

a Paradigm's or Key Concepts

a paradigm is a currently accepted, outstanding clear model, or archetypal example of the interpretation of the data.

it is the current set of practices that define a scientific concept...

what has been observed,
the kinds of questions asked,
and how the data should be interpreted.

it is the outstanding clear current model,
and what we should learn.

Key Concepts - Scientific Method

Scientific Method in Biology - Paradigm Concepts:

1. Biology explores Life and its properties
2. Biology uses many forms of INQUIRY to study Life
3. Science (Biological Science) is experimentally testable
4. Scales (spatial & temporal): questions arise on different scales (NRC #23)
5. What is included (the systems variables) depends upon the questions addressed, as does the hierarchical level in which the problem is framed (e.g. molecular, cellular, organismal) (NRC #24)
6. There are only a few basic data types - numerical, ordinal, categorical - but these may often be interconnected & expanded (e.g., as vectors or arrays) (NRC #39)
7. Consistency of the units with which one measures a system is important (NRC #40). Precision is important with measuring physical quantities, units, time/ length /mass (NRC # 86)
8. A variety of stat methods exist to analyze data sets and make comparisons(NRC #41)
9. There are diverse methods to display data, simple line graphs are often not sufficient, nonlinear transformations (NRC #44-45)
10. a SCIENTIFIC THEORY that has stood the test of time is a TRUTH.

Key Concepts - Unity of Life

Paradigm Concepts about Life:

1. Life exists from the microscopic (cell) to the global level (ecosystems)
2. Organisms include a great diversity of species
3. Evolution accounts for Life's Diversity and its Unity
4. Biological systems (Life) is much more than the sum of its parts
5. Biologists use scientific method & hypothesis-based testing to explore life
6. There are several THEMES that connect the CONCEPTS of Biology & Life

Key Concepts - Properties of Life

Unifying Themes & paradigm Concepts of Biology of Life:

1. Cell - Cell Theory is basis of all known life
2. Heredity - DNA is basis of inheritance & information transfer
3. Emergent Properties - interaction and complexity lead to unexpected properties
4. Regulation - maintains a steady state (homeostasis) far from equilibrium
5. Interactions with environment - cells exchange matter/energy with surroundings
6. Energy - all cells perform work requiring energy (mechanical, osmotic, electrical)
7. Unity/Diversity - similar molecules, Genetic Code vs. 3 Domains
8. Evolution - core theme allows adaptations to environs via reproductive success
9. Structure - form/function are correlated at all levels of biological organization
10. Scientific Method - observational based discovery & hypothesis testing

Key Concepts - Chemistry

CHEMISTRY - some paradigms:

1. **Matter** consists of chemical elements in pure form & in combinations called compounds
2. An **element's** properties depends upon
 - a. number of protons & neutrons in its nucleus
 - b. number of electrons in its orbital shells (outermost = valance shell)
3. Atoms with incomplete **valance shells** can form chemical bonds by sharing, gaining or losing electrons
 - a. in a covalent bond 2 atoms share a pair of electron
 - b. an ionic bond is the attraction between oppositely charged ions
 - c. weak bonds include hydrogen bonds and van der Waal's interactions
4. Metabolism is **CHEMICAL REACTIONS**, which **MAKES/BREAKS** chemical bonds.

WATER - Key Concepts

1. Water has a **tetrahedral shape**, which influences in physical properties
2. **Polarity** of water is due to **hydrogen bonds**
3. Four emergent properties of water (all due to H-bonds)
 - cohesion**
 - solvency**
 - temperature** (Specific Heat & Heat of Vaporization) provide insular properties (resistance to heat change in large bodies)
4. Dissocaiotn of water leads to acid/base consitions that affect life (**pH**)

Key Concepts - Organic Chemistry

Chemical Makeup of Life Paradigms -

1. Organic Chemistry - carbon compounds are the basis of life's molecules
2. Carbon atoms can form 4 covalent bonds, making the complex molecules of life
3. Functional groups are key to the chemical reactivity of life's molecules
4. Life's molecules are **POLYMERS**
 - a. Carbohydrates's fuel life,
 - b. lipids are hydrophobic,
 - c. proteins have multiple shapes resulting in broad functionality,
 - d. nucleic acids store hereditary information.

Key Concepts - Cells

ancient prokaryotic bacteria (**Archaea**) and moderns (**Eubacteria**) both lack significant membrane structure

Gram +/- staining differentiate bacterial wall structure

eukaryotic cells have internal membranes that compartmentalize thier functions

eukaryotic genetic info is housed in a membrane encapsulated nucleus

the endomembrane system regulates protein traffic and performs metabolic fuctions

mitochondria & chloroplasts change energy from one form to another

the cytoskeleton is a network of protein fibers that organize cell structures and activities

extracellular components and conneciosn between cells help coordinate cellular activity

virus genome can only reproduce within a host cell

Key Concepts - Organelles

Eukaryotic Organelles Key Paradigms -

1. Study of cell & organelles requires use of microscopes & many biochemical analyses
2. Eukaryotic cells have internal membranes and compartmentation
3. Genetic information is housed in the cell's nucleus
4. Endomembrane system regulates protein trafficking and the metabolic functioning of cells
5. Mitochondria/Chloroplasts convert energy from one molecular form to another
6. Cytoskeleton is a protein fiber network that provides form & function to a cell
7. Extracellular matrix and intercellular connections help coordinate the multicellular activities of cells.

Key Concepts - Membranes

Cell Membranes - Paradigms

1. Cell membrane is a fluid mosaic made of proteins and lipids
2. Cell membrane is selectively permeable, regulating molecular transport in/out
3. Passive diffusion (high-low) requires no expenditure of cell energy
4. Active transport (low-high) requires energy, often ATP hydrolysis or cotransport
5. Bulk transport (large pieces of molecules) occurs via exo/endocytosis.

Key Concepts - Cell Communication

Cell Communication - paradigms

1. External molecular **SIGNALS** (molecules as hormones) trigger intracellular responses
2. **RECEPTION**: signal molecules bind to cell membrane receptor proteins causing shape changes and subsequent metabolic reactions
3. **TRANSDUCTION**: cascades of molecular relay reactions convert inactive/active forms of molecules and vice versa
4. **RESPONSE**: cell signals lead to regulation of cytoplasmic activities and/or gene transcription.

Key Concepts - Metabolism

Metabolism - Paradigms.

1. Cell metabolism transforms matter & energy in accord with Laws of Thermodynamics (NRC#2 & #94-95)
2. Living systems are far from equilibrium. (NRC#5)
3. Release of Free Energy indicates that a cellular reaction will occur spontaneously
4. ATP hydrolysis powers cellular work by making and/or breaking chemical bonds
5. a Coupled Reaction works by linking the exergonic release of energy to an endergonic cellular reaction (NRC#5)
6. Enzymes regulate rates of metabolic reactions
7. Enzymes function by lowering the Energy of Activation of a reaction (its inertia)
8. Michaelis-Menten kinetic define enzyme action
9. K_m is measure of affinity of enzyme for its substrate. V_{max} is enzymes maximum velocity
10. Regulation of Metabolism is via controlling the rate of enzyme reactions via subtle changes in the shape and efficiency (K_m) of enzymes.

Key Concepts - making ATP

Making ATP - Paradigms

1. **Cell respiration** uses 3 catabolic pathways to oxidize sugars to yield energy as ATP
 - A. **Glycolysis**: in the cytosol, anaerobically converts (oxidizes) glucose to pyruvate makes 2 ATP (net) & 2 NADH. Subsequent pathways include: fermentations producing lactate or ethanol while recycling NADH
 - B. **Citric acid cycle (Krebs cycle)**: in mitochondria; occurs in 2 steps aerobically: 1st: conversion of pyruvate to acetyl-CoA by PDH, 2nd: which is oxidized to CO₂ by cycle enzymes that make 3 NADH, 1 FADH₂, & 2 GTP; couple electron transport & ATP synthesis.
 - C. **Oxidative phosphorylation**: inner mitochondrial membranes - passages of electrons thru protein carriers to O₂ forming water; protons are pumped to perimitochondrial space creating a proton gradient for ATP synthesis
2. **ATP Synthase** is a multienzyme complex that converts the energy of a hydrogen ion gradient to the phosphorylation of ADP
3. **Glycolysis and Krebs cycle** are key intermediary pathways of all other metabolic pathways.

Key Concepts - Photosynthesis

Photosynthesis - Paradigms.

1. Photosynthesis converts light energy (photonic electrons) into chemical bond energy
2. Light reactions convert light energy into ATP/NADPH
3. Calvin Cycle uses ATP/NADPH to reduce CO₂
4. C4 cycles (Hatch-Slack & CAM) reduce CO₂ to organic acid, then again to PGA without presence of photorespiration's interference.

Key Concepts - Cell Cycle

The CELL CYCLE

1. asexual cell division results in genetically identical progeny cells
2. the 3 phases of life cycle of a cell are:
 - a. Interphase (G1 - S - G2)
 - b. mitosis - nuclear division
 - c. cytokinesis
3. the cell cycle is controlled by regulatory (kinase active) proteins & passes through Checkpoints

Summary of MEIOSIS

1. Nuclear division phase of sexual cell reproduction
2. Two successive divisions, results in 4 daughter cells... Meiosis 1 and Meiosis 2
3. Reduction/division occurs... diploid ----> haploid daughter cells ½ number of parent chromosomes
4. Stages have same nomenclature as Mitosis: prophase, metaphase, anaphase, telophase,
5. Only one S phase, where DNA is duplicated often may be no interphase between M1 & M2
6. Homologs separate in Meiosis 1
Chromatids separate in Meiosis 2 (mitotic-like)
7. Random Assortment occurs..... homologs align at equatorial plates independent of each other
8. Crossing over... may occur in Prophase I...
synapsis: pairing homologs allows exchange
chiasma: point exchange of sister chromatids

Key Concepts - Mendelian Genetics

Genetics & Inheritance

1. Mendel used scientific methodology to identify 2 Laws of Inheritance
 - a) Law of Segregation - genes separate during gamete formation
 - b) Law of Independent Assortment - gene sort independent of each other
2. Statistical Probability governs Mendelian Inheritance
3. many human traits obey Mendel's Laws

Molecular Genetics

1. DNA is the genetic material
2. genes specify proteins via transcription & translation
3. eukaryotic cells modify RNA after transcription
4. mutations may affect protein structure & function
5. individual bacteria respond to environmental change by regulating their gene expression
6. chromosome structure is based upon successive levels of DNA packing
7. gene expression in eukaryotes is regulated at many levels, but key step is transcriptional control
8. eukaryotic genomes contain much noncoding DNA
9. duplications, rearrangements, & mutations of DNA contribute to genomic evolution
10. DNA cloning can produce multiple copies of genes
11. entire genome can be mapped at DNA level

Key Concepts - Animal Physiology

ANIMAL STRUCTURE & FUNCTION Paradigms

Chordates have a notochord
and a dorsal, hollow nerve cord

Vertebrates are craniates that have a backbone

Craniates are chordates that have a head

Vertebrates contain 4 major tissues:
epithelial, connective, nerve, and muscle

Blood is a connective tissue
with cells suspended in plasma

The endocrine system and the nervous system act individually and together in regulating an animal's physiology

Key Concepts - Development

REPRODUCTION and DEVELOPMENT

1. gametes are formed via MEIOSIS in specialized tissues
2. fertilization depends on molecular recognition between sperm & egg of same species
3. development proceeds in continuous steps: cleavage, gastrulation, & organogenesis
4. morphogenesis in animals involves changes in cell shape, migration, and adhesion
morphogenesis in plant depends more upon plane of cell division
5. all cells have the same genetic potential, i.e., they are totipotent or pluripotent
6. cells differentiate via differential gene activity

Key Concepts - Neurophysiology

NEUROPHYSIOLOGY PARADIGMS

Nervous systems consist of circuits of neurons and supporting cells

Ion pumps and ion channels maintain the resting potential of a neuron

Action potentials are the signals conducted by axons

Neurons communicate with other cells at synapses via chemical diffusion of neurotransmitters

Key Concepts - Sensory Physiology

SENSORY PHYSIOLOGY & MUSCLE PHYSIOLOGY

Sensory receptors transduce stimulus energy and transmit signals to the central nervous system

The mechanoreceptors involved with touch detect changes by deflection of hairs in response to force

Similar mechanisms underlie vision throughout the animal kingdom

Muscles move skeletal parts by contracting

AP is 2-3 msec and muscle twitch 50-100 msec
muscle are typed by contraction time

slow twitch - 100 msec - type 1 - aerobic

fast twitch - 50 msec - type 2a/2x - anaerobic

