BHARATHIDASAN UNIVERSITY

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Programme: M.Sc., Botany

Course Title : CELL BIOLOGY AND BIOINSTRUMENTATION
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Unit – IV
BIOINSTRUMENTATION
Topic: Acids, pH, and Buffers

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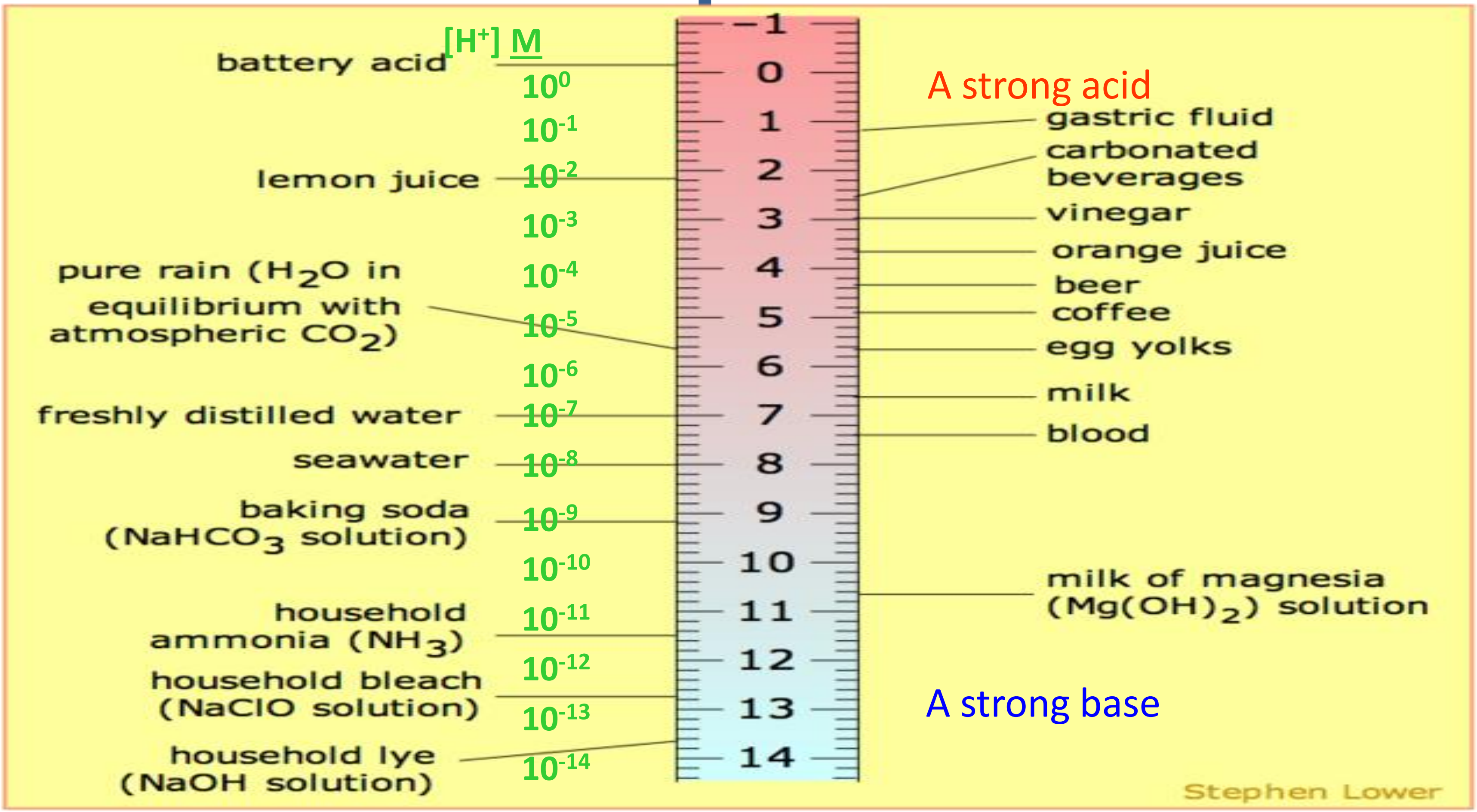
Acids, pH, and Buffers:

What is an Acid?

- An acid is a substance which, when dissolved in water, releases protons.
- The extent of dissociation, that is, the amount of protons released compared to the total amount of compound, is a measure of the strength of the acid.
- For example, HCl (hydrochloric acid) is a strong acid, because it dissociates completely in water, generating free $[H^+]$ and $[Cl^-]$.

- Acidity can be measured on a scale called pH (more scarily, "the negative logarithm of the hydrogen ion concentration")
- pH= -log [H+]
- pH – measure of acidity and alkalinity of a solution

pH



The pH scale goes from 0 to 14—because [H^+][OH^-] = 10^{-14}

- Most living cells have a *very* narrow range of tolerance for pH, i.e. $[H^+]$.
- The $[H^+]$ concentration will be important (either explicitly or implicitly) for many other topics in biology.
- $[H^+]$ is controlled in all biological organisms, and in virtually all biochemical experiments.
- Each pH unit represents a factor of 10 difference in $[H^+]$.

- Acid – proton donor
- Increase H^+
- Base – proton acceptor
- Increase the hydroxide ions (OH^-)
- $pH = -\log [H+]$
- Acids –do not dissociate significantly in water –weak acid

- Some substances, like acetic acid (vinegar!) dissociate poorly in water.
- Thus, they release protons, but only a small fraction of their molecules dissociate (ionize).
- Such compounds are considered to be weak acids.

- Acid dissolves in water to furnish H^+ ions
  - HCl H^+ + Cl^-
  - HNO_3 H^+ + NO_3^-
  - HF H^+ + F^-
- Base dissolves in water to furnish OH^- ions
  - NaOH Na^+ + OH^-
  - KOH K^+ + OH^-
  - NH_4OH NH_4^+ + OH^-

How Can You Actually Determine the pH of a Solution?

- Use a pH meter—read the number.
- Use pH paper (color patterns indicate pH).
- Titrate the solution with precise amounts of base or acid in conjunction with a soluble dye, like phenolphthalein, whose color changes when a specific pH is reached

- Coffee pH 5!
- Vinegar pH 3!

- pH of
- Cola ?
- Lemon juice?
- Your stomach?

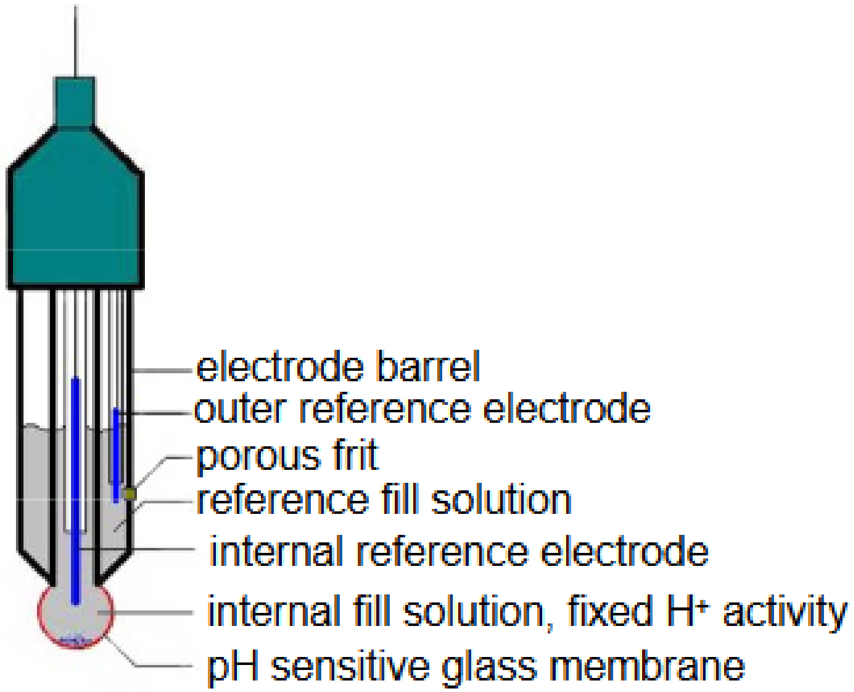
gastric juice	1.0
lemon juice	2.3
vinegar	2.8
orange juice	3.5
coffee	5.0
milk	6.6

blood	7.4
tears	7.4
seawater	8.4
milk of magnesia	10.6
household ammonia	11.0

pH

- pH is a Unit of Measurement
  - pH = Power of Hydrogen (H^+)
  - Defined as the Negative Logarithm of Hydrogen Ion Activity
    - pH = log ($1/H^+$)
- Used for Determining the Acidity or Alkalinity of an Aqueous Solution
  - Practical pH Scale for Industrial Instrumentation
    - 0 - 14 pH

pH electrode



http://upload.wikimedia.org/wikipedia/commons/e/e9/Glass_electrode_scheme.jpg

pH Sensor Components

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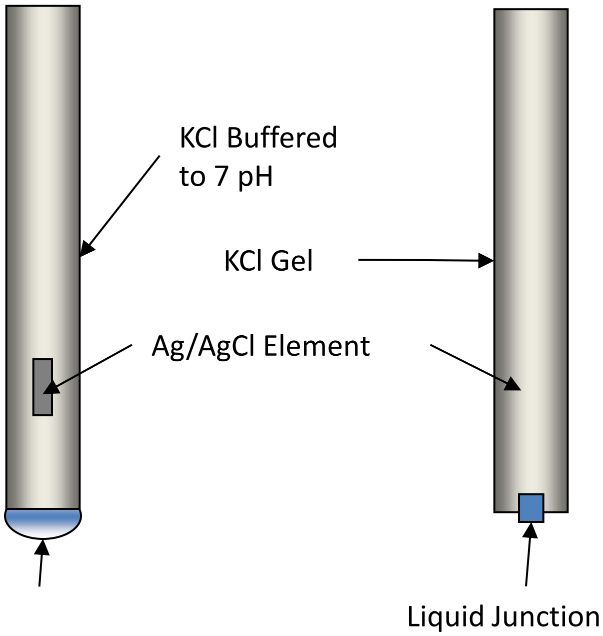

- The Measuring System consists of a pH Measuring Electrode and Reference Electrode
- The Potential Difference Between the Two Electrodes is a Function of the pH Value of the Measured Solution
- The Solution Must Be Conductive and is Part of the Electrical Circuit

- pH Measuring Electrode
  - Purpose is to Develop a Millivolt Potential Directly Proportional to the Free Hydrogen Ion Concentration in an Aqueous Solution
- Reference Cell
  - Purpose is to Maintain a Constant Reference Potential Regardless of pH Change or Other Ionic Activity in the Solution
- Reference Cell Liquid Junction
  - Purpose is to Maintain Electrical Contact Between the Reference Electrode and the Measuring Electrode by way of the Solution

- Lithium Ions in the pH sensitive glass act as current carriers
- Positive Charged Free Hydrogen Ions (H^+)Develop Positive mV Potential Relative to Internal Buffer
  - Acidic Solutions
- Fewer Hydrogen Ions Relative to Internal Buffer Produce a Negative mV Potential
  - Alkaline Solutions

The Hydration of Carbon Dioxide in Water

$CO_2 + H_2O$

$\rightleftharpoons$ $HCO_3^- + H^+$

H_2CO_3

As carbon dioxide goes into solution, carbonic acid is formed, which partially dissociates, liberating protons (H^+) and thus causing the solution to become more acidic, i.e., *lowering* the pH.

Buffer

- **Mixture of an acid and its conjugate base**
- **<u>Buffer solution</u> $\rightarrow$ resists change in pH when acids or bases are added or when dilution occurs**

Buffer

- A **buffer** is a solution of a weak acid and its conjugate base that resists changes in pH in *both* directions—either up or down.
- A buffer works best in the middle of its range, where the amount of undissociated acid is about equal to the amount of the conjugate base.

- pH control is important, as many enzymes have a narrow range in which they function optimally.
- Buffering capability is essential for the well-being of organisms, to protect them from unwelcome changes in pH.
- For example - stomach is about pH 1, yet the adjacent portion of your intestine is near pH
- Many compounds and macromolecules in addition to bicarbonate can serve a buffering function—proteins comprise one of the major class

- Acidic buffers - combination of weak acid and its strong base
- Basic Buffers – combination of weak base and its strong acid

- Thank You