

- 1 Introduction to Themes and Basic Chemistry
- 2 The enduring unifying themes in biology:
 - There is order! Hierarchy of organization
 - Emergent properties: the sum is greater than the parts.
 - Cellular basis of life
 - Heritable information
 - A feeling for organisms-flow and structure
 - Correlation between structure and function (FFF: form fits function)
- 3 The enduring unifying themes in biology (cont):
 - Interactions of organisms and their environment
 - Unity in diversity
 - Evolution is the core process
 - Scientific inquiry: a way to investigate questions
- 4 hierarchy
 - Each level builds on the levels below it
 - Complex organism has organ systems.
 - Organ systems are interacting organs.
 - Organs are made of coordinating tissues.
 - Tissues are made of related cells and noncellular materials.
 - Cells have organelles or regions.
 - Organelles have molecules which have functional groups and structure made of atoms.
- 5 Upper levels of hierarchy
 - A population is made of organisms of same species
 - Interacting populations form communities
 - Interactions between communities and their environment are ecosystems
 - Ecosystems (having distinctive organisms due to climate) found within a specified climate and latitude characterize a biome
 - All the biomes and the flow of resources between them form the biosphere.
- 6 Emergent properties
 - Properties that results from the interactions between components
- 7 Emergent properties associated with life
 - Order
 - Reproduction

- Growth and development
 - Energy utilization
 - Homeostasis
 - Response to environment
 - Evolutionary adaptation
- 8 **order**
- organisms are highly ordered and other characteristics of life emerge from this complex organization
- 9 **reproduction**
- Organisms reproduce like organisms; biogenesis.
- 10 **Growth and development**
- Heritable programs stored in DNA direct the species specific pattern of growth and development
- 11 **Energy utilization**
- Organisms take in and transform energy to do work, including the maintenance of their ordered state
- 12 **homeostasis**
- Organisms regulate their internal environment to maintain a steady-state, even in the face of a fluctuating external environment
- 13 **Response to environment**
- Organisms respond to stimuli from their environment
- 14 **Evolutionary adaptation**
- Life evolves in response to interactions between other organisms and their environment
- 15 **Holism vs reductionism**
- Holism: a higher level of order cannot be meaningfully explained by examining component parts in isolation
 - Reductionism: a complex system can be understood by studying its component parts
 - Neither is adequate on its own to fully understand biology
- 16 **Cells are an organism's basic unit of structure and function**
- Lowest level of structure capable of performing all activities of life
 - All organisms are composed of cells
 - May exist singly as unicellular organisms or as subunits of multicellular organisms
 - MICROSCOPES
 - Cell theory: Schleiden and Schwann
 - Prokaryotes vs eukaryotes
- 17 **Continuity of life is based on heritable information in the form of DNA**
- 4 nucleotides based on 4 nitrogenous bases

- Gene is the unit of inheritance
 - Inheritance is based on complex mechanism for copying DNA
 - The copy must be passed on from generation to generation
 - All forms of life have the same 4 nucleotides
 - Differences are a reflection of the order of the nucleotides
- 18 **Organisms are open systems that interact continuously with their environments**
- Both organism and environment are affected by the interaction between them
 - Ecosystem dynamics include 2 major processes: nutrient cycling and energy flow
- 19 **Diversity and unity of organisms**
- There are between 5 million and 30 million different species on the Earth
 - There is a universal genetic code
 - They all have similar metabolic pathways
 - They all have similarities of cell structure
- 20 **Evolution is the one unifying theme in biology**
- Species change over time
 - Similar species have a common ancestor
 - Less closely related species diverged longer ago from their common ancestor
 - A mechanism of evolutionary change is natural selection
 - Natural selection does not create adaptations; it increases the frequency of inherited variants that arise by chance
 - Descent with modifications
- 21 **SCI is to KNOW**
- Science is a way of knowing
 - Inquiry is a way of questioning and looking for answers
 - Scientific method is a series of steps to help clarify the question and elucidate the answer
 - Hypothesis is a guess based on previously acquired information
 - One hypothesis is just one possible answer or explanation for a question that may have many possible answers
 - Hypotheses may be rejected, but not supported with absolute certainty.
- 22 **Science and technology are interdependent**
- Technology extends our ability to observe and measure
 - Technology allows us to ask more questions and more specific questions
 - Science generates new possibilities for technology
- 23 **Chemistry Review**
- Life needs about 25 elements, CHON are main part 96% of living matter
 - Other elements include Ca, P, K, S, Na, Cl, Mg
 - Trace elements are REQUIRED for life in minute quantities B, Cr, Co, Cu, F, I Fe, Mn, Mo, Se, Si, Sn, V, Zn

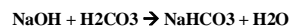
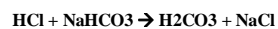
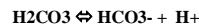
- 24 **Isotopes**
- Atoms with same atomic number by different mass number
 - Different isotopes of the same element react chemically the same way
 - Some are radioactive
 - Applications include determining reactions, rate of reactions, structure, locate compounds in body, diagnose disease, treat cancer
- 25 **Valence Electrons**
- Those that are involved in bonding in outermost orbital
 - Octet rule contributes to understanding of what kind of bonds are likely to form
 - Most life is bonded covalently
 - Hydrogen bonding, Van der Waals forces and hydrophobic interactions are not bonds, but are important ways that molecules retain structure and function
- 26 **Weak Chemical Attractions**
- Make chemical signaling possible in living organisms
 - Can bind briefly and reversibly
 - Can form between molecules or between different parts of a single large molecule
 - Help stabilize the 3 dimensional shape of large molecules (DNA and proteins)
- 27 **Chemical Reactions**
- Most chemical reactions in body are reversible; some are complete
 - Many biological activities depend on chemical equilibriums and buffering reactions
- 28 **Water contributes to the fitness of the environment to support life**
- Life probably evolved in water
 - Living cells are about 70-90% water
 - Water world
 - Water exists in all 3 states on planet
 - Water's properties are emergent properties resulting from its structure and molecular interactions
- 29 **Water molecules form H bonds**
- 30 **Properties of Water**
- Cohesion; adhesion
 - High specific heat
 - High heat of vaporization
 - High evaporative cooling
 - Less dense as a solid (most dense at 4C)
 - Polar solvent
 - High viscosity
- 31 **Dissociation of Water Molecules**
- $\text{H}_2\text{O} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-$

- Pure water at 25C dissociates 10^{-7} moles
- Only 1 out of 554,000,000 water molecules dissociates
- Acids have more hydronium than pure water; bases less hydronium ions
- pH and pOH scales are logs that range from 0-14
- Each increment on the pH or pOH scale is an order of magnitude-10x

32 Buffers

- Minimize wide fluctuations in pH helping to maintain homeostasis (most life narrow range from 6-8 pH)
- Are combinations of H^+ donor and H^+ acceptor forms of weak acids or bases
- Work by accepting H^+ ions from solution when they are in excess, and by donating H^+ ions to the solution when they are depleted

33 Bicarbonate buffer



34 Acid Rain

- Buffers or lack of buffers
- Yorktown formations vs Sandy Bottom State Park

35 Organic Chemistry

- Specializes in the study of carbon compounds
- 4 valence electrons $1s^2 2s^2 2p^2$
- Bonds covalently
- Most commonly bonds in organic molecules to C, H, O, N

36 Chemical vs structural formulas

- Structure can vary in length, straight or branched, bonds, rings and placement of functional groups
- Hydrocarbons: only H and C
- Hydrocarbons are hydrophobic
- Fats have hydrocarbon chains

37 Isomers

- Structural- difference in carbon skeleton
- Geometric- functional groups rotate around a db bond
- Enantiomers- mirror images that form around an assymmetric carbon
- cis, trans, lynx, dex

38

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40 Most common functional groups

- Hydroxyl -OH
- Carbonyl -CO
- Carboxyl -COOH
- Amino -NH₂
- Sulfhydryl -SH
- Phosphate -PO₄
- Methyl -CH₃

41 Hydroxyl

- Polar
- Water soluble
- Forms alcohols

42 Carbonyls: aldehydes and ketones

- Polar
- Water soluble
- Sugars
- Terminal- aldehyde
- Within skeleton-ketone

43 carboxyl

- Polar and water soluble
- Hydrogen reversibly dissociates as H⁺ acid

44 Amino group

- Polar and water soluble
- Weak base can accept proton
- amines

45 sulfhydryl

- Stabilize protein structures
- thiols

46 phosphate

- Loss of 2 protons – acid

- Polar and soluble in water
- Important in energy in cell (ATP)

47 methyl

- NONpolar not water soluble
- R-CH₃