requirements:

- 1) I required every student to have a composition notebook OR spiral notebook. I provided notebooks if students couldn't get one for the second day of class.
  - a) AP Biology
  - b) IU Chemistry C101/C121
  - c) Chemistry 1
  
- 2) I specifically tell students they will hand-write A LOT. It will be slow, but that's where learning happens.
  
- 3) Day 1, I post an assignment for them to complete on their own that looks like this....

# REMEMBER: Students are really good at following directions....

It's all about structure!

Day 1: they receive this assignment and it needs to be done before class the next day.

Assignment adapted from one of my colleagues Dr. Matthew Williams and his mentor Dr. Kirsten Milks

## Setting up your Chemistry 1 laboratory notebook, 2025-2026

This year, you'll be using your lab notebook a fair bit -- because writing things down, sketching, and graphing are all powerful practices for learning!

- Get a bound college-ruled composition notebook with **sewn-in pages**. I will also accept spiral bound notebooks.
- Try to use only **black or dark blue pen** (erasable OK) to make all text entries into the notebook.
- Pencil for problems is okay.
- Graphs and diagrams may be in pencil.
  - Be careful when making entries.
  - **Incorrect entries may be lined out with a *single line only* and must be labeled with initials and the date.**
  - **No white-out; no pasting pages in.**
- **Number every page of the notebook**, at the bottom outside corner, starting with the front side of the first page as number 1 and the back of the first page as number 2. Continue numbering the front and back of every page of the notebook. Do this while you watch TV or something... but keep the counting correct! If you mix it up, simply cross out with a single line and record the updated one above it.
- Keep reading to learn how to format the first pages!

- Make page 1 the title page. In the middle of the page, in big bold print, write and box:

Chemistry 1 Lab Notebook  
Period \_\_\_ Semester \_\_\_  
Bedford North Lawrence  
(Your name here)  
2025-2026

Inside front cover

Chemistry 1 Lab Notebook  
Period \_\_\_ Semester \_\_\_  
Bedford North Lawrence  
(Your name here)  
2025-2026



ACP Chem Notebook  
Period 3 Semester 1  
Bedford North Lawrence  
Noelle Gammon  
2025-2026

AP Bio Lab Notebook  
period 2 semester 1  
Bedford North Lawrence  
Isabel Mason  
2025 - 2026

pg Table of Contents  
Assignment  
6+7 Toothpickase

9 Phenotype Reading

11 Unit 1 bellwork

12 Protein Folding Modeling

13 →

14 Translation & Transcription

15 Reebop breeding simulation

16 Punnet Square & Inheritance Statistics

17 Bozeman Chi Square Test Video

19 Darwin & Natural Selection

20 Unit 1 question

21 Standard Deviation & Error

22 Mutations Effect

23 Structure of H<sub>2</sub>O

24-25 WATER on a penny

26 graphing in the sciences

27 Protein Structure

28 Kim Foglia's "building macromolecules"

29-30 chap 3 notes

pg Table of Contents  
Assignment

31-32 1.4-1.7 notes

33 BANANA LAB 36

35 BOND NOTES

37 AUG field experience 38 SEPT

39 diffusion + osmosis lab

41-44 unit 2 notes 55-56, 49-51

45-46 cell permeability lab

53 potato lab

54 OCT field experience

59 PRO + EUK notes

61, 63, 102, 103, 105 fast plants

64-66 yeast spheres + CER

67-69 unit 3 notes 76-77

71-72 chap 6 notes

73 chapter 7 notes...

74 cellular respiration

75 bond notes ATP + energy

78 DEC field experience

79 Nov field experience

80-85 unit 4 notes

87-88, 90-92, unit 6 notes 109-

## Table of Contents

Page	Assignment
6	Unit 1 reading notes: What is Chemistry
8	Unit 1 recap
9	Extra help: Specific heat Calculations
10	Chapter 2 reading notes: The Numerical Side
12	Measurement activity
17	Unit 3 reading notes: Atoms
20	Boron Atomic Mass Problem
24	Unit 4 Reading Notes: E <sup>-</sup> in Atoms : PT
29	Unit 4 Recap
31	e <sup>-</sup> configuration : P.T. W/S
32	P.T. Blocks
34	Writing e <sup>-</sup> configurations
37	Trends
39	Unit 5 Recap Page
40	Constructing Lewis diagrams
43	Naming : Bonding Notes
46	Unit 6 Reading Notes <sup>Lewis Diagram</sup> <del>(Lewis Diagram)</del> / Geometric Shapes
54	Unit 7 Recap
56	Unit 7 Reading Notes
58	Unit 8 Recap
59	Net Ionic Equations
64	Experiment #1 Procedure
65	Experiment #1: Background/pre-lab/disposal
66	Data Table #1
68	post lab #1
69	Lighting a Burner
70	Claim Evidence Reasoning Notes
71	Metals in the Water Digital Lab
2	

## Table of Contents

Page	Assignment
75	Separation Schemes
76	CEB #2: Metals in water
77	Accuracy : Precision Lab
80	Electromagnetic lab end procedure
85	Help for google sheets
86	Trend Line Lab
88	% Sugar Lab
92	Making a solution of known [ ]
93	Extrapolating data
94	Synthesis of aspirin Lab
99	Midterm protocol : script
101	Check up activity 9.1 work
102	9.3 add on notes
105	Unit 10: oxidation : reduction reading notes
107	Redox observations
108	Electrochemical Cell diagram/notes
109	Unit 11: gases reading notes
111	Unit 11 Phenomenon
112	Stoichiometric relationships with gases (extra notes)
113	IMP Crash course
114	gas stoich example
115	Unit 12: Solutions reading notes
117	Unit 12 Recap
118	Reactions in solution stoich (action from notes)
119	Unit 13 Recap
120	Unit 13 backwork
121	Unit 14: Chemical Equilibrium reading notes
122	Unit 14 Recap
123	Unit 15: Acids : Bases reading notes

- Hold them accountable early and often, and establish their rhythms for the class.
- Dual Credit/AP: this is a homework assignment they complete and I grade, simply setting up the notebook.
- Chemistry 1: I set this up together with them.

# Reading notes and AP Daily video notes

---

Homework style notes - either completed outside of class or during class work time.

## **Setting up reading notes:**

I give them very specific but vague instructions:

Specific enough that it guides students into effective note taking.

Vague enough that it forces students to generate for themselves.

# Unit 1: Reading Guide - Helpful tips:

- 1) Title the next page in your notebook: Unit 1 Reading Notes - Matter and Energy
- 2) Add this title to your table of contents and list the page numbers.

The main goal of this reading guide is to *guide* you through how to read, annotate, and spend time with a text. This is an **ESSENTIAL** skill in the college classroom.

## Directions:

- If there is a heading in the text, you should have a heading in your notes.
- Write important information under the heading. Then start a new section when you reach the next subheading.
- You should find the important information in each section, and make note of it. Do not copy word for word. Re-write in your own words. Except for perhaps definitions!
- If there's an example, **determine** if you need to copy/annotate the example. Most times, if there are example problems, it is a good idea to try them, work the problems, and check your work with the book.
- **Diagrams:** If there's an important diagram with an annotation, hand draw the diagram AND explain the annotation in your own words.

Science  
Reeds  
Technology

# What is Chemistry?

## 1.1 Science & Technology

- Science is advancing quickly
- Science is the experimental investigation and explanation of natural phenomena
- Or "knowledge from experience"
- Technology is the application of scientific knowledge
- Drives of technology benefit profit & enemies
- Chemistry = central science
- physics  $\leftrightarrow$  practice of biology

How  
Why?

Chemistry = the study of matter and the transformations it undergoes

## 1.3 Matter: Its Physical Transformations

- Study of changes in matter
- Physical transformations leaves it the same substance different physical state
- States of matter: solid, liquid, gas, vapor
- ex.) water  $\xrightarrow{\text{melting}}$  ice  $\xrightarrow{\text{melting}}$  vapor
- Vaporization: change from liquid to vapor state
- Condensation: vapor returns to liquid
- physical properties: characterize physical state and behavior
- Physical properties (other): color, odor, taste

## 1.2 Matter:

- matter = "stuff"
- anything that has mass
- ex.) air
- Pure substance & mixture
- Pure substance is only a single type of matter is present
- mixtures occur when 2 or more substances are mixed together
- ex.) table salt (P)  $\leftrightarrow$  rock (m)
- ex.) Soup (m)  $\leftrightarrow$  Lemonade (m)
- mixtures split into Homogeneous & heterogeneous
- lemonade mix  $\leftrightarrow$  table salt
- Homogeneous: identical throughout / solution
- Heterogeneous: not the same throughout
- All matter is made from elements
- Greek philosopher atomic theory of universe
- Democritus: "all things made of indivisible particles"
- 1950 Aristotle said matter was continuous
- atom: smallest piece of element
- Scanning tunneling microscope = image of atoms
- elemental substance: made of atoms of just element
- Compounds: made from atoms of 2 or more different elements
- Sublimation: pure substance goes directly from solid to gas ex.) ice  $\rightarrow$  gas

Mix sodium and chlorine a tremendous amount of heat is given off when heated  
the salt is not like the parents

# What is Chemistry Cont.

## 1.4 Matter: Its Chemical Transformation

- A pure substance is said to have undergone chemical transformation if after it is a different substance(s) only described
- Chemical properties are described when it has a chemical transformation
- ex.) color change  $\neq$  chemical change
- ex.) flammability = chemical change
- reactants: starting substance
- products: new substance
- Chemical reaction: happens during the conversion
- Symbolic ex.)  $2Na + Cl \rightarrow 2NaCl$
- reactants  $\rightarrow$  products
- gas (g), liquid (l), solid (s)
- ex.)  $2Na(s) + Cl(g) \rightarrow 2NaCl(s)$
- ex.) of chemical transformation = rusty nail, digestion
- Cannot convert element to another

## 1.5 Scientific Method

- experiments & tests
- law: generalization that consistently summarizes the outcome of series of experiments
- Theory: attempt to explain why a law exists
- model: physical picture or mathematical expression of theory
- Scientific method: collecting data from experiments using it to fashion a law - is called "hypothesis"
- based on new laws, theories are further tested, and refined
- hypothesis: first time theory is postulated
- Ex.) Albert dated testing Chasped (looks above and below neckline  $\rightarrow$  the hand changes above neckline = better dates)
- Bias: impartial judgement
- trouble cuz can't observe atoms directly

## 1.6 Learning Chem. w This Book



- Advice:
  - 1) read chapters slow
  - 2) take notes
  - 3) draw pics
  - 4) write down questions
- Impossible to prove a theory

## Summary

- Pure substance = single matter
- Compound vs. elemental substance
- mixture = heterogeneous; homogeneous
- Chemical transformation = different substance
- Physical transformation = same substance different physical state
- Scientific method:
  - 1) hypothesis
  - 2) experiment
  - 3) restructure / fix / improve

# AP Bio - AP Daily video notes

- The directions are the same, hand draw diagrams, include essential information and be able to answer the main focus of the AP topic per the course and exam description.
- Enough direction to give students a specific focus, but not requiring specific styles. Because this lets students design, generate, and make their own notes.

# 3.1 Enzymes

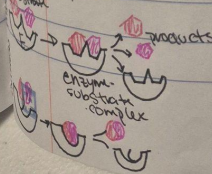
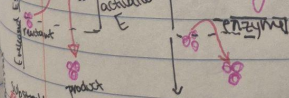
- enzymes: biological catalysts, speed up rxn's
- proteins, tertiary shape for function
- substrate - unique shape can have chemical charge, physical + chemical properties of substrate must be compatible, bind to active site
- ase ex: sucrase digests sucrose
- enzymes are REUSABLE, NOT chemically changed by reaction, maintain specific enzyme con.
- E can facilitate synthesis OR digestion reactions
- biochem rxns require initial starting E. activation energy
- some rxns absorb, others release (like light E)
  - ↳ is released  $\Rightarrow$  less activation E VICE VERSA

ROLE OF ENZYMES: speed up reactions

STRUCTURE + FUNCTION: 3-D shape determines substrate to bind

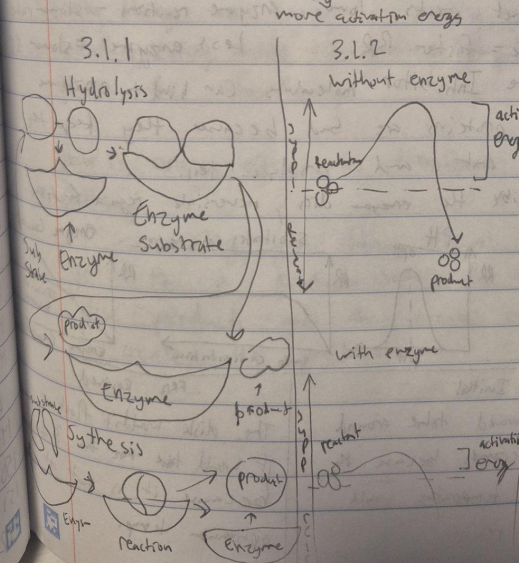
REUSABLE! after the completion of a reaction

HOW THEY WORK: by lowering activation E for rxn to occur



# Enzymes 3.1 Video Notes

- Enzymes are macromolecules  $\rightarrow$  proteins  $\rightarrow$  active sites
- Enzymes are biological catalysts that speed up reactions
- molecules that reacted with active site  $\rightarrow$  substrate
- substrates are unique to active site, shape/charge/physical/chemical
- Enzymes are -ase and reusable
- Enzyme facilitate synthesis or digestion reactions
- biochemical reactions require activation energy
- Some reactions absorb energy and others release it



Initial P.R.O. The control group is the type of enzyme used. This is true because all the other variables are changed.

Revised P.R.O. The control group is the temperature, this is true because the temp represents the temp of a normal human cell.

# Those are dual credit examples, but I really ran with this in my Chemistry 1.

Title a new page in your notebook:

## The Kinetic Molecular Theory of Gases

Open this reading: [LINK](#) and start on page 283

Make a subheading "**vocab**"

List the vocab words and write their definitions.

Read the introduction

Make a subheading: "**States of matter - A Microscopic View**"

- *list the main points that are significant in this section.*
- *Draw any relevant diagrams by hand and add a phrase that describes them.*
- ***DRAW figure 13.2 and write a phrase that explains it using the next sections.***

Make a subheading: "**The kinetic molecular theory of gases**"

- *list the main points that are significant in this section, you need to hand write all 6 points.*

Make a subheading: **Summary:**

- Summarize these points

Title a new page in your notebook:

## Aqueous Chemistry: Solutions

Open this reading: [LINK](#) and start on page 326.

**Directions:** READ THESE CAREFULLY!

1. This will be a little different from the last reading. Essentially, you'll need to approach the reading the same way you did for the unit on gases, but I'm not going to give as many instructions. You need to build your reading and note-taking skills using the strategies from last unit.
2. Remember, you **MUST**
  - a. Hand draw important diagrams and write phrases to explain them.
  - b. Include *at a minimum* 2-3 points per subheading.
3. You will need to include the following subheadings for each chapter. Use these to help you make subheadings in the notes and determine the sections you'll need to read and take notes on for the reading sections.

### 15.1: Properties of Water

- Lesson Vocabulary
- Introduction
- Water, Ice, Steam
- Ice
- Liquid Water
  - Density, Surface Tension, Heat capacity
- Steam
- Lesson Summary

## Unit 10: Aqueous Chem Reading Guide

### 15.1 Properties of Water

**Vocab** - crystalline solid: A solid in which molecules are fixed in an arranged pattern

- frost: A type of ice produced by the deposition of water vapor

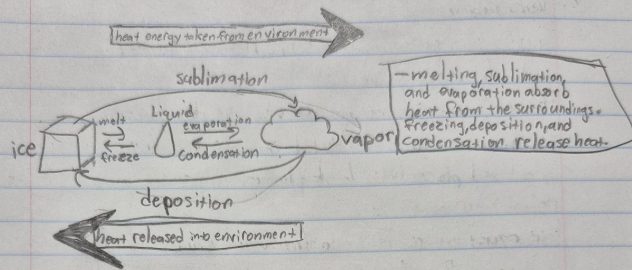
- amorphous solid: A solid in which molecules are in a fixed place but lack the organization of a regular repeating pattern

- surface tension: A property of liquids describing the tendency of surface molecules to be pulled in towards the liquid's center, creating a surface that is tightened like a film.

- heat capacity: An inherent property of a given substance indicating how much heat the substance must absorb to cause a certain increase in temp.

- Intro:**
- ① water molecules are highly attracted to each other due to strong hydrogen bonds.
  - ② That leads to high surface tension
  - ③ Water expands when froze, absorbs heat with little to no change.

### α Water, Ice, and Steam



### α Ice

Water can freeze into both crystalline and non-crystalline (amorphous) forms. Crystalline solids refer to solids in which the atoms or molecules are packed in a precisely arranged order. The environmental conditions under which the transition occurs dictate whether this phase change produces regular crystals or not. In its crystalline form, water molecules are generally arranged in a hexagonal array. When water vapor turns directly to a solid, it is called frost. When water freezes in a non-crystalline, amorphous form as frost, the water molecules are fixed in place, but not in a regular, repeating pattern. Because ice comes in both amorphous and crystalline forms, there are differences in the physical properties such as its hardness and density.

## Introduction:

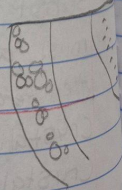
Water is a substance, it can exist in all states at normal pressures and temperatures. Approximately 70% of the Earth's surface is covered in water. For a small molecule, water molecules are highly attracted to one another, due to particularly strong hydrogen bonds. This leads to a number of properties, such as relatively high surface tensions.

**Ice:** ice on earth forms when liquid water freezes. However, it can also be produced by the deposition of water vapor (i.e.,  $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{s})$ ). When this is the case, ice is often referred to as frost.

**liquid water - H<sub>2</sub>O:** liquid water is formed when water vapor condenses (i.e.,  $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ ) or when ice melts (i.e.,  $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$ ). Because water is a molecular substance, it is a poor conductor of electricity in its pure form.

Properties: surface tension, heat capacity

Density is cool & ldk man.



## Unit 10: Aqueous Chemistry Reading Guide p.1

Properties of water:

**Vocab:**

**crystalline solid:** A solid in which molecules are fixed in an arranged pattern

**frost:** A type of ice produced by the deposition of water vapor

**amorphous solid:** A solid in which molecules are in a fixed place but lack the organization of a regular repeating pattern.

**surface tension:** A property of liquids describing the tendency of surface molecules to be pulled in towards the liquid's center, creating a surface that is tight and like a film.

**heat capacity:** An inherent property of a given substance indicating how much heat the substance must absorb to cause a certain increase in temperature.  
Water, Ice, Steam:

- All substances can transform from one state to another, depending on the temperature and pressure of the environment
- melting, sublimation, and evaporation absorb heat from their surroundings.
- Freezing, deposition and condensation all release heat

**Ice:** water in solid form

includes: snow, sleet, hail, or frost

water can seep into cracks then freeze, causing expansion

Crystalline form: honeycomb



**Liquid water:** formed when water vapor condenses or ice melts

• Water molecules are polar

**Density:**

Solid water:



liquid water:



(Density of liquid water higher than ice)

## Aqueous Chemistry: Solutions

### Unit 10: Aqueous Chemistry Reading Guide Part 1

#### Vocab

**Crystalline solid** - A solid in which molecules are fixed in an arranged pattern.

**Frost** - A type of ice produced by the deposition of water vapor.

**Amorphous solid** - A solid in which molecules are in a fixed place but lack the organization of a regular, repeating pattern.

**Surface tension** - A property of liquids describing the tendency of surface molecules to be pulled in towards the liquid center, creating a surface that is tightened like a film.

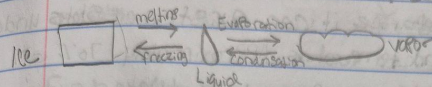
**Heat capacity** - An inherent property of a given substance indicating how much heat the substance must absorb to cause a certain increase in temp.

#### Introduction

Water can exist in all three states under ~~press~~ normal pressure & temperatures. At room temp., it is tasteless, odorless, colorless. A blue ~~here~~ is presented in large volumes. Water molecules are attracted to each other. Water expands when it freezes. Water also absorbs large amounts of heat with minimal changes in temp. The ocean & clouds are a byproduct of water's thermal regulating capacity. Water is not only on Earth.

## Aqueous Chemistry: Solutions

### Properties of Water: water, ice and steam



#### Vocab

**Crystalline solid**: a solid in which molecules are fixed in an arranged pattern.

**Frost**: a type of ice produced by the deposition of water vapor.

**Amorphous solid**: a solid in which molecules are in a fixed place but lack the organization of a regular repeating pattern.

**Surface tension**: a property of liquids describing the tendency of surface molecules to be pulled in towards the liquid center, creating a surface that is tightened like a film.

**Heat capacity**: an inherent property of a given substance indicating how much heat the substance must absorb to cause a certain increase in temperature.

Ice-water can freeze into both crystalline and non-crystalline (amorphous forms). Crystalline solids refer to solids in which the atoms or molecules are packed tightly.

## Some thoughts on what I've seen:

- If they have just enough direction to guide them, I've been amazed with what they've done in their own notebooks.
- At the end of the year/semester, I can just give them the specific pages, tell them what to title their notebook page and they can read and take notes on the text.
- I've invested a lot into the Chemistry 1 students' notebooks *because they will go on to take dual credit courses*. Then, hopefully at that point, they know how to do it!

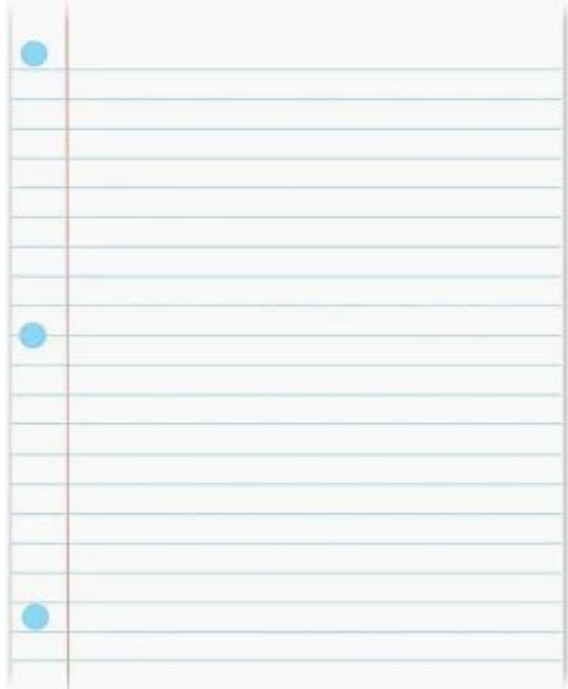
# How do you assess reading notes and AP daily style video notes?

- Honestly, I'm not sure, I haven't come up with a good plan.
  - I tried giving "reading quizzes" this year but that was a complete flop.
  
- My plan for next year: some type of revision based structure that ensures they're really taking high quality notes. I'll have them re-do them if they are insufficient and I'll regrade. (yes, more work...)
  - The goal isn't to trick students into the skill but rather to have students develop and cultivate the skill.

# Setting up in class notes: Dual Credit Chemistry

---

# Protocol/Structure



## Conveying elemental information

### Nomenclature Review

element (X); mass number (A), atomic number (Z):

mass number = number of protons + number of neutrons

atomic number =



- **Isotopes** – Nuclei with the same Z but different A; e.g.  $^1\text{H}$ ,  $^2\text{H}$ ,  $^3\text{H}$
- **Nucleons** – particles found in the nucleus of an atom
  - Protons or  $p^+$  or  $^1_1\text{H}$
  - Neutrons or  $n^0$  or  $^1_0\text{n}$
- **Nuclide** – each unique atom characterized by a specific number of protons and neutrons.

# Protocol/Structure

- Direct instruction with a slideshow because there is so much information.
- Stop lecture after one specific topic.
  - That may be 1 slide, it may be 10 slides
- Give students 3 minutes of silence to summarize the slides.
- Give them 1 minute to verbalize it to the person next to them.
- Yes, this does take time.
- It is worth the time.

## Conveying elemental information

### Nomenclature Review

element (X); mass number (A), atomic number (Z):

mass number = number of protons + number of neutrons

atomic number = number of protons



- **Isotopes** – Nuclei with the same Z but different A; e.g.  $^1\text{H}$ ,  $^2\text{H}$ ,  $^3\text{H}$
- **Nucleons** – particles found in the nucleus of an atom
  - Protons or  $\text{p}^+$  or  $^1_1\text{H}$
  - Neutrons or  $\text{n}^0$  or  $^1_0\text{n}$
- **Nuclide** – each unique atom characterized by a specific number of protons and neutrons.

# Unit 13

- Thermodynamics: exothermic and increasing entropy
- Kinetics: collision model, activation energy, and reaction mechanism
- Collision model: particles are in constant motion and that collisions between particles can lead to chemical changes

Energy requirement: breaking bonds requires E

② orientation: allows product bonds to form

- a reaction mechanism is the sequence of steps that molecules undergo while changing from reactants to products
- a transition state is a high-energy, unstable state that is under too much stress

↳ probable and rapid

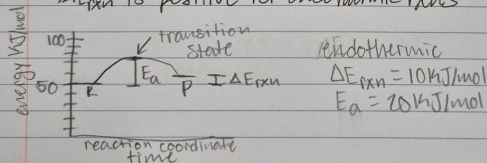
- a substitution reaction is favorable because only need to break one bond

- exothermic rxn: release energy - surroundings are hot
- endothermic rxn: absorbs energy - surroundings are cold

$$\Delta E_{rxn} = \Delta E_{product} - \Delta E_{reactants}$$

•  $\Delta E_{rxn}$  is negative for exothermic rxns

•  $\Delta E_{rxn}$  is positive for endothermic rxns



- catalysts: speeds up a chemical rxn by lowering the  $E_a$ 
  - ↳ provides an alternative rxn mechanism
  - ↳ ~~not~~ not changing reactants or products catalyst
  - ↳ not being used up
  - ↳ not viewed as a reactant, viewed as a "facilitator"
- enzymes: biomolecules
  - ↳ active site: a "pocket" in enzyme where rxn occurs
  - ↳ substrate: a reactant molecule that fits into the active site of the enzyme

# Unit 13 : Day 1

collision model: particles are in constant motion, chemical change = collisions between particles can lead to this

reacting particles need proper orientation for new product bonds to form ②

reaction mechanism: sequence of steps that molecules undergo to get from reactants to products

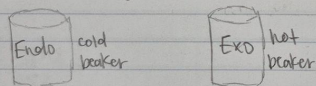
Transition State: high energy, unstable

↓  
formation of products from this are probable + rapid

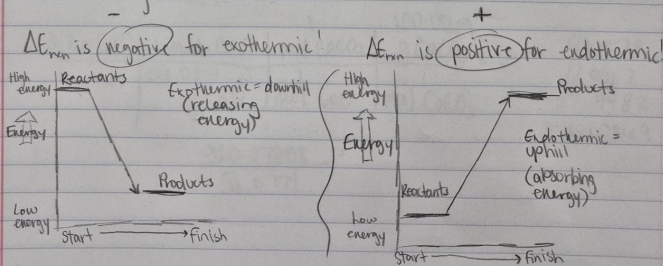
Exothermic: releasing energy to surroundings

Endothermic: absorbing energy from surroundings

Net Energy Change Equation:  $\Delta E_{rxn} = \Delta E_{products} - \Delta E_{reactants}$



Reaction Energetics:



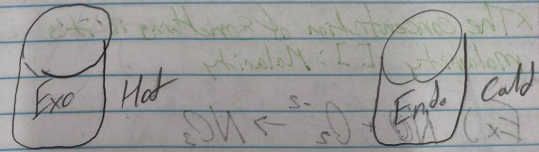
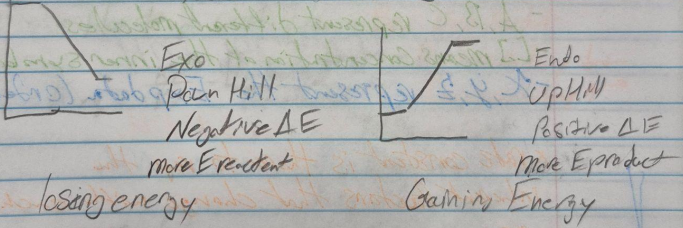
# 013 Notes Jax Jax Jax

Bonds: Need E to Break

## Requirements

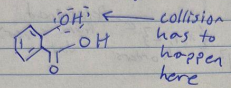
- 1. E need it to break apart
- 2. Orientation need the particles to be in the right spots.

Trans state: High E, unstable = short  
Transition States

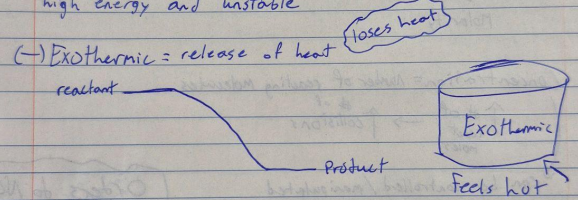


# Unit 13 Recap

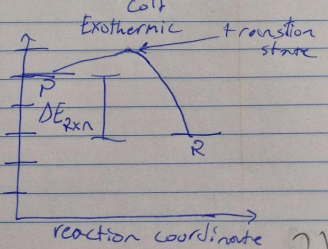
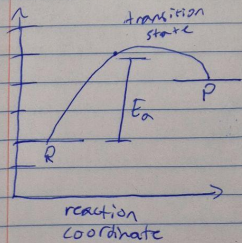
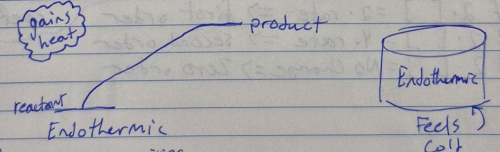
- Need 2 things to cause a RXN
  1. Energy requirement - you have to have energy to break bonds
  2. Orientation requirement



-A transition state is high energy and unstable



(+) Endothermic = absorbs heat



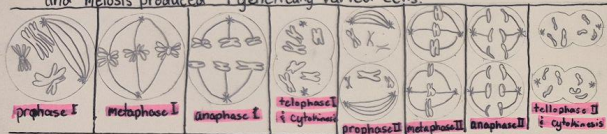
# AP Biology Study Folders - 1 folder per unit

- It's all about the directions!
- Students receive a “guideline” document. They generate the work.
- Everything is hand drawn.

Adapted from Dr. Kirsten Milks adapted from Angelia Floyd

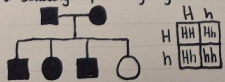
## 5.1: Meiosis

- **diploid** cells have pairs of chromosomes (full set), 1 from each parent, and are represented by  $2n$ . **haploid** cells have a single chromosome set by  $n$ .
- the purpose of meiosis is to produce haploid gametes
- meiosis involves 2 rounds of cell division
  - **meiosis I**: pairs of chromosomes separate, resulting in 2 haploid cells with  $n$  of the chromosomes from each pair
  - **meiosis II**: double chromosomes separate, resulting in 4 haploid cells, each w/ single chromosomes
- mitosis & meiosis are similar in the overall process (PMAT) of how genetic info is passed onto daughter cells. However, mitosis produces 2 genetically identical cells and meiosis produces 4 genetically varied cells.



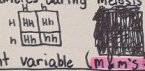
## 5.2: Meiosis & Genetic Diversity

- Crossing over in prophase I occurs when nonsister chromatids exchange segments. This results in recombinant chromosomes
- random assortment of chromosomes in metaphase I can result in diff. combos of chromosome in gametes
- during sex reproduction, any gamete from 1 parent can combine w/ any gametes from another parent, resulting in genetically different offspring. This increases the genetic diversity within a pop. of organisms
- chromosomes are inherited as full units and passed from parent to offspring
- patterns of inheritance of traits/diseases/disorders can be analyzed to determine how chromosomes were inherited
- visual reps (pedigree) can be used to help us predict the causes or effects of changes in chromosomal inheritance from parents to offspring
- the segregation of parental alleles into gametes provides opportunity for more varied combos of alleles when fertilization occurs
- the assortment of genes independently into gametes provides more possible gene combos when fertilization occurs
- nondisjunction: failure of chromosomes to fully separate during the formation of gametes  $\rightarrow$  results in too few chromosomes in sex cells
- random fertilization leads to genetic variation in offspring of sexually reproducing organisms
- certain human genetic disorders can be attributed to chromosomal inheritance and can result in genetically varied offspring



## 5.3: Mendelian Genetics

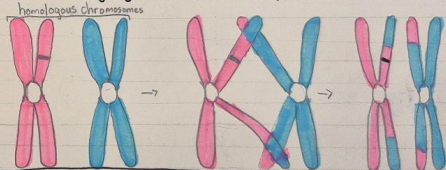
- shared and conserved processes support the concept of common ancestry bc fundamental traits that link organisms by lines of descent
- processes like cellular respiration and transmission of genetic info allow life to continue thru gens.
- Mendel's **Law of Separation**: alleles are segregated into separate gametes during meiosis
- Mendel's **Law of independent assortment**: genes aren't linked
- monohybrid cross: 1 trait cross; dihybrid cross: 2 traits
- chi-squared goodness of fit test: chance or independent variable (M.K.M.S.)



## 5.4: Non-Mendelian Genetics

- **linked genes**: genes located on the same chromosome that are typically inherited together. map distance tells you how close together a pair of linked genes is. smaller the map distance: the closer together the genes are on the chromosome, also more likely to be inherited together
- **sex-linked traits**: traits determined by genes located on sex chromosomes
- sex-linked traits differ from Mendelian traits bc each parent doesn't contribute sex-link alleles to every bio offspring, like w/ Mendelian inheritance; bio sex will determine what sex-linked alleles r inherited
- inheritance determined by multiple genes = larger range of possible phenotypes compared to inheritance determined by a single gene. these traits don't segregate in Mendelian patterns
- non-nuclear inheritance seen in chloroplast & mitochondria in maternally inherited. these traits don't segregate in Mendelian patterns

Pendaflex  
MADE IN MEXICO

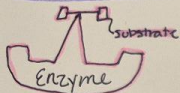


## 5.5: Environmental Effects of Phenotype

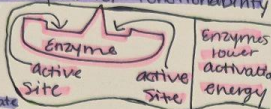
- **Phenotypic plasticity** is the ability of 1 genotype to produce more than 1 phenotype
  - ex.) hydrangeas color
- the same genotype can result in multiple phenotypes due to changes in environmental conditions
- environmental factors can influence how genes are expressed. This leads to phenotypic plasticity

### 3.1.1 - Enzymes

- Enzymes are biological catalysts that speed up biochemical rxns.
- Most enzymes proteins must be tertiary shaped for functionality (have a region called an active site)
- Enzymes are macromolecules
- The active site interacts w/ the substrate



- the shape & charge of the substrate must be compatible w/ the active site of an enzyme for a rxn to occur



### 3.1.2 - Enzymes

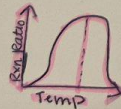
- Enzymes are biological catalyst, typically proteins, that speed up biochemical reactions
- Enzymes affect the rate of biochemical rxns.
- Enzymes lower activation energy

### 3.1.3 - Enzymes

- Experimental procedures should align w/ testable question
- \* - control test (group)
  - ↳ generated data under conditions w/ no treatment
- \* - experimental test (group)
  - ↳ generated data under abnormal/unknown conditions

### 3.2.1 - Environmental impacts on enzyme function

- A change to the molecular structure of an enzyme may result in loss of function.
- Environmental temperatures can alter the efficiency or enzyme activity
- Enzymes have unique functional 3D shapes; known as the conformational shape or tertiary structure
- Environmental decrease in temperature
  - generally slows down rxn rate
  - measured on logarithmic scale
  - does not disrupt enzyme structure
- no denaturation, environmental pH can alter the efficiency of enzyme activity.



### 3.3.1 - Cellular Energy

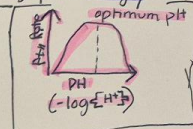
- All living things require a constant input of energy
- sunlight is the main input for living systems.
- Autotrophs capture energy from physical sources, like sunlight, or chemical sources; transform that energy → energy

### ATP: Energy

Energy → Free energy (G)  
↳ available energy to do work

$$\Delta G = \Delta H - T\Delta S$$

Free energy    Heat energy    Entropy

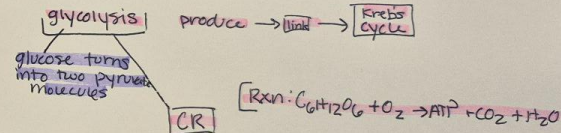


- exergonic - releasing energy to do work
- endergonic - energy must be input
- ↳ depends on entropy → measure of a systems organization
- energy = heat + light

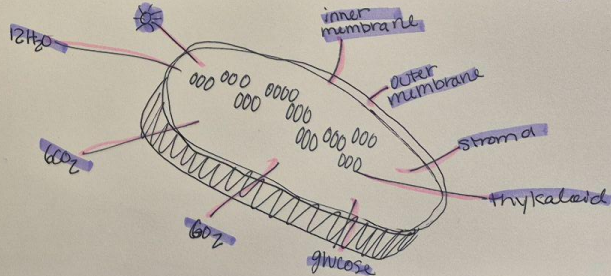
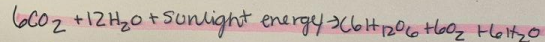
### Cellular Respiration

Cellular respiration goal = make energy

Pendaflex  
MADE IN MEXICO



### Photosynthesis



make  
kung

# PERCENT CHANGE

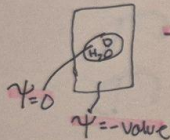
% Change = (final - initial) / initial (100)

# WATER POTENTIAL

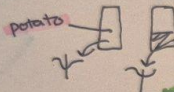
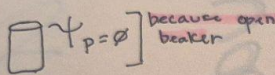
$\Psi_s$   
Solute Potential

→ iCRT sink

- 0.2M
- 0.4M
- 0.6M
- 0.8M
- 1.0M



Distilled H<sub>2</sub>O  $\Psi=0$



\* Water moves from high H<sub>2</sub>O potential to low H<sub>2</sub>O potential

**Mitochondria:** double membrane provides compartments for different metabolic rxns

**Chloroplasts:** specialized for photosynthesis & capturing energy from the sun to produce sugar

\* All living cells contain a genome & ribosomes, reflecting the common ancestry of life

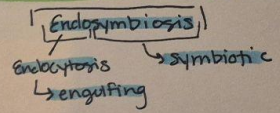
**Polarity**  
 ○○○○○○ polar  
 ○○○○○○ nonpolar  
 polar - faces water; water is polar  
 nonpolar: hydrophobic because it needs to be away from water

# Eukaryotes & Prokaryotes

- Both cell types have plasma membrane that separates their internal environment from their surrounding environment
- Prokaryotic cells have internal regions, that contains genetic materials
- Prokaryotic cells occupy these two domains: **Bacteria & Archaea**

# OTHER IMPORTANT

- Membranes may become polarized by the movement of ions
- External environments can be hypertonic, hypotonic, or isotonic to the internal environment of the cells



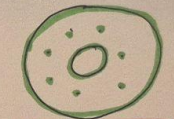
# OSMOSIS & TONICITY

**ISOTONIC**

**Hypotonic**

**hypertonic**

Pendaflex  
MADE IN MEXICO



Water movement  
CELL STAYS SAME



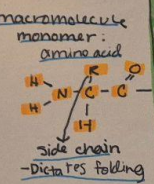
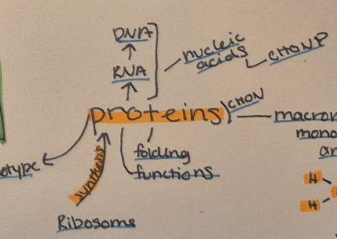
Water movement  
Cell swells



Water movement  
Cell shrinks

# AP BIO OVERVIEW

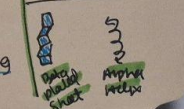
- water moves by osmosis from areas of low osmotic solute concentration to areas of high osmotic solute concentration  
 - Diffusion: movement of molecules from high concentration → low concentration  
 - Facilitated Diffusion: allows hydrophilic molecules + ions to pass through the membranes



# Solution Mass

- hypertonic decreases solutions  
 isotonic  
 hypotonic

**Functions -**  
 - lysosomes: keep waste out of cell  
 - ribosomes: reads genetic coding  
 - Peroxisomes: fatty acid oxidation



### 8.1 Responses to the Environment:

Response and communication impact natural selection and evolution

- Natural selection favors innate and learned behaviors that increase survival and reproductive success
  - Innate: Usually genetically controlled; don't need to be taught
  - Learned: Need to be taught
- Cooperative behaviors involve teamwork between organisms of the same species
  - Increases the fitness of the individual
  - Increases the survival of the population

### 8.2 Energy Flow Through Ecosystems:

Organisms use different strategies to regulate body temperature and metabolism

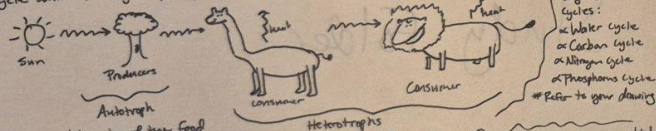
- Endotherms: Use thermal energy generated by metabolism to maintain homeostatic body temperature
  - Heart rate changes, fat storage, etc.
- Ectotherms: Lack internal mechanisms to regulate body temperature
  - Rely on behavior
  - Like crawling in/out of shade
- Metabolic rate: The amount of energy expended by an animal over a specific amount of time
  - A net gain of energy may lead to energy storage, growth, or increased reproductive output
  - A net loss may lead to loss of mass, decreased reproduction, or even death
  - Generally, the smaller the organism, the higher the metabolic rate

Animals usually try to reproduce when energy is available

Different levels of Ecological Organization:

- Population: group of the same species living in the same area
- Community: All the different populations that live in the same area and interact with one another
- Ecosystem: The community of organisms in an area and the biotic and abiotic factors they interact with
- Biosphere: large geographic area with similar climate and vegetation

In ecosystems, energy flows from producers to consumers and is ultimately lost by heat, while nutrients cycle within the system, being reused and transformed through various processes



Changes at the top of the food chain can cascade down - think of the others

### 8.3 Population Ecology:

Population growth dynamics depend on a number of factors

- Age of reproductive maturity
- Number of offspring produced
- Frequency of reproduction
- Survival of offspring to reproductive maturity

Population growth equation:

$$\frac{dN}{dt} = B - D$$

- Change in population size:  $dN$
- Change in time:  $dt$
- Birthrate:  $B$
- Death rate:  $D$

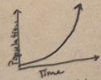
Exponential growth represented by:

Where:  $dN = \Delta \text{population}$

$dt = \Delta \text{time}$

$N = \text{population size}$

$r_{max} = \text{maximum per capita growth rate of a population}$



$$\frac{dN}{dt} = r_{max} N$$

### 8.4 Effect of Density on Populations:

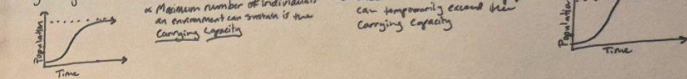
Resource availability in an environment impacts population density

- ↑ Food, ↑ density
  - Higher reproductive rate, space is limited
- ↓ Food, ↓ density
  - Lower reproductive rate, individuals may spread out

Limits to population growth are due to density-dependent and independent factors

- Density-dependent examples:
  - Competition for resources, territoriality, disease, predation, etc.
- Density-independent examples:
  - Natural disasters, pollution, etc.

A population can produce a density of individuals that exceeds the system's resource availability



### 8.5 Community Ecology:

Species diversity measured using an equation called the Simpson's Diversity Index

- The higher the index, the more diverse the community

$$\text{Diversity Index} = \frac{1}{\sum (\frac{1}{n_i^2})}$$

Where:  $n_i = \text{total number of organisms of a particular species}$   
 $N = \text{total number of organisms overall}$

Trophic Cascade: The negative effect of the removal or decrease in a key species has on other trophic levels

Niche Partitioning: A decrease in competition over shared resources between two similar species because each species is accessing the resource in different ways

### 8.6 Biodiversity:

Ecosystem diversity is related to its resilience to changes in the environment

- Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment

Abiotic and biotic factors contribute to maintaining the diversity of an ecosystem

- Abiotic factors examples:
  - Climate, water, nutrient availability, light availability
- Biotic factors examples:
  - Producers, dominant predators

The effect of keystone species are disproportionate relative to their abundance

### 8.7 Disruptions in Ecosystems:

Evolution is characterized by change in the genetic makeup of a population over time

Invasive species affect ecosystem dynamics

- Exploit new niches

The distribution of local and global ecosystems changes over time

- Human impact accelerates change at local and global levels
  - Urbanization, deforestation, pollution, etc.

Logistic growth can be modeled by:

$$\frac{dN}{dt} = r_{max} N \left( \frac{K-N}{N} \right)$$

Where:  $r_{max}$  = Max per capita growth rate  
 $N$  = population size  
 $K$  = carrying capacity

# Science Specific Practices

---

Lab protocols and data analysis

# Lab protocols:

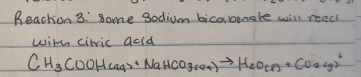
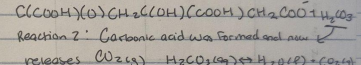
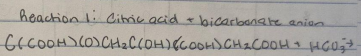
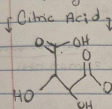
- Students are required to handwrite everything.
- I post a digital laboratory protocol that includes
  - Background
  - Prelab
  - Data tables
  - Post lab
- They're required to:
  - Read the background
  - Hand-write the protocol
  - Draw an image for each step
  - Hand draw data tables, we will print and glue data tables if they're really involved).
  - Hand draw graphs

# Unit 9: % by Mass

background, protocol, prelab  
 questions, charts, poster  
 sheet

## Background:

- Sodium Bicarbonate ( $\text{NaHCO}_3$ ) • Alka Seltzer advertised for Complete relief from headaches, indigestion, heart burn, and upset stomach.
- Popped in water Creates bubbling
- The "Fizz" = the relief
- Each tablet is 325 mg of aspirin, 1000 mg of citric acid, 191 mg of Sodium bicarbonate



- 1) Clean, dry flask
- 2) Add 50ml water to clean beaker
- 3) Record mass of flask and water
- 4) Get mass & record

- 5) Drop into flask/beaker make sure it dissolves
- 6) Stop bubbling weigh beaker with solution
- 7) Do this process with each trial

Record in Data Table  
 Rinse liquids down drain

What was the limiting reactant?

Data table 2 evidence  
 graph trend line  
 notebook upload where google sheet is

## Data Table:

Trial #	Vinegar ml	Water ml	Flask w liquid (g)	Alka Seltzer tablet (g)	Flask after reaction	Loss of mass $\text{CO}_2(\text{g})$
1	0	35	117.86g	3.00g	120.23g	0.3
2	5	30	118.92g	3.01g	151.29g	
3	10	25	117.85g	2.98g	120.01g	
4	15	20	117.51g	3.00g	119.76g	
5	20	15	118.50	3.02g	150.79g	
6	25	10	117.69g	2.96g	119.89g	
7	30	5	119.19g	3.09g	151.47g	
8	35	0	117.73g	3.03g	119.95g	

Trial #	$\text{NaHCO}_3$ reacted (g)	% by mass in tablet
1		
2		
3		
4		
5		
6		
7		
8		

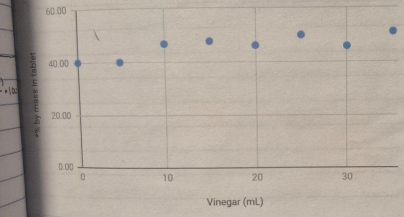
mass (component) / mass total = 100  
 mass (component) / mass total = 100  
 mass (component) / mass total = 100

# CER 9:

Claim: The Vinegar is the limiting reactant in  $\text{C}_6\text{H}_8\text{O}_7(\text{aq}) + \text{NaHCO}_3(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) + \text{NaC}_6\text{H}_7\text{O}_7(\text{aq})$

Evidence: Graph 1 represents the relationship between % of Sodium Bicarbonate being reacted and Vinegar

Graph 1: % by mass in tablet vs. Vinegar (mL)



Vinegar (mL)	% by mass in tablet
0	40.09
5	40.09
10	46.76
15	47.72
20	46.14
25	49.96
30	45.81
35	51.03

Table 1 Shows the % by mass found, while increasing vinegar amounts in the lab.

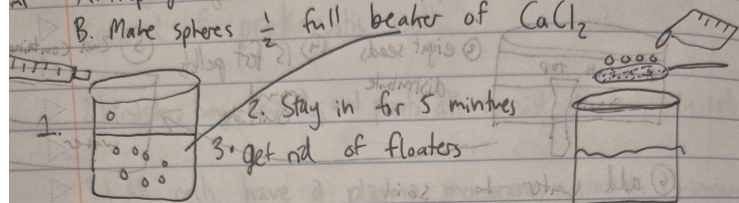
Reasoning: The Vinegar is the limiting reactant in  $\text{C}_6\text{H}_8\text{O}_7(\text{aq}) + \text{NaHCO}_3(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) + \text{NaC}_6\text{H}_7\text{O}_7(\text{aq})$ . A limiting reactant is a substance that is completely consumed first in a chemical reaction. The percent by mass represents the percent of Sodium bicarbonate that reacts. The relationship between Vinegar and percent mass is proportionally related, so as the amount of vinegar increases so does the percent by mass. This proves that when there is more supply of Vinegar, more of the excess reactant reacts. When there is 0ml of vinegar only 40.09% of Sodium Bicarbonate reacts, but when 35ml of vinegar is added 51.03% of sodium bicarbonate reacts. However, if the experiment continued eventually vinegar would be in excess and % by mass would be 100%. On a graph this would be shown as a horizontal line.



# Measuring Catalase activity using yeast spheres

A. Prep yeast solution - 20ml yeast & 20ml 2% Sodium

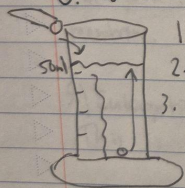
B. Make spheres  $\frac{1}{2}$  full beaker of  $\text{CaCl}_2$



5. mix spheres under water

6. put spheres in beaker with water

## C. Test the Catalase Reactions



1. 50ml of hydrogen peroxide into 50ml graduated cylinder

2. Drop sphere time when sphere hits the bottom

3. Stop time when reaches top

4. same sized spheres

TIPS: make sure spheres and  $\text{H}_2\text{O}_2$  same temp

if different put spheres in water same temp of  $\text{H}_2\text{O}_2$

catalase enzyme - separates  $\text{H}_2\text{O}_2$  into  $\text{H}_2$  gas and  $\text{O}_2$  gas

# Measuring Catalase activity using yeast sphere

	Control	Condition 1	Condition 2
Trial	0.6% $\text{H}_2\text{O}_2$	0.3% $\text{H}_2\text{O}_2$	0.15% $\text{H}_2\text{O}_2$
1	106	60	22
2	105	59	22
3	105	58	22
4	111	61	22
5	113	65	23
6	111	62	22
7	114	60	23
8	107	65	22
9	113	64	21
10	108	69	22
Avg	109.3	63.2	22.1

It travels 13cm from bottom to 15ml mark

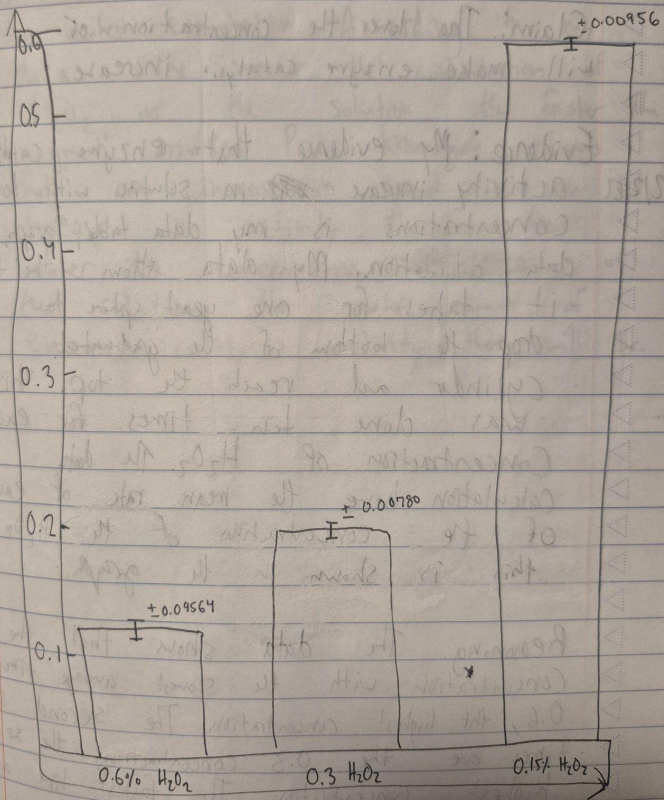
# Measuring Catalase activity using yeast spores

Calculation support table for catalase yeast sphere experiments.

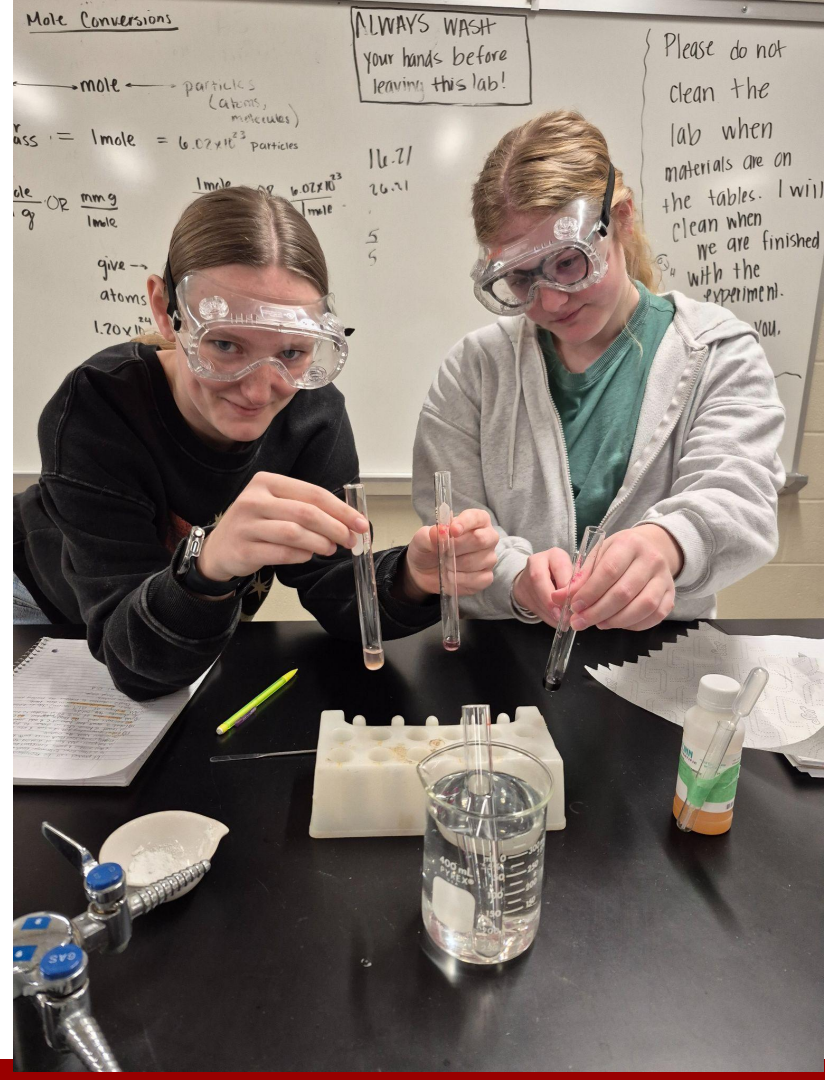
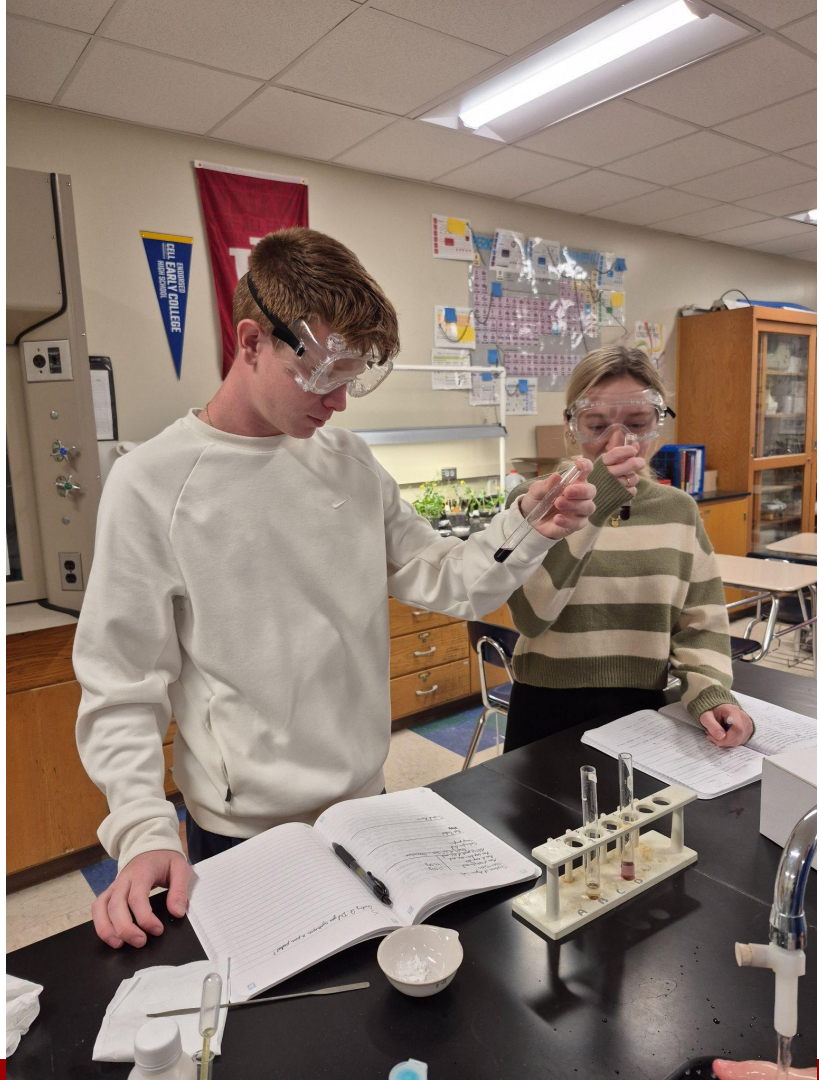
Condition	Description of independent variable	Mean rate of n trials, with units	Standard deviation (use this spreadsheet)	n for this condition	Standard error (standard deviation $1/\sqrt{n}$ )	+/- 2 SEM (confidence interval) Write as "Low error bar value to High error bar value", like 3.71 to 8.53
A	0.6% $H_2O_2$	0.11904840 72	0.003309951 446	10	0.001204812	0.04563571
B	0.3% $H_2O_2$	0.2063951516 31	0.01257183262	10	0.003975569	0.007951139
C	0.15% $H_2O_2$	0.5885846 31	0.0157213516	10	0.004981761	0.009563572

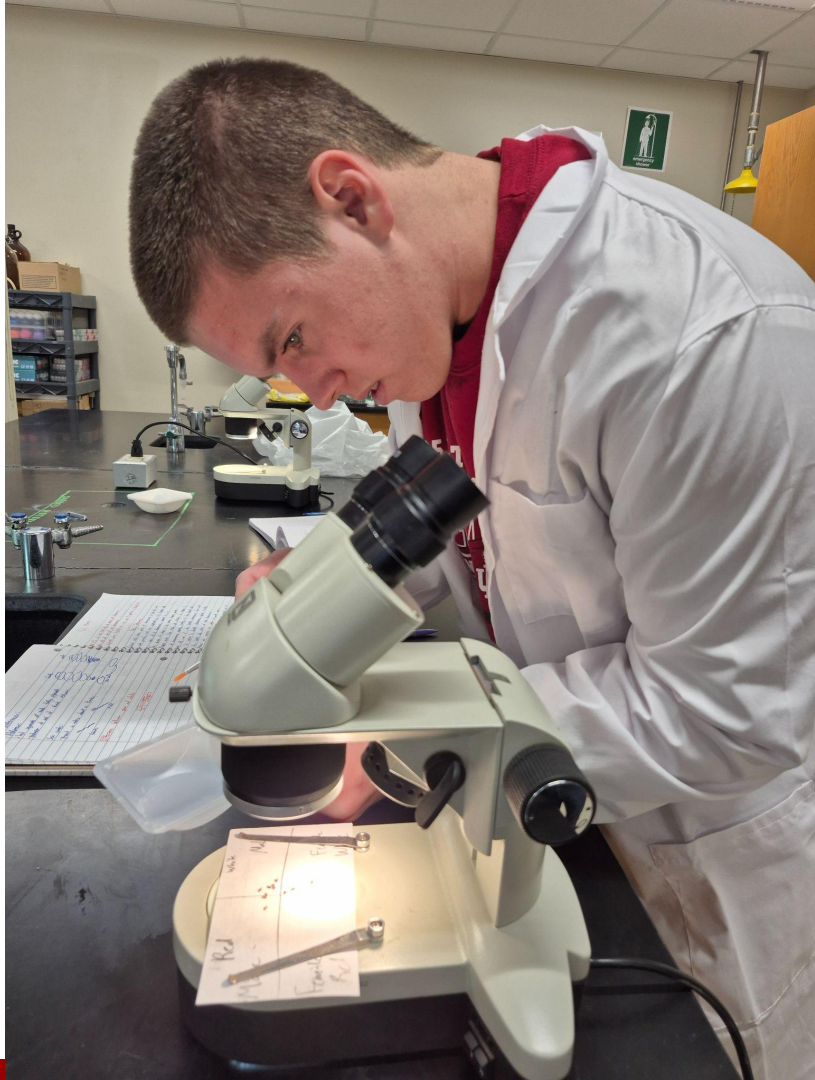
# Measuring Catalase activity using yeast spores

Catalase Activity



Concentration of H<sub>2</sub>O<sub>2</sub>





# A few conclusions.

Students want to *passively* “study.” Reading notes that I had given them.

Students need to *actively* recall and *generate* their work.

- Shifting to active recall during *note taking AND* self-practice.
- The main things the best students do:
  - Study alone
  - Minimize distractions
  - Chunk their study time
  - Active recall.

They're half way there just by forcing students to do so much handwriting in class.

They can do it, and they can generate some *really* good work!

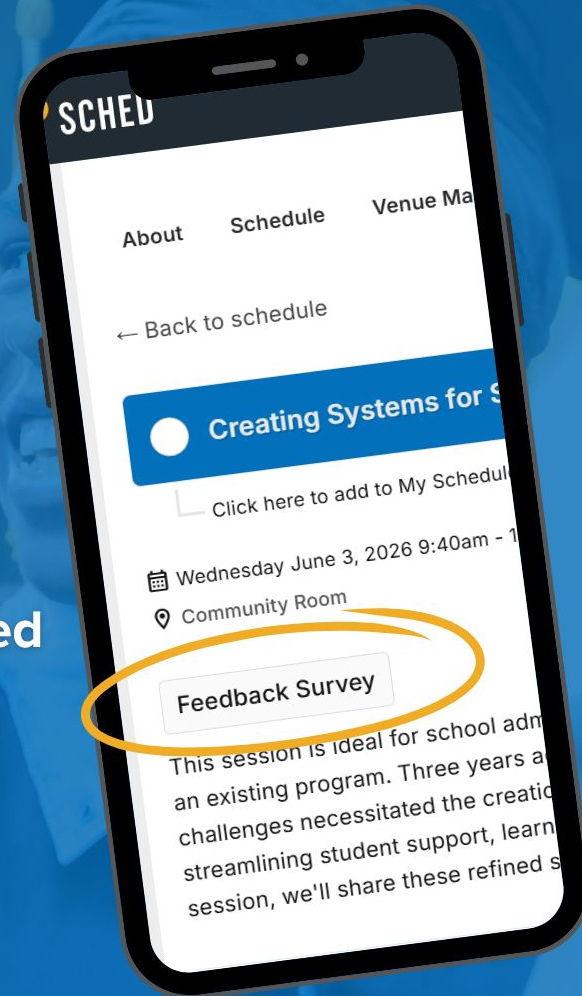
CELL

CENTER OF EXCELLENCE IN  
LEADERSHIP OF LEARNING

UNIVERSITY OF INDIANAPOLIS

## SURVEY REMINDER

Please complete a survey in Sched  
for each session you attend.



INDIANA EARLY  
COLLEGE SUMMIT