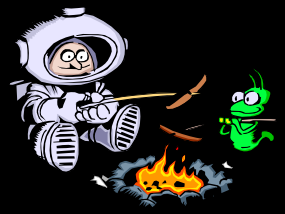
Acids & Bases

Acids & Bases: Traditional Properties

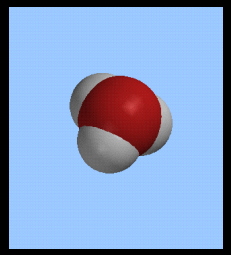
Property	Acid	Base
Taste	Sour	Bitter
Feel	None	Slippery
Litmus	B→R	R→B
Phenolphthalein	Colorless	Magenta
With Carbonate	CO_2 evolution	None
With “active” Metals	H_2 evolution	None
With most metals	None	Water Insoluble



Arrhenius Theory: Acids

Acid = substance that forms hydrogen ions in water solution

$$HA_{(aq)} \rightarrow H^+_{(aq)} + A^-_{(aq)}$$



H^+ = proton

But, individual protons do NOT exist in water:

$$H^+ + H_2O \rightarrow H_3O^+$$ **(Hydronium Ion)**

Arrhenius Acids form *hydronium ions* in solution

Arrhenius Theory: Bases

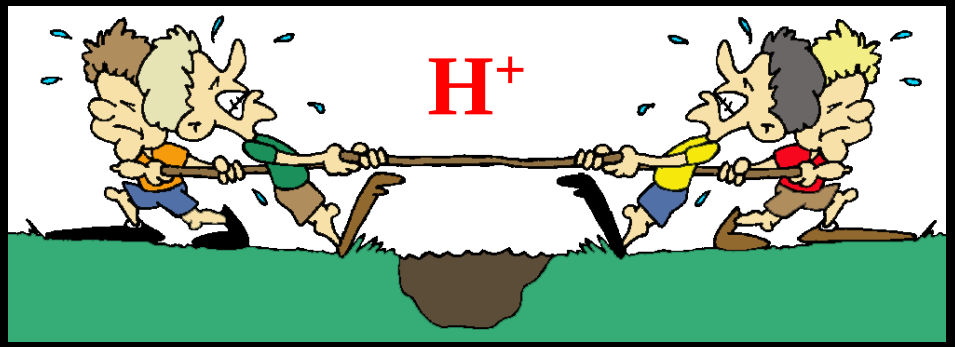
Base = substance that forms hydroxide ions (OH^-) in water

Bronsted-Lowry Theory of Acids & Bases

$$AH + B \rightleftarrows BH^{+} + A^{-}$$

Acid = proton donor

Base = proton acceptor (Prime departure from Arrhenius)



pH Scale

Measurement of relative acidity

Determined by hydrogen ion concentration

Values range between 0 – 14

- **pH < 7 ➔ acidic**
- **pH = 7 ➔ neutral**
- **pH > 7 ➔ basic (alkaline)**

Measured using

- **indicators (pH papers or solutions)**
- **pH meter**

pH: A Measure of $[H^+]$ (Molar Concentration of H^+)

$[H^+]$	pH
1×10^{-1}	1
1×10^{-2}	2
1×10^{-3}	3
1×10^{-4}	4
1×10^{-5}	5
1×10^{-6}	6
1×10^{-7}	7
1×10^{-8}	8
1×10^{-9}	9
1×10^{-10}	10
1×10^{-11}	11
1×10^{-12}	12
1×10^{-13}	13
1×10^{-14}	14

$[H^+]$ (Acidity) increasing, pH decreasing

$$[H^+] = 1 \times 10^{-pH}$$

$$pH = -\log [H^+]$$

$[H^+]$ (Acidity) decreasing, pH increasing

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pH Scale

Focus of pH scale is the proton (acidity)

Strong acids: pH < 4

Weak acids: pH 4-6

Strong Bases: > pH 11

Weak Bases: pH 8-11

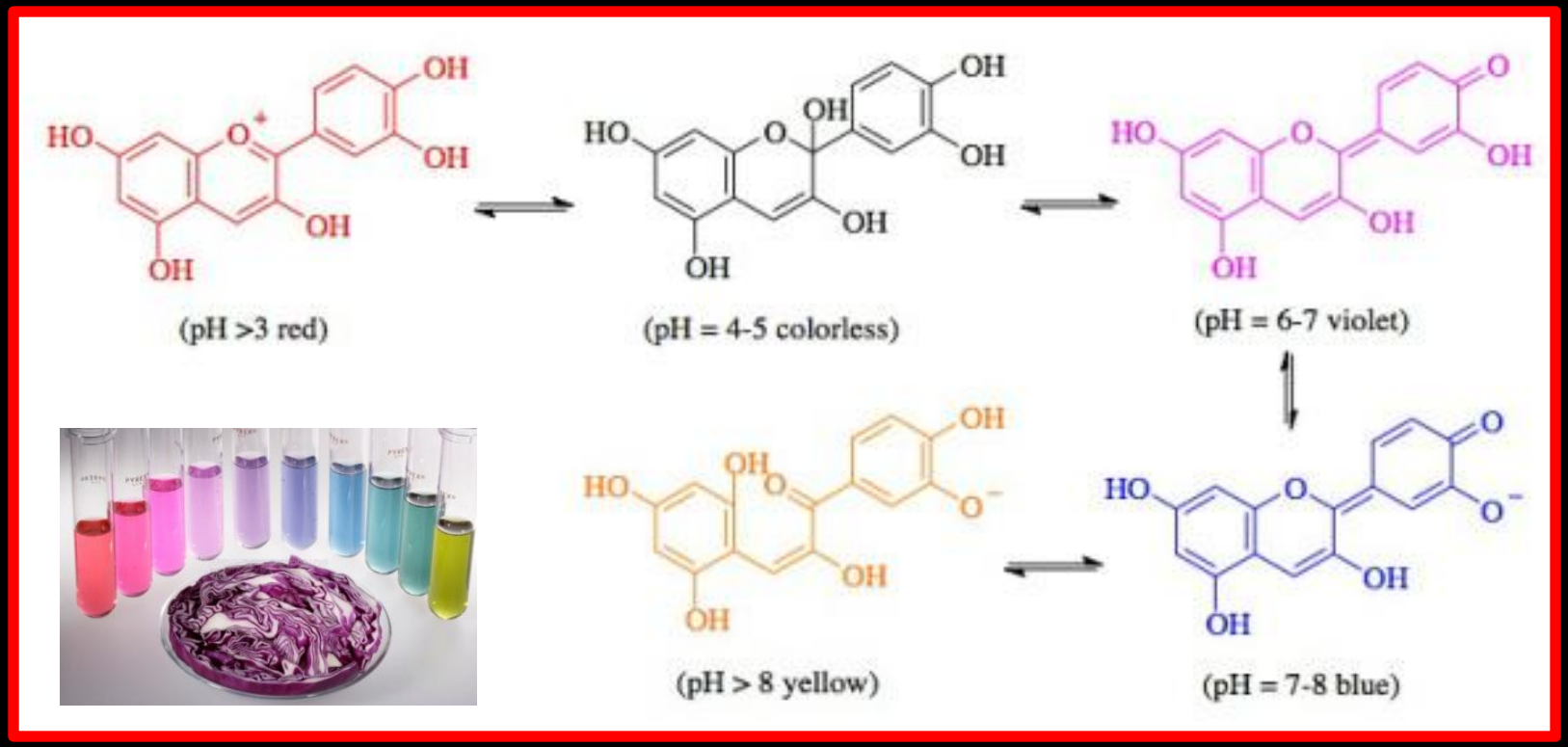
Many Plant Colors (Anthrocyanins) are pH Indicators

Indicators ➔ color depends on pH
Color change ➔ Chemical change

The "colors" in vegetables have significant cancer risk reductions

Hydrangea Basic Soil

Hydrangea Acidic Soil



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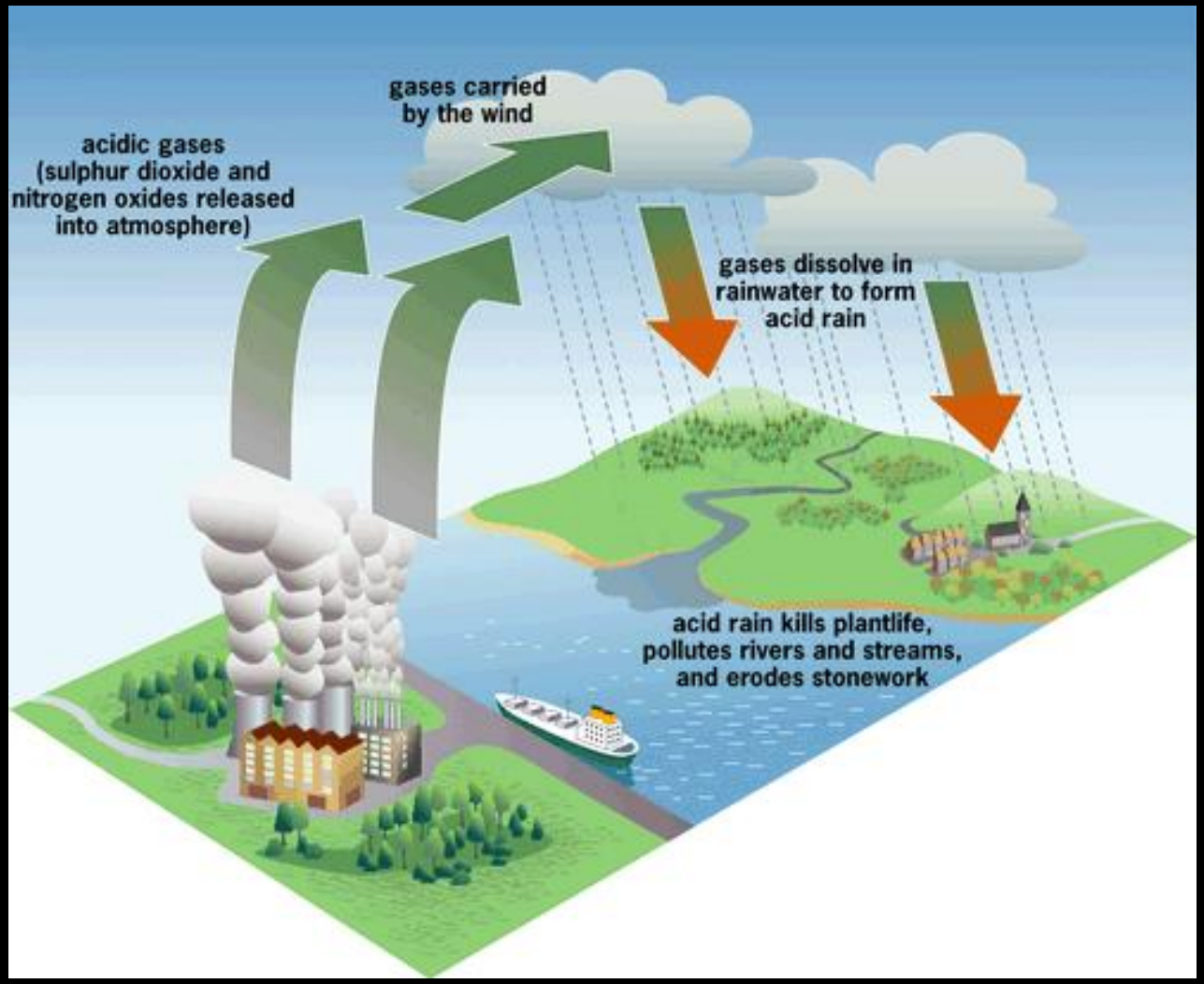
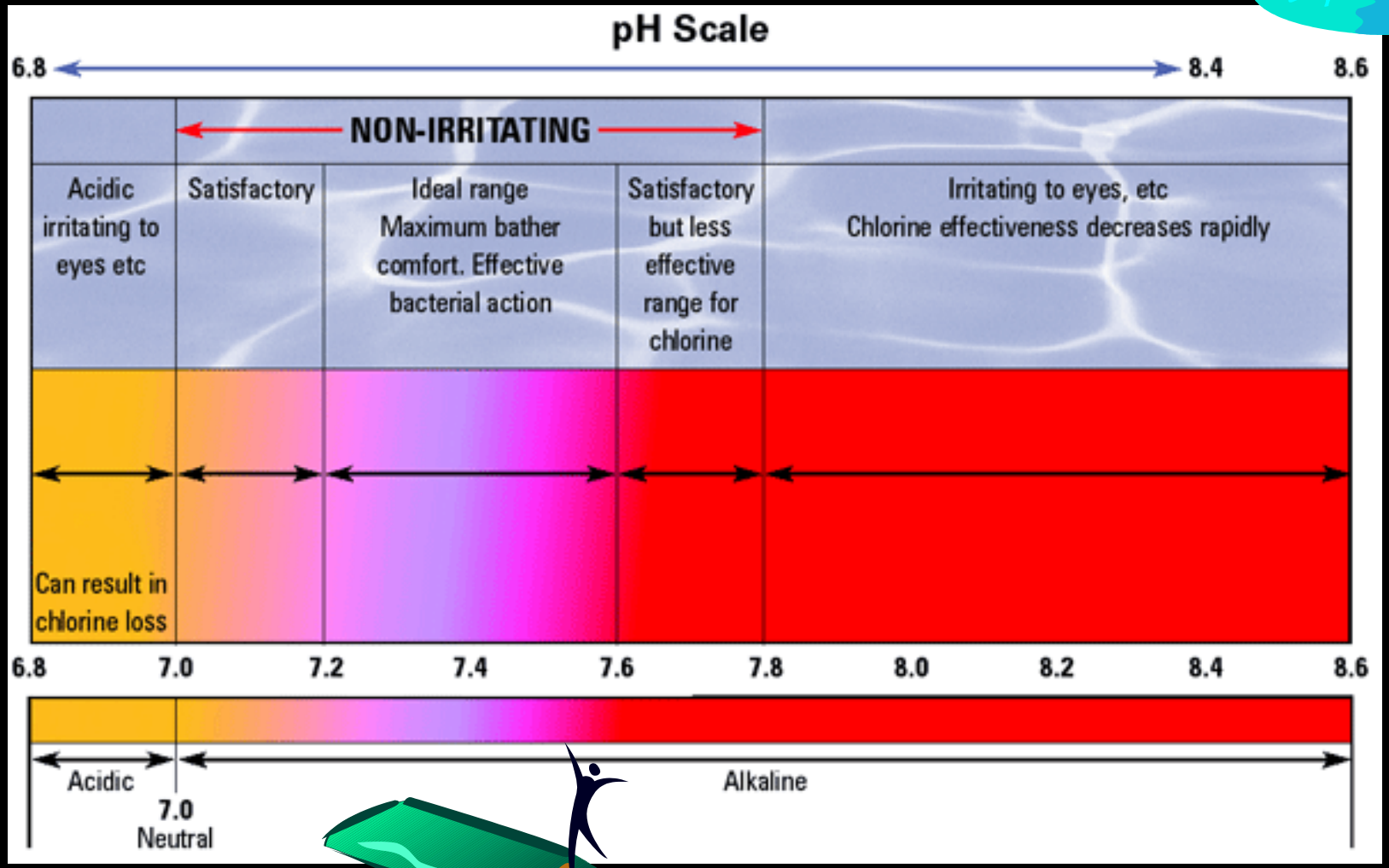
Air-borne Pollution + Water = Acid Rain



Proper pH Keeps Pools Healthy



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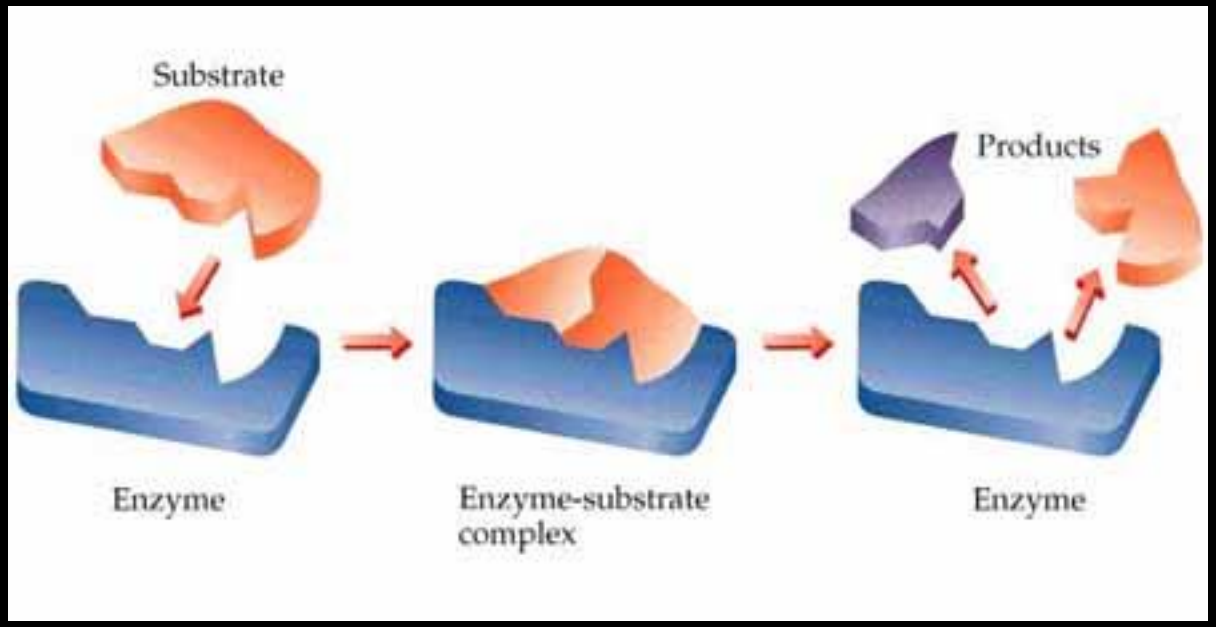
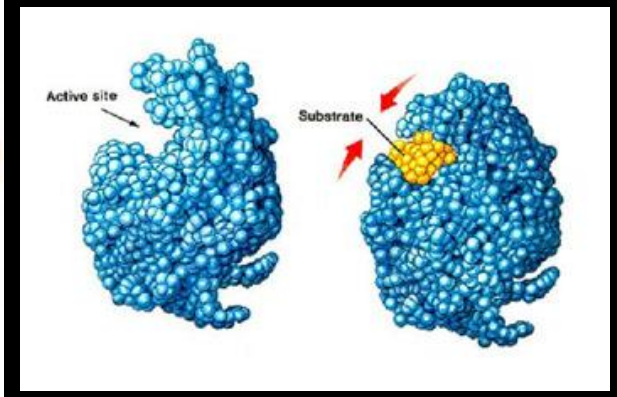
All biochemical reactions have an optimum pH





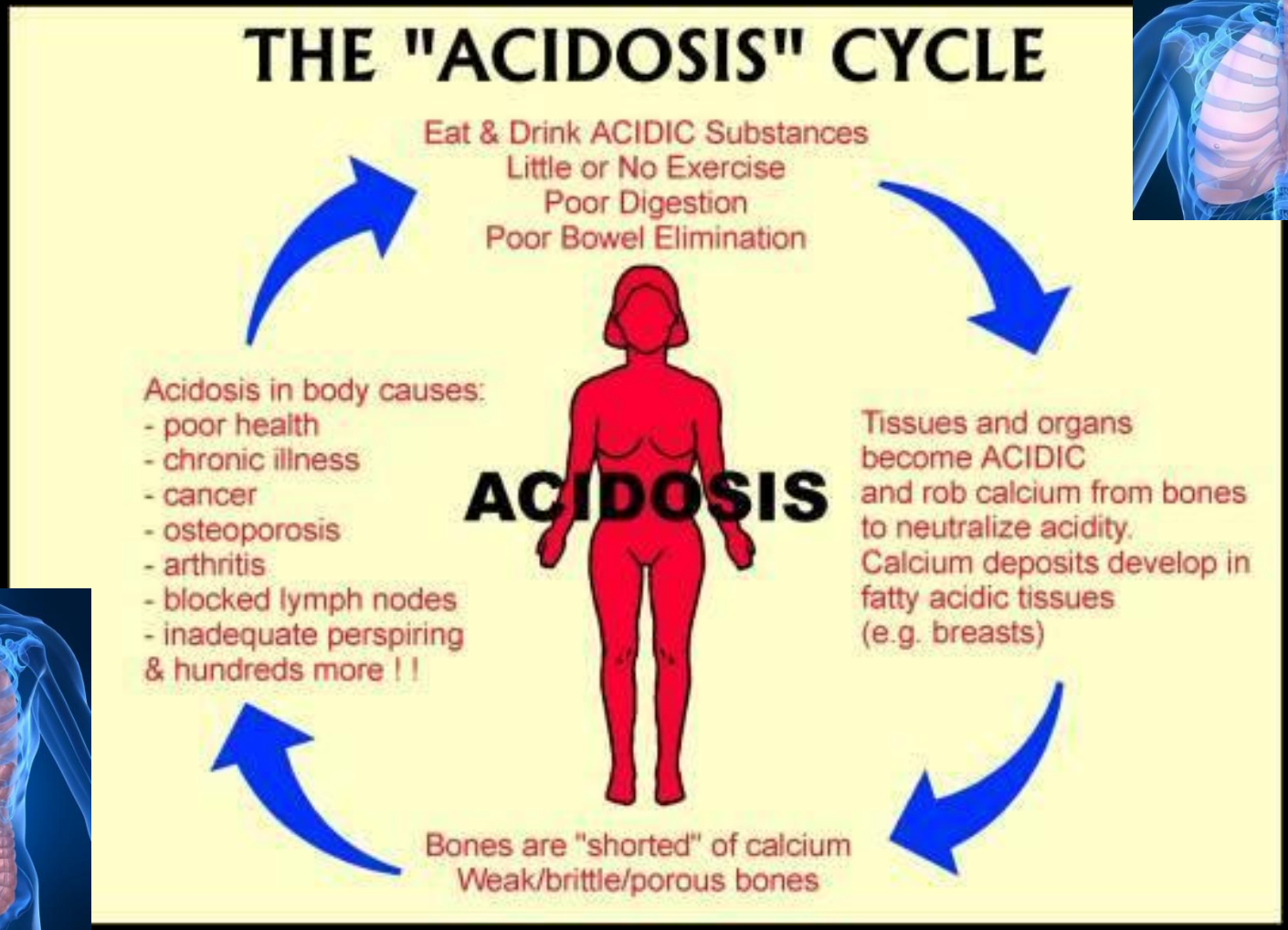
Changes in pH can change protein shape

&

prevent/alter molecular interactions

Many "genetic diseases" result from incorrect protein shapes

Improper pH Balance Has Many Negative Health Consequences



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Proper pH is important to Plant growth

Acids & Bases Lab

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Today's Lab (Work in Pairs)

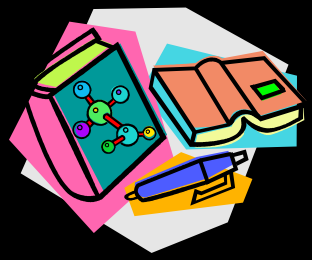
Purpose:

Observe the properties of acids and bases

Use a pH indicator to monitor acidity level

Classify 2 household substances as acids or bases.

Preparation of Indicator Dye
(One Batch per Lab)



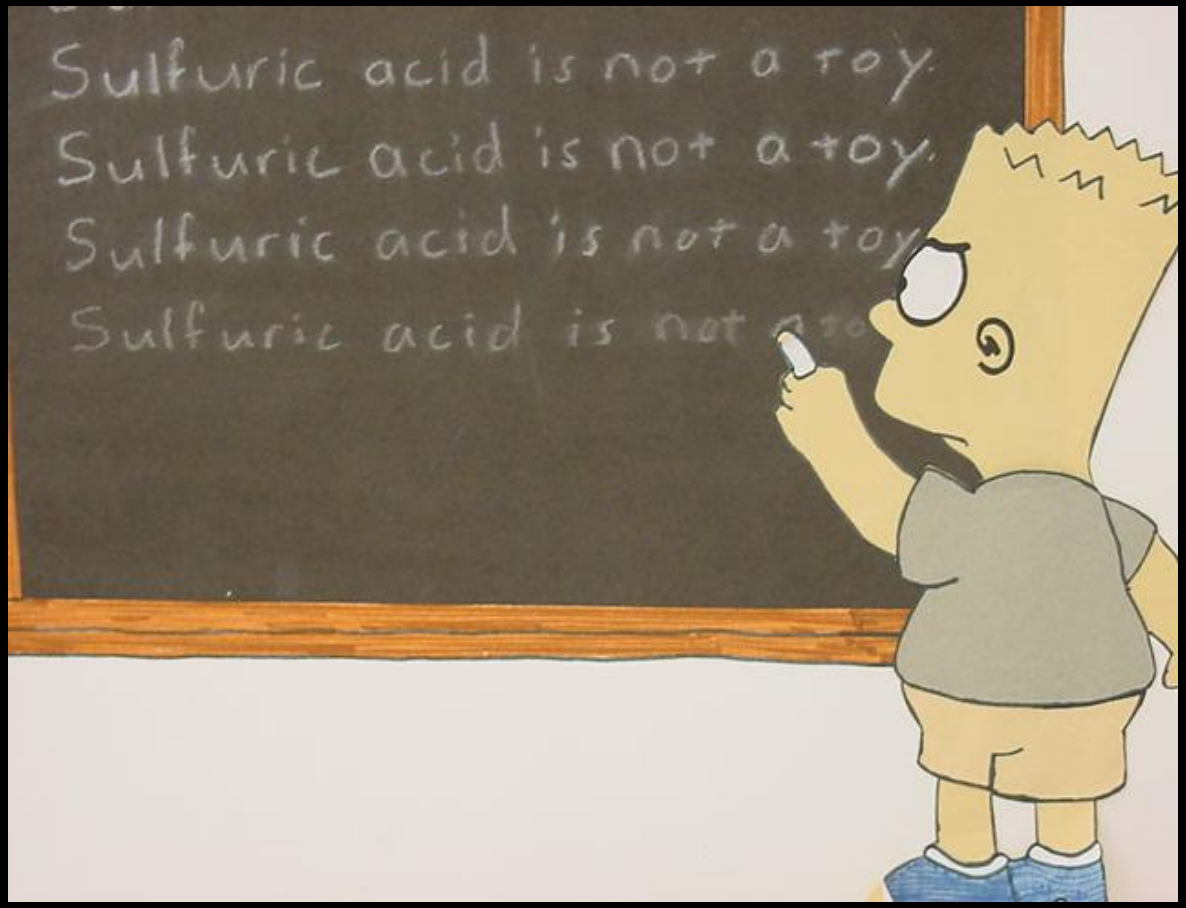
Procedure:

- 500 mL of RO water into a 1-L beaker
- Heat on a hot plate
- When the water boils, add ~2 cups of shredded red cabbage
- Boil for 5 minutes
- Filter with a large Buchner funnel into a clean beaker
- Let the purple indicator solution cool while you do part II

Extract

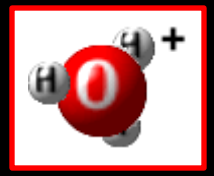
Chemistry department has done this for you!

Handle Acids & Bases With Care!



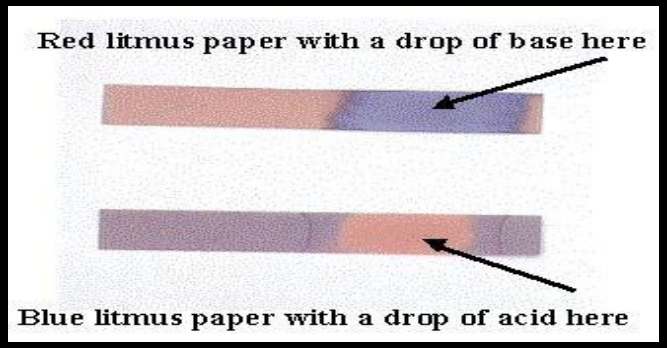
Avoid Contact with acids and bases
Wear your safety goggles
Immediately wash any contact areas with lots of cold water
Notify instructor if you contact any acid or base

Acids & Bases Properties: Litmus



The acids/bases to be tested: HCl, CH_3COOH, NH_4OH, & NaOH

Litmus Test



The main use is to test whether the solution is acidic or alkaline.

	Test with acid	Test with alkali
Red litmus paper	No changes	Red → blue
Blue litmus paper	Blue → red	No changes

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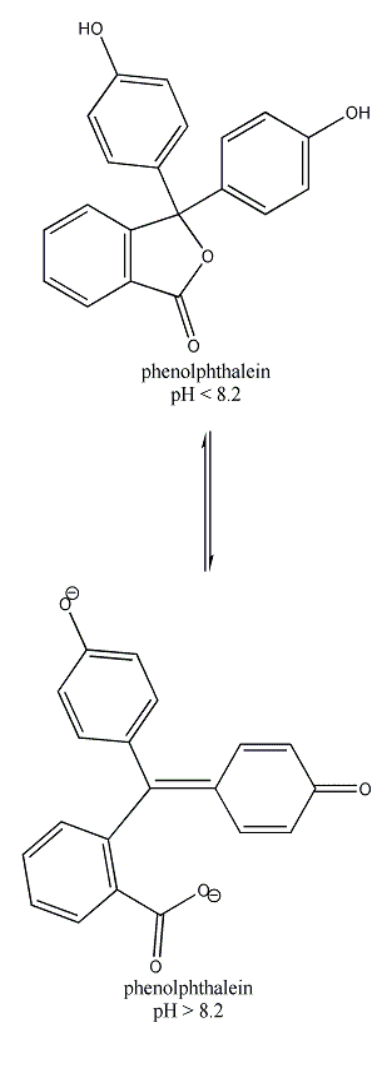
Acids & Bases Properties: Phenolphthalein



One of the most common indicators used

Most common OTC laxative

C.S.I. = used to determine if stain is blood

Kastle-Meyer Spot Test

- Phenolphthalein plus sample
- Add H_2O_2
- Hemoglobin present oxidizes to pink form

OH^- attacks acid form and changes structure

Acid form: colorless

Basic form: magenta

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Acids & Bases Properties: Metals with Acids

Metals	Metal Ion	Reactivity
K	K^+	reacts with water
Ca	Ca^{2+}	
Na	Na^+	
Mg	Mg^{2+}	reacts with acids
Al	Al^{3+}	
Zn	Zn^{2+}	
Fe	Fe^{2+}	
Ni	Ni^{2+}	
Sn	Sn^{2+}	
Pb	Pb^{2+}	
H_2	H^+	
Cu	Cu^{2+}	highly unreactive
Hg	Hg^{2+}	
Ag	Ag^+	
Pt	Pt^+	
Au	Au^{3+}	

Metals Above Hydrogen Produce Hydrogen gas In presence of acid

Mg, Al, Zn, Fe, Ni, Sn, Pb react with acids:

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

Acids & Bases Properties: Metals with Bases

Metals form insoluble hydroxides

Bases react with most metal ions:

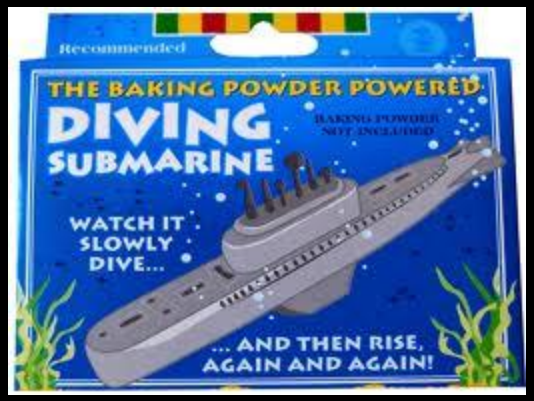
$$2\ OH^-_{(aq)} + M^{2+} \rightarrow M(OH)_{2(s)}$$

Hydroxide Pollution
Difficult to clean

Acids & Bases Properties: Carbonates

Acids react with carbonate ions:

$$2\ H^+_{(aq)} + CO_3^-{}_{(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)}$$



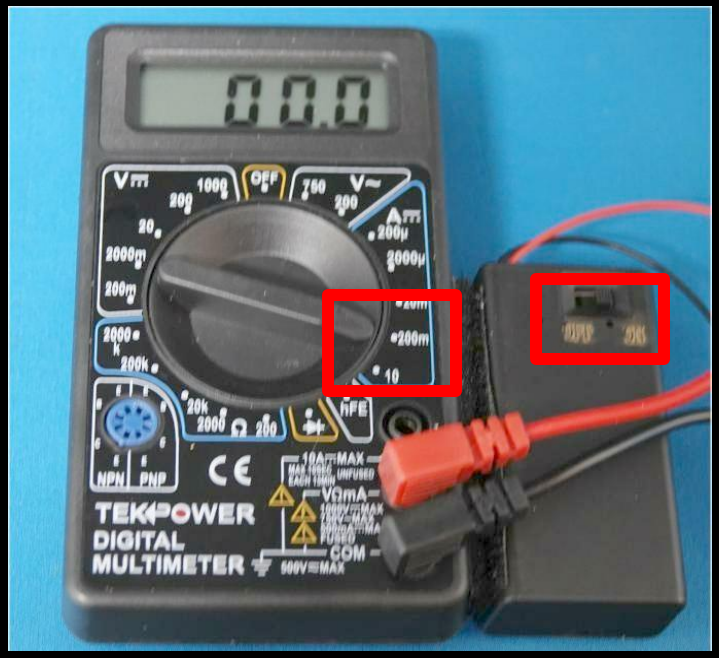
Atmospheric $CO_2 + H_2O \rightarrow H_2CO_3$

Dissolves Carbonates

A major erosion process

Geologists test minerals with HCl:
If it "fizzes," it's a carbonate mineral

Carbonates do not react with bases



Conductivity

Set meter to 200 m

Set battery to On

Insert probes

Metal only in solution

Do not touch glass

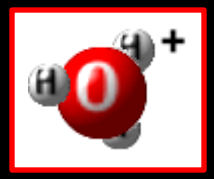
Read meter

Record value

Turn Battery Off

Turn Meter Off

Cabbage Dye Indicator



Use Indicator to infer pH

Test the acidity level of the acids & bases used in Part I & RO water.

Pair A: Test HCl & NH_4OH

Pair B: Test CH_3COOH & NaOH

- **Add two droppers full of the substance to be tested into a small test tube.**
- **Add 3 drops of the cabbage indicator and mix by "flicking" the test**
- **Record the pH of each solution**
- **Combine Results**

pH Indicator Color Chart

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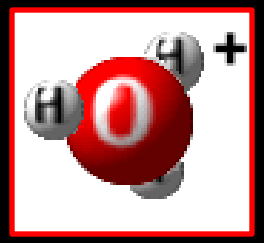
Effect of Concentration on pH (Serial Dilution)



Pair A: Test HCl **Pair B: Test NaOH**

Label the test tubes 1 and 2.

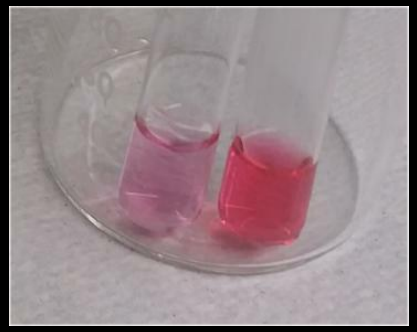
Test tube 1: add 20 drops of acid or base; add 3 drops of the cabbage indicator. Record the color and pH in Table 7.

Dilution of the acid or base:

- **Measure 100.0 mL of distilled water using the graduated cylinder.**
- **Pour it into the clean 150. mL beaker.**
- **Add one drop of the acid or base to the beaker. Stir with a clean stirring rod.**

Test tube # 2: Add 1 mL of the diluted acid or base; add 3 drops of cabbage indicator. Record the color and pH in Table 7.

Exchange data with the other pair in your group to complete Table 7.



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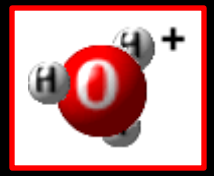
Household Substances



Test 2 Different Household Products (Found in the Hood)

- Put two droppers full of the substance to be tested into a small test tube
- Add 3 drops of the cabbage indicator
- Mix well and then record the color and pH of the substance.
- Classify each substance as acidic, basic or neutral.

Data / Observations / Data Interpretation:

Fill in tables

Conclusion

Summarize the characteristic properties of acids and bases (that you observed).
Describe the relationship between the pH value and the level of acidity in a solution.

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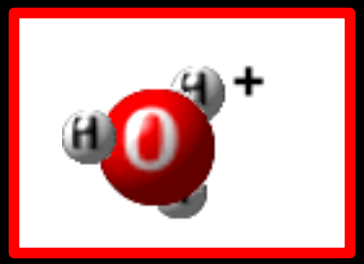
Self-Protolysis of Water

$$H_2O + H_2O \rightarrow H_3O^+ + OH^-$$

Case for: ions present; current flows
Case against: no ions present; no current

Typically, H^+ is ~ 10^{-7} (pH 7)
But,
measurement apparatus sensitivity dependent



Let’s Boldly Go Explore Today’s Lab