AP Biology Rapid Learning Series – Course GuideBook

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Chemistry : Biology : Physics : Math

RL211 - AP Biology Rapid Learning Series

Course Overview

Welcome to the world of Biology. Biology is the study of life. Life comes with various shape, size and color, but they share a number of characteristics: organization, energy use, reproduction, growth, response to stimuli and homeostasis. The purpose of study biology is to understand how life is formed, reproduced and function in various environments, therefore it is possible to provide better living conditions for humans.

Tutorial Series Summary

Core Unit I: AP Biology Basics

Tutorial 01 – Introduction to AP Biology

- What AP Biology is
- The Scope of AP Biology
  - I: Molecules and Cells
  - II: Heredity and Evolution
  - III: Organisms and Populations
- How to Study AP Biology
- What the AP Exam is
- AP Study Tips
- AP Exam Tips

Tutorial 02 -- The Science of Biology

- What is Biology?
- Basic Theories on Biology
- The diversity of life
- Branches of Biology
- Methods to study Biology

Core Unit II: Molecules and Cells

Tutorial 03 -- Chemistry Basis of Life

- Atoms and Chemical Bonds
- Organic Chemicals
- Acids, Bases and buffers
- Biochemical reactions

Tutorial 04 -- Macromolecules in Organisms

- Carbohydrates
- Proteins
- Lipids
- Nucleic Acids

Tutorial 05 – Cells and Membranes

- Definition of a cell
- How the cell maintains life using organelles
- Organelle --structures and functions
- How the plasma membrane provides a stable internal cell environment
- Cell membrane composition

Tutorial 06 -- Cell Communication and Cycle

- Cell communication
- Chemical signal
- Signal reception
- Signal transduction
- Signal Amplification
- Cell cycle

Tutorial 07 -- Metabolism and Cellular Respiration

- Metabolism
- Anabolism pathways
- Catabolism pathways
- The energetics of biological reactions
- The management of cell resources
- How cells use cellular respiration to produce ATP
- Aerobic respiration
- Anaerobic respiration

Tutorial 08 -- Photosynthesis

- Importance of photosynthesis
- Process of photosynthesis
- Light Reaction
- Dark reaction
- Photorespiration
- C3 and C4 pathways

Core Unit III: Heredity

Tutorial 09: Meiosis and Chromosomes

- Chromosome Laws of Segregation
- Meiosis and Recombination
- Hardy Weinberg Principle
- PCR Amplification and Genetic Fingerprinting
- Gene Splicing

Tutorial 10: Molecular Genetics and Human Genetics

- Molecular Basis of Genetics:
  - Structure and Function of DNA
  - Structure of RNA
  - Protein Synthesis
- Molecular Genetics:
  - Northern Blot
  - Southern Blot
  - and DNA Cloning
- Human Genetics
  - Karyotype
  - Population Genetics
  - Genetic Counseling

Tutorial 11 – Viruses and Nucleic Acid Technology

- What Viruses Are
- Structure and Classification of Viruses
- Replication of Viruses
- Viral Genetics and Pathogenesis
- Nucleic Acid Technology and Application

Core Unit IV: Evolution

Tutorial 12 -- Evolution: Concepts and Mechanisms

- The concept of Evolution.
- Apply the concept to your life and the environment around you.
- Hone your skills of analysis by judging the soundness of Darwin's theory of Evolution.

Tutorial 13 -- The Origin of Species

- How new species originate.
- What makes a species, a species?
- How environmental change effects biodiversity.
- The continual evolution of species today

Tutorial 14 -- Evolutionary History

- Evolutionary theory
- The origin of life
- How Geology & Biology affect one another
- Today's evolving world
- Evolution of modern humans

Core Unit V: Diversity of Organisms

Tutorial 15 -- Plant Evolution and Diversity

- Plant Evolution
- Plant Diversity
- Plant Classification
- Plant Adaptations

Tutorial 16 -- Animal Evolution and Diversity

- Animal origin
- Animal Diversity
- Animal Evolution
- Cambrian Explosion
- Animal
- Classification

Core Unit VI: Structure and Function of Plants and Animals

Tutorial 17 – Plant Structure

- Plant Cell
- Plant Tissues
- Plant Body
- Root
- Stem
- Leaf
- Flower

Tutorial 18 – Plant Function

- Plant Nutrition
- Plant Hormones
- Plant Defense
- Plant Reproduction

Tutorial 19 – Animal Structure

- Animal Cell and Tissue
- Animal Organ Systems
- Homeostasis

Tutorial 20 – Animal Function

- Energy source: Nutrition, Digestion and Respiration
- Circulation and Defense
- Reproduction and Development
- Sensor and Movement

Core Unit VII: Ecology

Tutorial 21 – Introduction to Ecology and the Biosphere

- Scope of Ecology
- Changing Environments of the Biosphere
- Responses of Organisms to Environmental Change
- Terrestrial Biomes
- Aquatic Communities

Tutorial 22 – Population Ecology

- Density and Dispersion
- Models of Population Growth
- Regulation of Populations
- Demographic Statistics
- Human Population Growth
- Evolution of Life Histories

Tutorial 23 – Community Ecology and Ecosystem

- Views of Communities
- Properties of Communities & Co-evolution
- Community Interactions
- Succession
- Geographic Aspects of Diversity
- Ecosystem

Tutorial 24 – Conservation Ecology

- Natural Resources
- Concept of Sustainability
- Conservation of Water
- Conservation of Soil
- Conservation of Forests
- Conservation of Wildlife
- Habitat Improvement

COURSE FEATURES

This tutorial series is a carefully selected collection of core concept topics that cover the essential concepts. It consists of three parts:

1. Concept Tutorials – 24 essential topics
2. Problem-Solving Drills – 24 practice sets
3. Super Condense Cheat Sheets – 24 super review sheets

Core Tutorials

Self-contained tutorials…not an outline of information which would need to be supplemented by an instructor.
Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
Definition slides introduce terms as they are needed.
Visual representation of concepts.
Conceptual explanation of important properties and problem solving techniques
Animated examples of processes and cycles in human physiology.
A concise summary is given at the conclusion of the tutorial.

Problem Solving Drills

Each tutorial has an accompanying Problem Set with 10 problems covering the material presented in the tutorial. The problem set affords the opportunity to practice what has been learned.

Condensed Cheat Sheet

Each tutorial has a one-page cheat sheet that summarizes the key concepts and vocabularies and structures presented in the tutorial. Use the cheat sheet as a study guide after completing the tutorial to re-enforce concepts and again before an exam.

Chapter by Chapter Detailed Content Descriptions

Core Unit I: AP Biology Basics

Tutorial 01: Introduction to AP Biology

Chapter Summary

AP Biology is the study of life with many subdivisions required by AP. The definition and scope of this AP course are discussed. The study tips and exam tips are presented in this first tutorial of the AP Biology series.

Tutorial Features

- Concept map to describe internal links among branches of Biology
- Question/answer sets to review each topics
- Detailed graphics to describe the scope and subtopics
- Illustration to show how to study AP biology and prepare for the exam

Key Concepts

What is Biology?
What AP Biology is
The Scope of AP Biology
    I: Molecules and Cells
    II: Heredity and Evolution
    III: Organisms and Populations
How to Study AP Biology
What the AP Exam is
AP Study Tips
AP Exam Tips

Chapter Review

AP Biology Exam:
The AP Biology exam is a combination of multiple-choice (60%) and essay (40%) questions. The exam is scored between 1 and 5; individual institutions set their standards for credit but, on average, scores ranging between 3 and 5 will be enough to gain credit.

Scope of the Exam:
the writers acknowledge that teachers vary a little in the content and emphasis of a General Biology Course. Therefore, they write questions over every topic and do not expect any one student to know them all!

Free Energy Changes:
Gibbs free energy (Δ G) refers to the energy that a system has available for work. Δ G is the net change in free energy (products – reactants), given as kcal/mol or kJ/mol.

Enzymes:
Enzymes lower the activation energy, as compared to the same reaction without one, which

helps ensure the reaction will proceed.

Cell Cycle:
The cell cycle is a series of events that takes place before the cell divides, during mitosis (M phase). G1 Phase, S Phase, G2 Phase, M Phase.

Photosynthesis:
Converts CO_2 + H_2O + energy into sugars and oxygen; this process is mainly done by plant life on land and phytoplankton of the oceans.

Meiosis:
Meiosis is the process of gamete formation. Before meiosis, the chromosomes also have to be duplicated. The first division involves a prophase, a metaphase, an anaphase and a telophase, which are very similar to mitosis.

Gene Regulation:
The regulation of genes allows cells to adapt to changing environments, respond to cellular stress, and perform functions, such as cell division.

Phylogenetic Tree:
A phylogenetic tree is a branching graph that shows the evolutionary inter-relationships between species and shows the common ancestor. Each node represents the most recent common ancestor of the descendants. The lengths of the branches are time estimates.

Community Ecology:
It is the study of all the populations that inhabit a particular area and their interactions with each other.

Tutorial 02: The Science of Biology

Chapter Summary

Biology is the study of life. There are many subdivisions within biology. Life can be autotrophy or heterotrophy; all lives are built with cells. They use energy to grow and reproduce; they respond to environment; they evolve over the time. There are common aspects of scientific experimentation to study biology. Hypothesis is more than an "educated guess". Prediction is written before an experiment is performed. Once a theory is established, more hypotheses will be formed on the base of a theory, more experiments can be performed to confirm or deny these hypotheses, thus science advances.

Tutorial Features

- Concept map to describe internal links among branches of Biology
- Question/answer sets to review each topics
- Detailed graphics to describe classification and nomenclature
- Flow chart to show how to study biology

Key Concepts

What is Biology?
- Definition
- Characteristics of living things

Basic theory of modern biology
- Cell theory
- Gene Theory
- Homeostasis
- Theory of evolution

Classification of living things
- Linnaeus system
- Five kingdoms
- Systemic names of living things

Branches of biology
- Molecular level
- Cell/organism level
- Population level

How to study biology
- Defining theory and hypothesis
- General approach

Chapter Review

What is Biology and what is life?
Biology is the study of life. Life exists in many forms. The common characteristics for life is that all lives are well organized, they need to use energy, they grow and they reproduce themselves, all lives can respond to environmental stimuli and maintain relatively stable

internal environment (homeostasis).

Branches of Biology
There are many subdivisions in biology. For example, if classified by the subject of the study, there are anatomy, botany (or plant sciences), marine biology, anthropology, zoology and microbiology. If classified by the functional studies, there are molecular biology, biochemistry, biophysics, genetics, physiology, cell biology, developmental biology and ecology. To understand how life evolves and changes over the time, there is evolutionary biology. All these branches are aimed to understand life, and the purpose is to better serve our human health and living conditions. Medical science is overly based on biology studies.

Classification of living things
Living things vary tremendously on size, shape, and many other aspects. Carolus Linnaeus used comparative anatomy to group living things according to shared physical characteristics. The smallest group is species, several species share certain characteristics and form genus, certain genus are then grouped into family, order, class, phylum or division, and kingdom. There are five kindoms, monera, protista, fungus, animalia and plantae.

Basic Theories of Biology
There are four major theories of biology which form the base of modern biology. These are cell theory, gene theory, homeostasis and theory of evolution. Cell theory was developed by three German scientists: Shleiden, Schwann and Virchow. Cells are the building unit for living things and all cells are derived from previously existed cells. Gene theory is based on Watson and Crick's DNA double helix model, DNA is the genetic material. Homeostasis provides a theory of auto-regulation of life, and theory of evolution provides explanation of how modern live forms are evolved over the time.

Scientific processes
A hypothesis is an educated guess (prediction) and a theory can become a law if enough evidence is found. There are common aspects of scientific experimentation like observations, questions, hypothesis formation, experimentation, trend recognition, conclusion formation, communication and validation of results and model formation.

How to study Biology
Memorize basic information to save time later. Learn vocabulary quickly for understanding when it is used later. Take each problem in steps. Connect each thing you learn with previous concepts.

Tutorial 03: Chemical Basis of Life

Chapter Summary

An atom is made up of protons, neutrons and electrons. Isotopes have same number of protons but different number of neutrons. Loss or gain of electrons forms ion bonds, sharing electrons forms covalent bonds. Intermolecular attractions among polar molecules bridged by hydrogen are termed hydrogen bonds, which are usually weaker than ion or covalent bonds. Biochemical reactions are usually involves breaking old covalent bonds and forming new ones. Nearly all biochemical reactions are catalyzed by enzymes and occur in a buffer system which provides relative stable condition for enzymes to be active. Four major classes of macromolecules in biochemistry are polysaccharides, proteins, lipids and nucleic acids.

Tutorial Features

- Concept maps to describe relationships between chemicals and biology
- Colorful straightforward drawing to describe atomic structures
- Chemical structures on important organic molecules
- Direct explanation on buffer and pH
- Graphic explanation on biochemical reactions

Key Concepts

Atomic and Molecular Structure
- Atomic structure
- Electrons and energy
- Chemical bonds
- Water as the cradle of the life

Organic Molecules
- Definition
- Molecular formula
- Chemical bonds in organic molecules
- Types of organic molecules
- Important organic molecules and macromolecules

Acids, Bases and Buffers
- Definition
- pH
- Buffering mechanism

Biochemical Reactions
- The thermodynamics and ΔG
- Coupled reactions
- Types of biochemical reactions
- Enzymes in biochemical reactions

Chapter Review

Atomic and Molecular structure

An atom is made up of protons, neutrons and electrons. Protons are positively charged and they denote the atomic number. Neutrons have no electrical charge. Protons and neutrons are present in the nucleus. Electrons are negatively charged and present in the orbits surrounding the nucleus. Isotopes have same number of protons but different number of neutrons. Loss or gain of electrons is seen in ions. Sharing electrons form covalent bond in molecules. Hydrogen bond is a type of intermolecular attraction among polar molecules such as water.

Types of organic molecules

Organic molecules are those derived from living organisms and they all contain carbon backbones. There are 7 major classes of organic molecules categorized by their functional groups: alcohols, aldehydes, ketones, carboxylic acids, amines, organic phosphates and thiols. Four major groups of macromolecules in cells are polysaccharides, proteins, nucleic acids and lipids. Each of these macromolecules is built up on smaller molecules.

Acids, basis and buffers

Acids are electrolytes that release hydrogen ions in water. Bases are electrolytes that release hydroxyl ions in water that can combine with hydrogen ions to form water. pH represents the concentration of hydrogen ions [H+] in solution (pH = -log [H+]). Buffer solutions are solutions which resist change in pH upon addition of small amounts of acid or base. Buffers provide a relatively stable environment for biochemical reactions to take place.

Biochemical reactions

Like all other chemical reactions, biochemical reactions also favor ΔG negative reactions. Some reactions are ΔG positive and they can be coupled to other ΔG negative reactions in order to make the total ΔG of the **coupled reaction** to be negative. Nearly all biochemical reactions are catalyzed by enzymes, which decrease the activation energy but do not change the ΔG value of the reaction. Six major types of biochemical reactions are: oxidation-reduction, group transferring, hydrolysis, elimination or addition, isomerization and ligation of various groups. These reactions are catalyzed by corresponding enzymes: oxidoreductase, transferase, hydrolase, lyase, isomerase and ligase.

Tutorial 04: The Macromolecules

Chapter Summary

A macromolecule is a very large molecule made up of smaller units called monomers. The monomers may be the same or slightly different. Macromolecules are formed by dehydration reactions in which water molecules are removed from the formation of bonds. Four main types of macromolecules control all activities. They are proteins, carbohydrates, nucleic acids and lipids. Their monomers are amino acids, sugars, nucleosides and glycerol and fatty acids.

Tutorial Features

- Concept map to explain the core issues.
- Each category of chemical groups, macromolecules explained with colorful structures.
- Full and detailed classification of macromolecules.
- Summary tables for easy review.

Key Concepts

Macromolecule
- Definition
- Diversity
- Dehydration reaction
- Hydrolysis

Carbohydrates
- Components
- Ratio of Elements
- Types of Carbohydrates
- Carbohydrate Table

Proteins
- Components
- Amino Acids
- R Group
- Protein Structure

Lipids
- Components
- Types of Lipids
- Membrane lipids

Nucleic Acids
- Components
- Nucleotides
- DNA and RNA
- Functions

Chapter Review

Introduction

Living organisms should be able to transform matter and energy into different forms, show response to changes in their environment and show growth and reproduction. All living organisms undergo changes due to large organic compounds called macromolecules. Four main types of macromolecules control all activities. They are proteins, carbohydrates, nucleic acids and lipids.

What are macromolecules?

A very large molecule made up of smaller units called monomers. The monomers may be the same or slightly different. Only a few monomers can recombine to create a lot of different combinations—this gives the diversity of macromolecules. Macromolecules are formed by dehydration reactions in which water molecules are removed from the formation of bonds.

Carbohydrates

Carbohydrates typically have $C_nH_{2n}O_n$ formula. There are three types of carbohydrates, monosaccharides contain one sugar, disaccharides contain two sugars, and polysaccharides contain many sugars. Polysaccharides play important roles in cells such as energy storage (animal glycogen) and structure support (plant cellulose).

Proteins

Proteins are made of C, H, O, N and S. The building units of proteins are amino acids. Each amino acid contains an amino group, a carboxyl group, a central carbon and hydrogen, and an R group. Variation on R group defines different amino acids. There are 20 different amino acids. Proteins have 4 layers of structure, primary structure --Number and sequence of amino acids, secondary structure --Coiling and folding from H bonds, Tertiary structure--3-dimensional shape from increased folding, and quaternary --Peptide chains combine to make a functional protein.

Lipids

Lipids are made of carbon, hydrogen and oxygen. Storage lipids include fats, oils and waxes. Mono-carboxylic acids, containing a long hydrocarbon side chain. Based on the nature of the hydrocarbon side chain, they are divided into saturated fatty acids (no double bonds) and unsaturated fatty acids (containing double bonds). Biological membranes have a double layer of lipids which are amphipathic in nature.

Nucleic Acids

Nucleic acids are made of carbon, oxygen, hydrogen, nitrogen and phosphate. The basic building blocks of nucleic acids are nucleotides. Each nucleotide has three basic parts: a nitrogenous base, phosphate group and a sugar. There are two types of nucleic acids, DNA and RNA. DNA is long, linear double strand molecule; RNA is shorter and single strand. DNA and RNA are genetic material, carrying all the codes for the functioning of the cell. They also have the keys to heredity and the ability to make new cells.

Tutorial 05: Cell Structure and Membrane

Chapter Summary

A cell is a building unit of an organism that can function independently. The cell maintains life by assigning each responsibility to separate specialized machines. These machines are called organelles. An organelle is a compartmentalized structure that performs a specialized function within a cell. An animal cell contains a nucleus, ribosomes, mitochondria, rough endoplasmic reticulum, smooth endoplasmic reticulum, plasma membrane, Golgi apparatus and lysosomes. The nucleus controls the cell function. Other organelles provide energy and building blocks for cells. Cell membrane is a selectively permeable structure that envelops the cell and protects the cell's internal environment. The cell's membrane is made of bi-layer of phospholipids and proteins, which can communicate with other cells or environment.

Tutorial Features

- Concept maps to explain the topics which are dealt with.
- Flow-chart type of explanation on each function of a cell.
- Elegant structure details of a cell and each organelle.
- Detailed explanation on synthesis, delivery and function of proteins

Key Concepts

Cell
- What is a cell
- Type of cells
- Requirement for life
- A cell maintain life by assigning each responsibility to organelles

Organelle
- What are organelles
- Nucleus
- Ribosomes
- Endoplasmic Reticulum
- Golgi Apparatus
- Protein synthesis and delivery
- Mitochondria
- Lysosomes
- Summary

Cell Membrane
- What is a cell membrane?
- Cell membrane composition
- Cell membrane synthesis
- Cell membrane function

Chapter Review

The Cell

A cell is a smallest unit of an organism that can live independently. There are two cell types: prokaryotic and eukaryotic cells. Prokaryotic cells include bacteria and a large group of other microorganisms with no nucleus. Eukaryotic cells include plant cell and animal

cells, they have distinct nucleus and cell organelles.

How the cell maintains life using organelles?
The cell maintains life by assigning each responsibility to separate specialized machines. These machines are called organelles. An organelle is a compartmentalized structure that performs a specialized function within a cell. An animal cell contains a nucleus, ribosomes, mitochondria, rough endoplasmic reticulum, smooth endoplasmic reticulum, plasma membrane, Golgi apparatus and lysosomes. The nucleus controls the cell function.

Organelle structures and functions
Ribosomes: make proteins for the cell. Each ribosome is made of two protein subunits: the large subunit and the small subunit. The units clasp around a strand of nucleic acid instructions from the nucleus. The ribosome reads the strand instructions to make proteins for the cell to use in its normal activities.
Endoplasmic reticulum: Including rough ER and smooth ER. Rough ER is found attached to the outside of the nucleus. It appears rough because of the ribosomes on its surface. It helps the attached ribosomes in finishing protein synthesis. Smooth ER is NOT attached to the nucleus and DOES NOT have attached ribosomes (thus smooth). Smooth ER synthesizes carbohydrates and lipids.
The Golgi apparatus: made up of flattened, folded sacs, ships packages around the cell.
Mitochondria: converts carbohydrates taken from food into ATP -- produce energy to power the cell.
Lysosome: highly acidic, destroy waste to clean up the cell.

Cell Membrane: composition and function
A cell membrane is a selectively permeable structure that envelops the cell and protects the cell's internal environment. The cell's membrane is made of phospholipids, which have carbohydrate heads and lipid tails. Proteins can be embedded or anchored on cell membrane. Cell membranes provides a stable environment for cells, perform communication function among cells via the surface proteins, and selectively exchange material between a cell and its environment.

Tutorial 06: Cell Communication and Cycle

Chapter Summary

Cell-cell communication is critical for organism survival and homeostasis. All cell signals are chemical signals. Chemical signals are received by signal receptors on cell surface or inside cells. Three major types of receptors are RTKs, GCPRs and intracellular receptors. RTKs have intrinsic tyrosine kinase activities which are activated upon signal binding; GCPRs are coupled to G proteins which are activated by signal binding. Intracellular receptors can bind to signal molecules and then trans-locate into nucleus for activating gene expression. RTK and GCPR can activate downstream targets and initiate cascade signal transduction. Signals can be amplified through transduction, especially through second messengers such as cAMP/cGMP, DAG and IP3, and calcium ions. Dividing cells undergo cell cycle which includes G1, S, G2 and M phases. Cell cycle are controlled and checked at certain points to ensure proper DNA inheritance.

Tutorial Features

- Pictorial description of cell-cell contacts.
- Easy to understand classification of receptors and how they work
- Detailed analysis of second messengers.
- Diagram of cell cycle
- Logical link of cell cycle control to tumorigenesis

Key Concepts

Cell-cell contact and signal type
- Tight junction
- Adherens junction
- Gap junction
- Desmosomes
- Paracrine and endocrine signals

Signal Reception
- Key-lock model
- RTKs
- GCPRs
- Intracellular receptors

Signal Transduction
- Protein kinase
- Protein phosphotase
- Signal amplification

Second Messenger
- cAMP
- DAG and IP3
- Calcium ion

Cell Cycle
- Cell cycle phases
- Cyclins and CDKs

- Cell cycle checkpoints
- Cancer and cell cycle control

Chapter Review

Cell communication – Cell-cell contact
Local signal transduction channels are through cell-cell contact. There are 4 types of cell-cell contacts in mammalian cells: tight junctions, adheren's junctions, gap junctions and desmosomes.

Cell communication - Paracrine signal vs. Endocrine signal
Cell signals can be local signal (paracrine signal) which is communicated through cell-cell contacts, or endocrine signal which is mostly hormones secreted by glands and transported via blood.

Signal Reception
Cell signals are chemicals. Signal reception is a process of ligand binding to the receptors; mimic a lock and key model. There are three major types of signal receptors: receptor tyrosine kinases (RTKs), G protein-coupled receptors (GCPRs) and intracellular receptors. Ligand binding activates RTKs via dimerization and phosphorylation; Ligand binding activates GCPRs by activating G protein (replacing GDP by GTP) which can then phosphorylate the downstream targets. Intracellular receptors can be translocated into nucleus upon signal binding and activate gene expression directly.

Signal Transduction
Signal transduction is often achieved by phosphorylation and de-phosphorylation, and therefore involves kinase and phosphotases. Protein kinases are often involved in cell proliferation and phosphotases play antagonized roles.

Second messenger and signal amplification
Cell signals can be amplified during transduction because one kinase can phosphorylate multiple copies of downstream targets. Second messengers also play important roles in signal amplification. There are three major types of second messengers: cAMP/cGMP, IP3 and DAG, calcium ions. cAMP activates gene expression via CREB or PKA which further activates downstream targets. IP3 and DAG activate PKC and releases calcium ions. Calcium ions can also activate PKC which further activates the downstream targets. Calcium ions play multiple roles in cells in addition to second messenger.

Cell Cycle
Proliferating cells undergo cell cycle which is composed of G1, S, G2 and M phases. Resting cells are in G0. Cell cycle is controlled by cyclins and CDKs, when circumstances are not right, cell cycle checkpoints can be activated to restrain cell cycle. There are 4 major cell cycle checkpoints: G1 checkpoint, intra-S phase checkpoints, G2 checkpoints and spindle checkpoints. When cell cycle checkpoints are broken or cell cycle goes wrong, cells may undergo apoptosis or become cancerous.

Tutorial 07: Metabolism and Cellular Respiration

Chapter Summary

Metabolism includes catabolism and anabolism. Anabolism is the synthesis of complex molecules from precursors, while catabolism is the breakdown of complex molecules into smaller precursors from which they are synthesized. All these pathways involve biochemical reactions. Free energy describes whether a reaction will occur spontaneously. In metabolism, reactions which are spontaneous are favorable because these run automatically and release free energy. Every reaction has an activation energy which can be lowered down by enzymes. Enzymes do this by bringing the reactants closer together. ATP is the energy currency of all cells. Most of the reactions in the cell require ATP. A non-spontaneous reaction can be coupled to ATP hydrolysis reaction to enable the overall reaction release free energy and therefore become favorable. ATP is generated by cellular respiration, which contains fermentation (anaerobic respiration) and the Krebs cycle (aerobic fermentation).

Tutorial Features

- Concept map to explain metabolism pathways.
- Animation presentation to explain multiple concepts/process
- Summary/review slides after each topic
- Flowchart to show respiration branches
- Summary of ATP production during respiration

Key Concepts

Metabolism
- Building Blocks & Precursors
- Anabolism
- Catabolism
- The Role of ATP

Energetics of Biological Reactions
- Energy
- Thermodynamics
- Activation Energy & Enzymes
- Redox Reactions
- The Role of ATP in Metabolism
- Coupling

Cellular Respiration
- Definition
- Aerobic Respiration
- Anaerobic Respiration

Aerobic Respiration
- Glycolysis
- The Krebs cycle

- Oxidative phosphorylation

Anaerobic Respiration
- Glycolysis
- Fermentation

Summary on respiration

Chapter Review

What is metabolism?
All living things must have an unceasing supply of energy and matter. The transformation of this energy and matter within the body is called metabolism. Metabolism includes two different types: catabolism and anabolism. Catabolism is destructive metabolism. Typically, in catabolism, larger organic molecules are broken down into smaller constituents. This usually occurs with the release of energy. Anabolism is constructive metabolism. Typically, in anabolism, small precursor molecules are assembled into larger organic molecules. This always requires the input of energy.

Anabolism and catabolism Pathways
Anabolism is the synthesis of complex molecules from precursors. This includes synthesis of proteins, carbohydrates, nucleic acids and lipids, usually from their building block monomers. Catabolism is the breakdown of complex molecules into smaller precursors from which they are synthesized. It is a reversed process of anabolism. When cells have excess resources such as food and extra energy, anabolism occurs to store unused nutrients for later use. When cells are deficient for food or energy, catabolism occurs to break down the stored nutrients for the body to use.

Energetics of biological Reactions
Biological energy is the capacity to run biochemical reactions to enable the cells to do their work. Free energy (G) relates temperature, enthalpy and entropy. Free energy is used to determine if the reaction is spontaneous at a specific temperature.

Determining spontaneity of a process
Free energy describes whether a reaction will occur spontaneously. The First Law of Thermodynamics states that energy is conserved: energy can neither be created nor destroyed. The Second Law of Thermodynamics states that the work produced from a given energy can never be 100% efficient. In metabolism, reactions which are spontaneous are favorable because these run automatically and release free energy. Every reaction has an activation energy, which describes an energy barrier that is overcome every time the reaction occurs. Most of the reactions in the cell require enzymes. Enzymes are proteins to speed up reactions by grabbing onto reactants to bring them closer together. Reactants which are closer together can reach activation energy more easily. Thus, enzymes lower activation energy and speed up the reaction.

ATP
ATP is the energy currency of all cells. Most of the reactions in the cell require ATP. ATP is energy rich. When the energy is used by a reaction, ATP breaks up into ADP and Pi. In order to use the energy again, ADP and Pi must be changed back into ATP. This requires energy. Non-spontaneous reactions requires energy, and this is often done by coupling this reaction with an ATP breaking down reaction, the combined free energy will be negative and therefore enables the overall reaction.

Cellular Respiration

Cellular respiration is a series of metabolic processes which all living cells use to produce energy in the form of ATP. In cellular respiration, the cell breaks down glucose to produce large amounts of energy in the form of ATP. Cellular respiration can take two paths: aerobic respiration or anaerobic respiration. Aerobic respiration occurs when oxygen is available, whereas anaerobic respiration occurs when oxygen is not available. The two paths of cellular respiration share the glycolysis step. Aerobic respiration has three steps: glycolysis, Krebs cycle, and oxidative phosphorylation. During glycolysis, glucose is broken down into pyruvate and produces 2 ATP. The Krebs cycle is also known as TCA cycle which contains a series of Redox reactions to convert pyruvate into CO_2 and produce NADH and FADH2. During oxidative phosphorylation, NADH and FADH2 are used as substrate to generate a pH gradient on mitochondria membrane which is used to generate ATP via ATP synthase. Anaerobic respiration contains two steps: glycolysis and fermentation. Fermentation regenerates the reactants needed for glycolysis to run again. Fermentation converts pyruvate into ethanol or lactic acid, and in the process regenerates intermediates for glycolysis.

Tutorial 08: Photosynthesis

Chapter Summary

Photosynthesis is a process where by energy from light is harvested and used to drive synthesis of organic carbohydrates from carbon dioxide and water. Photosynthesis takes place in chloroplasts and can be divided into two steps: light reactions which require light and dark reactions which do not require light. During light reaction, light energy is captured by photosystems and electrons are transferred among the electron receptors. ATP and NADPH are generated. During dark reactions, CO_2 is fixed using ATP and NADPH generated by the light reactions and organic carbohydrates are synthesized via the Calvin Cycle. When the CO_2 is first fixed into a 3 carbon compound 3PGA, it is called C3 pathways and these plants are called C3 plants. The disadvantage of C3 plants is that they undergo photorespiration and thus waste some energy gained in light reactions. C4 cycle is the pathway adopted by C4 plants to bypass photorespiration.

Tutorial Features

- General concept map to explain the photosynthesis features.
- Pictorial explanation of light absorption and electron transfer
- Graphic explanation on ATP generation.
- Direct and easy-to-understand graphics on C3 pathways
- Progressively logical explanation on C4 pathway

Key Concepts

Importance of photosynthesis
- Definition
- Importance

Absorption of light
- Pigments
- Light absorption
- Photosystems

Light reactions
- Cyclic electron transfer
- Non-cyclic electron transfer
- Energy production

Dark reactions
- Important molecules
- The Calvin cycle

Photorespiration and C4 pathway
- C3 plants and C3 pathway
- Mechanism of photorespiration
- C4 pathway

Chapter Review

What is photosynthesis and why it is important

Photosynthesis is a process during which energy from light is harvested and used to drive

synthesis of organic carbohydrates from carbon dioxide and water, generating oxygen. Photosynthesis is the only way that radiant energy from the sun can be converted into organic molecules for plants and animals to consume.

Structure of Chloroplasts

Chloroplasts are specialized organelles in plant cells for the purpose of photosynthesis. Each cell may contain 1-1000 copies of chloroplasts. Chloroplasts are double membrane structure with stacked disc-like membrane structure (called thylakoids) inside the stroma. Light reactions of photosynthesis occur in thylakoids, and dark reactions occur in stroma.

Physics of light

Quantum is the elemental unit of energy. Photon is a quantum of electromagnetic energy and it is particle of light.

Light reaction and photophosphorylation

Pigments embedded on thylakoid membranes form photosystems. There are of two types: PS I P700, PS II P680. Components of photosystem I and II transfer the electrons from water to NADP via cyclic electron transfer or non-cyclic electron transfer. During electron transfer, the light energy captured by the photosynthetic organisms is transformed into the phosphate bond energy of ATP. This is called photophosphorylation. NADPH is generated during non-cyclic electron transfer.

Dark reaction – Calvin cycle

Second step of photosynthesis is called Calvin's cycle. Because it does not require light, so it is called dark reaction. During dark reaction, the ATP and NADPH generated by light reaction are consumed to fix carbon dioxide into organic carbohydrates. The first fixed carbohydrate is a three carbon compound 3-phosphoglycerate (3PGA). The final product is a high-energy 3 carbon compound glyceraldehyde-3-phosphate (G3P) which can be used to synthesize a broad range of organic molecules. An important intermediate molecule for carbon dioxide fixation is ribulose bisphosphate (RuBP), and the enzyme catalyzing the CO2 fixation is Rubisco.

Photorespiration

Under high oxygen and low carbon dioxide conditions, Rubisco favors binding to oxygen instead of carbon dioxide, therefore the energy produced in light reactions are consumed for no productivity of organic carbohydrates. The final result is that oxygen is consumed and CO2 is produced, which mimics respiration, and therefore named photorespiration.

C4 pathway

C4 cycle is the pathway adopted by C4 plants to conserve the carbon dioxide released via photorespiration. It adopts a new enzyme (PEPC, Phosphoenol pyruvate carboxylase) which does not react with oxygen; it also adopted a separated compartment for CO2 up taking and fixation.

CO2 is taken in mesophyll cells and further fixation occurs in bundle sheath cells. Carbon dioxide is incorporated to form 4-carbon oxaloacetate.

09: Meiosis and Chromosomes

Chapter Summary

In this visual tutorial, you will learn about the Mendel's Laws of Segregation, Meiosis and recombination and Hardy Weinberg Principle. The genetic technology is also discussed.

Tutorial Features

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts

Chromosome Laws of Segregation
Meiosis and Recombination
Hardy Weinberg Principle
PCR Amplification and Genetic Fingerprinting
Gene Splicing

Chapter Review

Gregor Mendel:
He was a scientist and a priest who studied the inheritance of traits in pea plants. Later in the 20th century, his results were part of the foundation of the discipline of genetics.

Mendel's First Law:
Law of Segregation - two members of a gene pair (alleles) separate (segregate) from one another when forming the gametes. Each gamete carries one allele.

Mendel's Second Law:
Law of Independent Assortment - Genes for different traits sort independently of one another in the formation of gametes.

Codominance:
When two alleles are co-dominant, the phenotype of each allele is not masked by the presence of the other alleles.

Meiosis:
Meiosis is similar to mitosis on the basis of how chromosomes are pulled to the two poles of a cell. Before meiosis, the chromosomes also have to be duplicated. The first division involves a prophase, a metaphase, an anaphase and a telophase which are very similar to mitosis. Cells continue to a second division immediately after first division, and the two sister chromatids are separated, generating four 1N gametes.

Hardy-Weinberg Law:
The genotype frequencies of a large, randomly mating population remains constant if immigration, mutation, and selection do not take place.

Hardy Weinberg and Evolution:
Evolution is a change in the genetic composition of a population from generation to

generation. Evolution happens in populations, not individuals.

Genetic Fingerprinting:
Genetic Fingerprinting or DNA profiling allows an investigator or police authority the opportunity to identify an individual based on the comparison of their DNA and a reference sample. The process involves collecting an individual DNA sample and then fragmenting it using restriction enzymes.

10: Molecular Genetics and Human Genetics

Chapter Summary

This tutorial will discuss the foundation of genetics, the structure and function of DNA. The molecular genetics and human genetics are then introduced.

Tutorial Features

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts

Molecular Basis of Genetics:
- Structure and Function of DNA
- Structure of RNA
- Protein Synthesis

Molecular Genetics:
- Northern Blot
- Southern Blot
- and DNA Cloning

Human Genetics
- Karyotype
- Population Genetics
- Genetic Counseling

Chapter Review

Molecular Genetics:
It is a division of biology that is involved in the study of gene structure and function.

DNA:
It is the blueprint of life; it is present in almost every cell in the body. A copy from a male donor and a copy from a female donor, through fertilization, can create a human being.

Genetic Code:
It dictates nucleic acid structure and function. The formation of the end-product amino acids and proteins is controlled by the genetic code set of rules. Within the code are codons, which are a nucleic acid sequence that specifies the formation of an amino acid.

RNA:
It is usually single-stranded. It is made from a DNA blueprint. RNA translates the message from the DNA to produce the correct protein.

Northern Blot:
RNA can be separated using gel electrophoresis. Gel electrophoresis involves applying a current to a gel matrix containing the RNA sample. RNA samples move through the gel and separate into bands based on their charge to mass ratio. After separation, they can be transferred to a blot membrane and probed for the RNA of interest using a specifically labeled probe.

Gene Cloning:
It can be used to create many copies of a defined DNA sequence. The sequence of DNA or gene can then be used to test the effect of over-expression or deletion of that gene from the genetic material of cells.

Karyotype:
It is a visual pattern of the chromosomes within cells. By using stains and probes, whole chromosomes, short and long arms, and even small regions on chromosomes can be visualized.

Y-linked Traits:
Y-linked traits appear only in males, and it is passed from father to son. It does not skip generation. The pedigree shown here is a typical Y-linked trait.

Population Genetics:
This type of study addresses changes in populations, such as adaptation and speciation. The frame work of population genetics, involving the mapping of a set of genotypes to a set of phenotypes, is called a genotype-phenotype map.

11: Viruses and Nucleic Acid Technology

Chapter Summary

This tutorial will discuss the definition of viruses, their structure, classification, and replication. The viral genetics and pathogenesis are also presented, along with nucleic acid technology and its applications.

Tutorial Features

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts

- Viruses
- Structure and Classification of Viruses
- Replication of Viruses
- Viral Genetics and Pathogenesis
- Nucleic Acid Technology and Application

Chapter Review

Viruses:
They are one of the smallest infectious agents. However, they are not classified as living biological organisms. Viruses contain genes made from either RNA or DNA, protein coats, and some contain an envelope surrounding them. Viruses must infect a host cell in order to replicate and impact the organism.

Virion:
A virion (a single infective viral particle) is made up of: (1) Capsid, which is a protein shell enclosing the nucleic acid; (2) Nucleic Acid – RNA or DNA; (3) Nucleocapsid, which includes the capsid + nucleic Acid; (4) Envelope - Glycoproteins embedded in bi-layer lipids surrounding the nucleocapsid (not all viruses have this layer).

Virus Classification:
The classification of viruses is based on: (1) Host Organism(s), and (3) Genome Type.
Viral Infection: The infection procedure includes finding a host cell, attachment to the cell, penetrating the cell and uncoating the virus. After uncoating, the virus is ready to replicate its genome and multiply.

Transformation:
Introducing foreign DNA into a cell is known as Transformation. This leads to the modification of the genotype of a cell by introduction of DNA from another source.
Transduction: Transduction is the introduction of foreign DNA by latent vial infection; the viral DNA becomes part of the host genome.

DNA Vector:
Vectors are designed to ensure that the DNA of interest is expressed in the target cell or tissue; this type is known as an expression vector and it's usually under the control of a strong promoter.

Transgenic Organisms:
They are organisms with genomes that have been modified by the introduction of novel

DNA. These provide a tremendously advantages model to study disease, as a certain gene can be knocked out or in to study the effects of a particular gene(s).

DNA Probe:
DNA probes can be engineered to allow the detection of minute changes in organismal DNA, such as a mutation in a binding site or a cleavage site for a restriction enzyme.

Tutorial 12: Evolution: Concepts and Mechanism

Chapter Summary

Evolution is "descent with modification". Theory of Evolution was first described by Charles Darwin. The core concept of evolution includes two points: 1) current day organisms arose from older ancestral species over time; 2) "survival of the fittest", the organism best fit to the environment survives to propagate. New species originate in the process of evolution. Speciation event occurs when members of a new reproductive community no longer interbreed with their ancestral population as a result of isolation and subsequent accumulation of adaptations to their new environment. The theory of evolution, like other theories in science, also was formed through steps of observation-hypothesis-hypothesis testing. Nowadays evolution theory is supplemented by some modifications including punctuated equilibrium and effects of ecosystems.

Tutorial Features

- Stick-note type of explanation for easy understanding
- Flowchart to show the process of natural selection
- Example of a phylogenetic tree to show evolutionary relationship of monkeys and humans
- Step-by-step deduction of Theory of Evolution

Key Concepts

Introduction
- Why evolution is important?
- Questions evolution tries to address
- What is evolution?

Understanding Darwin's Theory of evolution
- Descent with modification
- Natural selection
- Survival of the fittest

Origin of Species
- Evolution, speciation and origin
- Phylogenetic tree

Scientific Steps to Darwin's Theory
- Observations
- Hypothesis
- Hypothesis testing: evidence
- Fossil record
- Taxonomic groups
- Independent Traits
- Modern genetics

Evolution theory today
- Gradualism vs. Punctuated Equilibrium

- Global ecosystem change and evolution
- Other mechanism of species evolution

Chapter Review

Introduction

Evolution is "descent with modification" (Charles Darwin). The questions evolution tries to address include: why are so many types of species on our plant? Where did they come from? How is it that they all appear to be so different but in fact are all somewhat related? The study on evolution has a tremendous impact on your life. For example, it can explain why doctors do or do not give antibiotics when you are sick, it can also explain the HIV world crisis.

Theory of Evolution

Theory of Evolution was first described by Charles Darwin. To understand "descent with modification", one needs to understand 1) the idea that current day organisms arose from older ancestral species over time; 2) Modification is a mechanism or process of interaction between the environment and an organisms to select for inheritable traits. Natural selection is one important mechanism of modification. If a species survives long enough, it has been selected naturally. The survival depends on an organisms fit to the environment. In another word, the organism best fit to the environment survive to propagate—this is called "survival of the fittest".

Origin of species

New species originate in the process of evolution. Speciation event occurs when members of a new reproductive community no longer interbreed with their ancestral population as a result of isolation and subsequent accumulation of adaptations to their new environment. Evolution includes multiple speciation events over time, which can be depicted with a phylogenetic tree. A phylogenetic tree shows a relationship between ancestor and descendant, i.e., the pattern of evolution. Most often the pattern is branching; each branch containing the oldest ancestor in that line plus all of its descendants.

Scientific Steps to Darwin's Theory

Observation: 1) struggle of existence -- Reproducing organisms will produce more offspring than the environment can support if all offspring survive to reproduce; 2) within any given population, there is a range of individual, heritable characteristics; 3) survival depends on an organism's inherited traits. Hypothesis: 1) Attributes that lead to a better fit to an environment lead to greater chance for leaving behind offspring; 2) Disproportionate reproductive success among population members lead to gradual change in traits of that population. Hypothesis Testing: 1) fossil record; 2) comparative anatomy and embryology; 3) Independent traits; 4) DNA similarity.

Evolutionary Theory Today

Darwin thought evolution is a gradual process, today's evidence suggest that 1) evolution may follow a spurt and plateau pattern (punctuated equilibrium); 2) Changes of ecosystem play bigger roles in stimulating accumulation of new species then once thought; 3) other mechanisms of species modification have been discovered such as gene flow and non-random mating, although natural selection remains the major player.

Tutorial 13: The Origin of Species

Chapter Summary

Morpho-species hinges on differences in appearance. Biological species is based on whether or not animals can breed with one another successfully and generate viable fertile offspring. All species are related evolutionally, and the relationship can be reflected on a phylogenetic tree. On a phylogenetic tree, anagenesis is unbranching evolution, which indicates a direct descendant, while cladogenesis is considered to be "Branching Evolution"--one species may be a common ancestor for many other species. A key biological event in speciation involves isolation of gene pool of a population. Gene pool is the complete set of genes of all members in a population. Isolating a gene pool means producing barriers for interbreeding. There are two types of barriers, external barriers and internal barriers. In plants, sympatric speciation can occur.

Tutorial Features

- Concept maps for origin of species.
- Graphic presentation of a phylogenetic tree to describe anagenesis and cladogenesis
- Flow-chart to demonstrate speciation via external barriers
- Flow-chart to summarize the speciation events

Key Concepts

The Species concept
- Morpho-species concept
- Advantage and disadvantage of morpho-species concept
- Definition of biological species concept
- Weakness of biological species concept

Evolutionary Relationship and Biodiversity
- Basic patterns of evolution
- Anagenesis
- Cladogenesis

Speciation Event
- Isolation of gene pool
- External barriers
- Speciation via external barriers
- Internal barriers: types and function
- Summary of speciation events

Sympatric Speciation

Chapter Review

What is a species?

There are two concepts about a species: morphological species and biological species. Morpho-species hinges on differences in appearance. Biological species is based on whether or not animals can breed with one another successfully and generate viable fertile offspring. According to morphological species concept, animals belong to same species have similar form, shape and appearance. The advantage of morpho-species concept is its simplicity; the weakness is its ambiguity. Biological species concept generates less ambiguity in

classifying species. However, biological species concept is ineffective for organisms that procreate with asexual reproduction; it is also ineffective for extinct organisms, as there is no way to determine if fossilized organisms could mate.

Evolution Relationships and Biodiversity

There are two basic patterns of evolution: anagenesis and cladogenesis. Anagenesis: In terms of the phylogenetic tree, anagenesis is unbranching evolution, which indicates a direct descendant. Cladogenesis is considered to be "Branching Evolution"; one species may be a common ancestor for many other species.

Speciation Event

A key biological event in speciation involves isolation of gene pool of a population. Gene pool is the complete set of genes of all members in a population. Isolating a gene pool means producing barriers for interbreeding. There are two types of barriers, external barriers such as geographical isolation and land-shifting and internal barriers such as changes of intrinsic genetic composition. Internal barriers include wrong places (different habitats), wrong behavior, wrong anatomy, sterile offspring, etc.

Sympatric Speciation

Sympatric speciation is set of speciation events different from allopatric speciation in the following ways: 1) Internal barriers develop first without initial external barriers; 2) Internal barriers lead to instant reproductive isolation which leads to gene pool isolation. This mechanism of reproductive isolation is usually related to meiotic nondisjunction which results in doubling of gametic chromosomes, and therefore polyploidy is generated and hence inability to mate with usual diploid organisms. Most polyploids go extinct before reproducing. This speciation is more common in plants than animals.

Tutorial 14: Evolutionary History

Chapter Summary

Darwin discussed origin of species, but he was not sure about origin of life. To address this question, assuming a proto-life evolved from inorganic environment, Urey & Miller designed an experimental model of early earth atmosphere, in which organic molecules can be synthesized from inorganic molecules. This may explain how proto-life arose, but it is not known how proto-life is evolved into life. Each kingdom has its unique evolution history, some are explained scientifically and some are not.

Tutorial Features

- Concept map follow time course to show evolutionary history.
- Review slides for convenient overall concepts
- Graphic phylogenetic trees to show the evolutionary relationships among animal kingdom and primates
- Flowchart to explain modern human origin

Key Concepts

Origin of life on earth
- The beginning of the evolutionary history
- Darwin and the origin of life
- Search for earliest records of life

How and when did life start?
- The idea of proto-life
- Urey & Miller Experiment
- From prebiotic condition to proto-life

Prokaryotes Evolution
- Preview
- Prokaryotes
- Evolutionary Adaptations of Prokaryotes
- Prokaryotic Relationships
- Eubacteria

Protists Evolution
- Preview
- Groups of protists
- Major Evolutionary Acquisitions of Protists
- Endosymbiotic Hypothesis
- Multicellularity

Plant Evolution
- Preview
- Evolution from algae
- Reproduction adaptation

Fungus Evolution
- Preview
- Fungus traits
- Importance

Animal Evolution
- Preview
- Animal phylogeny
- Major Phyla & Relationships
- Causes of Major Morphologic Changes
- Paedogenesis & Urochordates
- Other Events
- Vertebrate Subphylum
- Primate evolution

Topical Review

Darwin's unanswered question
Darwin's unanswered question is: when did life begin on earth? One thing is for sure, life could not start earlier than the formation of earth. Earth was formed about 4.5 billion years ago. Darwin discussed origin of species, but he was not sure about origin of life. Fossils are undetected for first 3.8-4 billion years. The oldest stromatolite containing microorganisms (photosynthetic bacteria) determined to be ~ 3.5 billion years old. Life ends with fossil, not start with. So when did life start?

The idea of proto-life
If we assume life did not result from a seeding event from an asteroid or other interstellar body, then life had to have developed from inorganic materials. However, spontaneous animation to form life from non-life does not happen today. This could be due to the atmosphere environment is very different. Urey & Miller designed an experimental model of early earth atmosphere, in which organic molecules can be synthesized from inorganic molecules. With pre-biotic conditions set, Proto-life may occur according to many hypotheses: Organic compounds form polymers of repeating units**,** lipids & others can and do organize into spheres based on inherent properties. The lipid spheres can encapsulate organic molecules; the encapsulated organic molecules such as RNA can then self-replicate, are autocatalytic, and can act as rudimentary templates for protein synthesis**.** Competition for scarce resources such as RNA monomers leads to natural selection of "fittest" RNA molecule, resulting in reproduction of that RNA molecule.

When did life start?
Currently nobody knows how life starts from proto-life or when proto-life was evolved into life. Standard answer depends on fossil record as noted earlier. More specific date depends on answers to following theoretical questions: 1) When transition from proto-life to life occurred; 2) Definition of life used to determine transition.

Prokaryotes evolution
80% of the history of life on earth concerns prokaryotes (Monera). Prokaryotes evolved in isolation for ~ 2 billion years. Most Prokaryotic adaptations revolve around metabolic capacities as opposed to phenotypic changes. The major metabolic adaptations include glycolytic pathway, oxidative phosphorylation, photosynthetic enzymes, and each new metabolic capacity enabled bacteria to occupy new niches. For prokaryotes, most important speciation event is between archaebacteria & eubacteria.

Protists evolution
Major groups of protists include protozoan – for example, amoebas, algae and slime molds. Major evolutionary acquisition of protists is through endosymbiosis which results in eukaryotic organelles, and colony behavior which results in multicellular organisms. Endosymbiotic hypothesis is an attempt to account for the major evolutionary leap from prokaryotes to protists, the first eukaryotes. The hypothesis proposes a larger prokaryote ingested a smaller prokaryote such as a nutshell, organelles such as mitochondria and chloroplasts therefore arose. Much evidence comparing similarities of mitochondria to prokaryotes supports this idea.

Plant Evolution
All plants are multicellular eukaryotes with the capacity for photosynthesis. Plants are evolved from aquatic protists. The steps of adaptation include cuticles to prevent drying, developing system of specialized cells such as vascular conduits for more efficient water transport. These provide new niches further away from water sources. Early terrestrial plants such as ferns were seedless, gametes were dispersed via spores. One reproductive adaptation is evolving of seeds which carry plant gametes further from parents and therefore increased opportunities for uncontested resources. Evolution of flower (a specialized leave structure) enables more efficient seed dispersal and pollination secondary to pollinators.

Fungus Evolution
Fungi Evolved from protists via unknown mechanisms. Traits of fungi include branched hyphae, cell wall if chitin, dual reproduction modes, and absorption of food.

Animal Evolution
Animals are evolved from ancestral protists. Following the evolutionary history come Eumetazoa, Bilateria, Coelomates, Deuterosomes, Chordates, and Vertebrates, all of which have a major body plan difference. One major cause of body plan change is paedogenesis, which is the act of reproduction by an organism that has not achieved physical maturity. The hypothesis is that paedogenesis of early larval urochordates leads to maintenance of motile organism with all chordate features which caused major change in body plan. Selective pressures acting on paedogenic larval urochordates lead to modifications of chordate traits. Other events during evolution: 1) Extinction events: There have been several in the triassic period alone, not the least of which being the dinosaur extinction. Some estimate that 90% of all animal species were lost during this time period with an unknown reason. 2) Super continent Pangaea forms and breaks-up ~300 – 180 million years ago, this lead to geological isolation of gene pool.

Tutorial 15: Plant Evolution and Diversity

Chapter Summary

Plants are photosynthetic eukaryotes. As per the fossil evidence, plants were derived from green algae, 500 million years ago. Invading the land was difficult for plants to adapt for several reasons. Hence, plants underwent a number of adaptations like development of roots, stems, leaves and seeds. There is a great variation in the structure of plants. It ranges from microscopic to immense trees. Environment affects the shape, size, growth rate and physiological function of plants. There is a huge variation in types of environments. Embryophytes having tracheids are called tracheophytes. Plants are multicellular phototrophs, majority live on land and possess plastids, chlorophyll and generate energy by photosynthesis. Most plants reproduce sexually are capable of asexual propagation. Based on absence or presence of internal vascular system, plants are mainly divided into non vascular plants (Bryophytes) and vascular plants. Vascular plants are more complex and organized. They include seedless plants, seed bearing forms. Two types of seed bearing tracheophytes are known: Gymnosperms (naked seed plants such as conifers) and Angiosperms (flowering plants). Angiosperms may either be monocots or dicots. Leaves are adapted to absorb light with the help of chlorophyll and carbon dioxide. They have stomata to regulate water loss and have a waxy covering to prevent water loss and also possess rigid structures to prevent wilting. Angiosperms have special adaptations: To attract pollinators with bright colored flowers. Fruits are useful n dispersal of their seeds.

Tutorial Features

- Colorful concept map for clear understanding
- Pictures with animates statements
- Precise animated definitions
- Flow charts for easy understanding

Key Concepts

Plant Evolution
- Introduction
- Evolution
- Fossil Records
- Ancestral Origin
- Invasion of Land
- Adaptation to Land

Plant Diversity
- Introduction
- Embryophytes
- Plant species
- Plant kingdom
- Plant lifecycle

Plant Classification
- Introduction
- Bryophytes
- Tracheophytes

- Gymnosperms
- Angiosperms

Plant Adaptations
- Leaves and stems
- Growth
- Seed production
- Pollen
- Special adaptation of flowering plants
- Senescence and Death

Chapter Review

Introduction to Plant Evolution

Plants are photosynthetic eukaryotes and they are also called embryophytes since they produce an embryo that is protected by tissues of the parent plant. Plants are derived from a single branch of the evolutionary tree and hence said to be monophyletic. As per the fossil evidence, plants were derived from green algae, 500 million years ago. Invading the land was difficult for plants to adapt for several reasons. Hence, plants underwent a number of adaptations like development of roots, stems, leaves and seeds.

Plant Diversity

There is a great variation in the structure of plants. It ranges from microscopic to immense trees. Environment affects the shape, size, growth rate and physiological function of plants. There is a huge variation in types of environments. Tracheids are the specialized water conducting cells developed by plants as an adaptation to the terrestrial environment. Embryophytes having tracheids are called tracheophytes, which are made up of 10 phyla. Non-tracheophytes lack tracheids and have 3 phyla – Liverworts, Hornworts and Mosses. New mode of reproduction is required for land dwelling plants. More than 300,000 are present but many thousands remain unknown.
Plants are multicellular phototrophs, majority live on land and possess plastids, chlorophyll and generate energy by photosynthesis. They store starch as reserve food and their cell wall is made up of cellulose. Most plants reproduce sexually are capable of asexual propagation. Alternation of generations is a universal feature of the life cycles of plants.

Plant Classification

Based on absence or presence of internal vascular system, plants are mainly divided into non vascular plants (Bryophytes) and vascular plants. Bryophytes are the earliest plants, evolved 500 million years ago. They require constantly moist environment. They possess rhizoids which are root like structures. Visible green structures are the gametophyte, which is multicellular and contain chloroplasts. Sporophyte produces unicellular haploid spores through meiosis within sporangium or capsules. Spores germinate to give rise to gametophyte.
Early vascular plants (tracheophytes) had no roots, leaves, fruits or flowers. Most ancient tracheophytes are homosporous, bearing a single type of spore. Both gametophyte and sporophyte are photosynthetic. Plants of today reproduce more by gametophyte generation than 500 million years ago. Vascular plants are more complex and organized. They include seedless plants, seed bearing forms and specialized transport cells – Xylem (water and minerals are transported) and phloem (sugar is transported). Seedless tracheophytes include: club moss, horse tails, ground pines and Ferns.
Seed bearing plants are successful due to their extensive root system and efficient vascular system like xylem and phloem. Two types of seed bearing tracheophytes are known: Gymnosperms (naked seed plants such as conifers) and Angiosperms (flowering plants). Angiosperms may either be monocots or dicots.

Plant adaptations

Leaves are adapted to absorb light with the help of chlorophyll and carbon dioxide. They have stomata to regulate water loss and have a waxy covering to prevent water loss and also possess rigid structures to prevent wilting. In order to grow vertically, lignin provides skeletal support, maintains plant rigidity and reinforces cellulose. Production of seeds was a major advancement in plant adaptability to live on land. It avoids competition, pathogens, inbreeding. Seeds survive harsh conditions, help disperse plants and seeds can survive many years. Pollen is a male gametophyte which can be blown great distances by wind or insects. Angiosperms have special adaptations: To attract pollinators with bright colored flowers. Fruits are useful n dispersal of their seeds.
Annual plants live one season and die. Perennials live two years or more.

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Tutorial 16: The Evolution of Animal Diversity

Chapter Summary

The continuous genetic change in organisms that results from their adaptation, by natural selection to ever changing environments is called evolution. Animals are heterotrophic, eukaryotic and multicellular. Diversity is the abundance in the number of species in a given location. Most animal phyla are invertebrates. Extant (living) animals are divided into 35 phyla. Many animals such as humans are symmetrical. Acoelomates do not have body cavity, while coelomates have it. Pseudocoelomates have a false cavity. Embryological changes take place during evolution. Gastrulation is the differentiation of animal tissues into germinal layers. Bilaterally symmetrical animals produce three germ layers: Ectoderm, Endoderm and Mesoderm. About 500 million years ago extant animal body plans were identified on fossil records. Hard body parts were easily identified from the records. Animal classification has been discussed with each phylum and corresponding examples. Humans belong to the phylum Chordata.

Tutorial Features

- General concept map of animal evolution to show the evolution process
- Concept map to depict the characteristics of animals, animal embryology and animal birth.
- Flow charts are shown to simplify the aspects
- Each phylum has an example with a picture.

Key Concepts

Animal Origin
- Introduction
- Characteristics of animals
- Basic features
- Animal organ system
- Animal body fluids

Animal Diversity
- Introduction
- Splitting of Phyla
- Parazoa Vs. Eumetazoa
- Radiata Vs. Bilateria
- Acoelomates Vs. Coelomates
- Protosomes Vs. Deuterosomes

Animal Evolution
- Introduction
- Gastrulation
- Animal Embryology
- Animal Birth
- Evolution
- Diploblastic & Triploblastic Animals

The Cambrian Explosion
- Introduction
- Cambrian Explosion

- Explosive Evolution
- Expansion of Animal Diversity

Animal Classification

- Porifera
- Cnidaria
- Platyhelmenthes
- Nematoda
- Molluscs
- Annelida
- Arthropoda
- Eichinodermata
- Chordata

Chapter Review

Animal Origin

The continuous genetic change in organisms that results from their adaptation, by natural selection to ever changing environments is called evolution. Animals are heterotrophic, eukaryotic and multicellular. Life cycle of animals include a dominant diploid adult that produces eggs or sperms by meiosis. Animals are capable of complex and rapid movements and they develop from embryos like plants.

Animal Diversity

Diversity is the abundance in the number of species in a given location. Most animal phyla are invertebrates. Extant (living) animals are divided into 35 phyla. Phyla are split according to their adult and embryological forms. First spilt in evolution is Parazoa and Eumetazoa. Parazoa do not possess true organelles and their body parts are primitive. Eumetazoa have well developed tissues and organs. Animals under radiata have radial symmetry and are diploblastic. Animals under bilateria are bilateral in symmetry and are triploblastic. Many animals such as humans are symmetrical. Acoelomates do not have body cavity, while coelomates have it. Pseudocoelomates have a false cavity.

Animal Evolution

Embryological changes take place during evolution. Gastrulation is the differentiation of animal tissues into germinal layers. Bilaterally symmetrical animals produce three germ layers: Ectoderm, Endoderm and Mesoderm. Ectoderm becomes the outer surface and nervous tissue of animals. Mesoderm becomes muscle, skeletal and connective tissue. Endoderm becomes the lining of the digestive gut. Diploblastic animals (Cnidaria and Ctenophora) have only endoderm and ectoderm. Platyhelminths, Nematodes, Rotifers, Mollusks, Arthropods and Chordates are triploblastic animals with three germinal layers.

Cambrian Explosion

All surviving animals today can be traced back to their ancestors to this time period. About 500 million years ago extant animal body plans were identified on fossil records. Hard body parts were easily identified from the records. Animal diversity has been developed due to increased dependency or the predatory/prey relationship, development of jeans to assist embryonic development and adequate environment oxygen to support active animal lifestyle.

Animal Classification

Sponges are marine animals, live singly and attach to a substrate. Coelenterates exhibit radial symmetry. There are three major groups of flatworms: Planarians, flukes and tapeworms. Round worms have false body cavity which gives shape to the worms. Mollusks have two circulatory systems, bilateral symmetry, complete digestive tract and internal

organs. Segmented worms have nervous, circulatory and excretory systems in each segment. Insects belong to the most successful phyla – Arthropoda. They are segmented, have jointed appendages and have an exoskeleton composed of chitin. Starfishes are slow moving animals and have unique water vascular system. Vertebrates have a backbone or a vertebral column, humans belong to this phylum.

Tutorial 17: Plant Structure

Chapter Summary

A plant cell contains a polysaccharide cell wall, a central vacuole and chloroplasts, which distinguish them from animal cells. Plants are also made of tissues like animals do. There are three basic types of plant tissues, vascular tissues, ground tissue and dermal tissues. Vascular tissues include xylem and phloem, which are responsible for water, solute and organic chemical transportation. Ground tissues include tissue surrounding the vascular tissue. Its main function is for photosynthesis and storage. Dermal tissues cover the surface of a plant. Different tissue types include different types of cells. A plant body is made up of three major parts: root, leave and stem. Leaves and stems form a shoot. Root is often under the ground and anchors the plant. A stem is the part of the plant from which shoots and buds arise, it supports the plant and transport water, mineral and food. Leave is the major place for photosynthesis.

Tutorial Features

- Concept maps show the relationship between plants and our daily life
- Concept map for plant structure
- Diagram of plant cell
- Pictorial depiction of plant body and plant tissues

Key Concepts

Plant Cells and Tissues
- Plant cell structure
- Plant Cell Wall
- Plant Tissues
- Plant cells within various tissues

Organization of Plant Body
- Introduction
- Plant body and plant tissues
- Root: structure, type and function
- Stem: structure, type and function
- Meristem and bud
- Leave
- Flower

Monocots and Dicots
- Introduction
- Structure difference

Chapter Review

Plant cells

A plant cell contains a polysaccharide cell wall, a central vacuole and chloroplasts, which distinguish them from animal cells. Plant cells also contain mitochondria, a nucleus, Golgi apparatus, endoreticulum membranes, plasma membranes. On plasma membrane and cell wall, there are channels called plasmodesmata connecting neighboring cells for cell-cell communication.

Plant Tissues
Plants are also made of tissues like animals do. There are three basic types of plant tissues, vascular tissues, ground tissue and dermal tissues. Vascular tissues include xylems and phloems, which are responsible for water, solute and organic chemical transportation. Ground tissues include tissue surrounding the vascular tissue. Its main function is for photosynthesis and storage. Dermal tissues cover the surface of a plant. Different tissue types include different types of cells.

Plant Body
A plant body is made up of three major parts: root, leave and stem. Leaves and stems form a shoot. Each part contains the three major tissue types.

Root and Stem
Root is often under the ground and anchors the plant. From cross section, a typical root contains epidermis, cortex, endodermis and vascular bundles. From longitudinal view, a root contains a root tip which functions in gravity sensing, a zone of cell division, zone of elongation and zone of maturation. The function of a root is for anchorage of the plant, and water and mineral uptake. A stem is the part of the plant from which shoots and buds arise. The function of stem is for support of the plant, for transportation of water, mineral and food. Some stems have storage and reproduction function. Stems have specialized structure celled xylem and phloem for transportation.

Meristem, Leaves and Flowers
Meristem is found in areas of the plant where growth is or will take place - the roots and shoots. Apical meristem is on tips of roots or shoots, where growth results in increase in length of stems and roots by cell division and enlargement. A bud is an undeveloped shoot and normally occurs in the axial of a leaf or at the tip of the stem. Once formed, a bud may remain for some time in a dormant condition, or it may form a shoot immediately. A bud can be differentiated into a leaf or a flower. Leaves are the major sites for photosynthesis which provide food for almost all life forms. Upper surface of leaves are covered by cuticular wax, trichomes may be seen on some cells. The lower dermis cells have a specialized type called guard cells which regulate the opening of stomata. Flowers are the reproduction organs for plants.

Monocots and Dicots
Flower plants can be divided into monocots and dicots. The major difference is that monocots have one cotyledon, and dicots have two; Monocots usually have parallel leave veins and dicots have net-like veins; monocots have flower numbers of 3, dicots have flower numbers of 4 or 5; monocots have scattered vascular bundle and dicots have their vascular bundles arranged in a ring.

Tutorial 18: Plant Function

Chapter Summary

Plants absorb nutrients from air and soil via roots and leaves. Nutrients absorbed by roots are transported upwards via xylem. The driving force is the evaporation from leaves via guard cells. Evaporation of water via guard cells pulls up water from root is called transpiration. Five plant hormones regulate every aspect of plant growth, maturation and reproduction. Plants developed both physical and chemical defense strategy. Systemic defense system protects plants from wounding, and HR response protects plants from virus infection. Plants adopt two pathways to reproduce themselves: sexual and asexual reproduction approaches. Sexual Reproduction involves male gametes (sperms) and female gametes (eggs), they combine together to form zygotes, which develop into seeds.

Tutorial Features

- Concept map of plants and environment
- Concept map of plant hormones, growth and reproduction.
- Structural details of plant hormones
- Illustration of apical dominance, gravitropism and phototropism
- Illustration of life cycle of a flower plant

Key Concepts

Plant Nutrition
- Source
- Class
- Macronutrients
- Micronutrients
- Transportation of nutrients and water

Plant Hormones
- Definition
- Auxin
- Apical dominance, gravitropism, and phototropism
- Cytokinins
- Gibberellins
- Abscisic acids
- Ethylene

Plant Defense
- Introduction
- Systemic response
- Plant defense to pathogens

Plant Reproduction
- Introduction
- Life cycle of a flower plant
- Gamete formation
- Zygotes formation
- Seed formation

Chapter Review

Introduction

Plants play important roles in our daily life. Plants are the major organism undergoing photosynthesize, which support the majority of animal lives.

Plant Nutrition

Plants absorb nutrients from air and soil. According to the amount the plant requires, the plant nutrients can be classified as macronutrients and micronutrients. Primary macronutrients include nitrogen (N); phosphorus (P), and potassium (K), secondary macronutrients include calcium (Ca), magnesium (Mg), and sulfur (S). There are total 9 micronutrients: boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn). Macronutrients are usually not proficient in cultivation soil and need to be supplied in fertilizer. Other ways to obtain nutrients include Nitrogen fixation by bacteria, carnivorous feeding and symbiotic associations with fungi. Natural community recycles nutrients.

Transportation of water, minerals and food

Root absorbs nutrients from the soil. These nutrients are transported upwards via xylem. The driving force is the evaporation from leaves via guard cells. This process (evaporation of water via guard cells pulls up water from root) is called transpiration. On the contrary to transpiration, leaves make carbohydrates and these need to be supplied to roots and stems. This transportation occurs in phloem in vascular tissue and it is both directions, downwards and upwards.

Plant Hormones

There are 5 major plant hormones: auxin, gibberellins (Gas), cytokinins, ethylene and abscisic acids (ABA). Auxin is produced by apical tissues and developing leaves, the function is for cell division and elongation. Auxin is also the cause of apical dominance, phototropism and gravitropism. Cytokinins are another group of plant hormones that can stimulate cell division. Cytokinins are derivatives of the purine adenine. Function of cytokinins includes stimulate cell division; the major source is the roots and apical meritstem. Cytokinins are opposite to auxin in that they move upward and they promote growth of lateral buds. They prevent leaf senescence and are Essential for plant cell culture. Gibberellins include over 30 structurally related compounds. The function of Gibberellins includes promoting stem elongation, breaking dormancy of seeds, buds and stimulate flowering in mature plants. Abscisic acids are the major plant hormone response to stress. The main function includes bud dormancy, seed maturation and dormancy, abscission of leaves and fruits (opposite to auxin) and closing of stomata. Ethylene is the only gas form of plant hormone, it is produced by fruit. Major function of ethylene includes promoting fruit ripening and stimulates senescence and abscission in leaves and fruits.

Plant Defense

Plants developed both physical and chemical defense strategy. The physical barriers include cuticle wax on surface of leaves, trichomes, spines and bark. The chemical barrier is secondary metabolites or chemical toxins which could cause problems for the predators, for example, isoprene, phenolic compounds and alkaloids. Plants also developed a systemic response when they are wounded, in such a condition as insects attacking. Upon attacking, plants first synthesize a small peptide called systemin which then triggers a series of biochemical reaction to release proteinase inhibitors which are toxic to insects. Upon infection by plant virus, plants can undergo a hypersensitive response (HR) which leads to programmed cell death on the infected sites. There is a gene-for-gene theory for plant defense against virus. Basically, to every pathogen avirulence (*avr*) gene, there is a corresponding R gene (resistance gene) in plant to trigger HR. HR is commonly followed by a slower response that leads to systemic acquired resistance (SAR). SAR occurs when a hormone, which may be salicylic acid, travels from the infection site to nearby tissues and triggers the expression of a specific set of genes.

Plant reproduction

Plants adopt two pathways to reproduce themselves: sexual and asexual reproduction approaches. Sexual Reproduction involves male gametes (sperms) and female gametes (eggs), they combine together to form zygotes. After that, female structures house the embryo during development. Asexual reproduction refers to offspring produced by mitosis and therefore they are genetically identical to parent. Flowers are the reproductive organs for plants. The reproduction process typically includes flower blossom, pollination, seed development and seed maturation.

Tutorial 19: Animal Structure

Chapter Summary

The building unit for animals is also cells. A group of same cells form a tissue, several types of tissues form an organ which performs certain function, and several organs form an organ system to perform a more complete function. 11 major organ systems together form a vertebrate animal. Animals have four major tissue types: epithelial tissues, connective tissues, muscle tissues and nervous tissues. These tissues form 11 major organ systems: muscular system, skeletal system, skin or integument system, respiratory system, digestive system, circulatory system, lymphatic system, excretory system, nervous system, endocrine system and reproductive system. These organs cooperate with each other and reach homeostasis of the organism. Homeostasis is defined as living organisms regulating its internal environment to maintain a stable, constant condition, by means of multiple dynamic equilibrium adjustments, controlled by interrelated regulation mechanisms. The mechanism of homeostasis is through a negative feedback response.

Tutorial Features

- General concept map to explain the relationship among cells, tissue and organs
- Microscopic picture to demonstrate various cell types and tissue types
- Colorful illustration on organ systems
- Flowchart explanation of negative feedback regulation of homeostasis

Key Concepts

Animal Cells and Tissues
- Introduction
- Animal cell structure
- Animal tissue types
- Epithelial Tissue
- Connective Tissue
- Muscle Tissue
- Nervous Tissue

Animal Organ System
- Introduction
- Muscular system
- Digestive system
- Respiratory system
- Circulatory system (Cardiovascular system)
- Lymphatic system
- Excretory system
- Endocrine system
- Reproductive system
- Nervous system
- Skeletal system
- Skin or integument system

Homeostasis
- Introduction
- Mechanism
- Types
- Example

Chapter Review

Animal cells and Tissues

The building unit for animals is also cells. A group of same cells form a tissue, several types of tissues form an organ which performs certain function, and several organs form an organ system to perform a more complete function. 11 major organ systems together form a vertebrate animal. Animals have four major tissue types:

1) **Epithelial Tissue --**closely packed in either single or multiple layers, and cover both internal and external surfaces of the animal body. The function of epithelial layer is movement materials in, out, or around the body; protection of the internal environment against the external environment; secretion of a product.

2) **Connective Tissue** --tissue with an extensive extra cellular matrix and often serves to support, bind together, and protect organs. The function of connective tissues is binding, supporting, protecting, forming blood storing fats, and filling space. Blood and bones are specialized connective tissues.

3) **Muscle Tissue**--formed by muscle cells for movement of and/or within the animal. Cardiac muscle is striated muscle found only in the heart. The cells are usually connected to each other by intercalated disks. It powers the heartbeat.

4) **Nervous Tissue** --bundles of neuronal processes enclosed in connective tissue that carry signals to and from muscles. Nervous tissue is made up of two types of cells: neurons and glial cells. A neuron is made up of three parts: A cell body which contains the nucleus, mitochondria and other organelles; An anon which is a long fiber that carries signals away from the cell body and many dendrites which receive information from another cell and transmit the message to the cell body.

Animal Organ System

Organs are grouped together according to their functions.

Muscle system is composed of all skeleton-attached muscles. The function of muscle system is movement and locomotion, powering circulatory, digestive, and respiratory systems, and plays a role in regulating temperature.

Digestive system is composed of mouth, esophagus, stomach, small intestine, liver, pancreas, gallbladder, colon (large intestine), rectum, and anus. The function of digestive system is ingesting food and breaking it down into smaller chemical units; absorbing the nutrients; and eliminating solid wastes into the environment.

Respiratory system contains nose, pharynx, larynx, trachea, bronchi, and lung. The major function of respiratory system is exchanging gas between body and environment, which includes inhale oxygen and remove carbon dioxide.

Cardiovascular System is composed of three parts: blood vessels, blood and heart. The function of cardiovascular system is to transport oxygen, carbon dioxide, nutrients, and waste products between cells and the respiratory system and carries chemical signals from the endocrine system.

Lymphatic system is also called immune system. It is composed of central lymphoid tissue and peripheral lymphoid tissue. Function of lymphatic system is defense against invading microorganisms and viruses, and defense against the growth of cancer cells.

Excretory system contains liver, skin and urinary system. The function of excretory system is to remove organic waste and maintain fluid levels.

Endocrine system is composed of all glands including pineal gland, hypothalamus, pituitary gland, thyroid gland, thymus, parathyroid glands, adrenal glands, reproductive gland and pancreas. Function of endocrine system is to secret hormones to control growth and homeostasis, it also coordinate long-range response to external stimuli.

Reproductive systems are different in male and females. The function is secretion of hormones and reproduction.

Nervous system is divided into central nervous system and peripheral nervous system. The central nervous system includes brain and spinal cord. The peripheral nervous system

contains all neurons and nerves that are not in the central nervous system. The function of nervous system is to Coordinates the activity of the muscles, to monitor the organs constructs and to Processes input from the senses, and initiates actions.
Skeletal system contains all bones in human body and the majority of the bones are internally linked. The function of the skeletal system is to support for the body, producing blood and immune cells, to support muscle movement and to store minerals.
Skin system is made of skin, hair, nail and skin glands and their products. The skin is divided into two layers, epidermis which includes Keratinocytes, basal cells and melanocytes; and Dermis which contains elastic and collagen fibers, capillary networks, and nerve endings. The function of skin system is to for protection, exchange and secretion.

Homeostasis
Homeostasis is defined as living organisms regulating its internal environment to maintain a stable, constant condition, by means of multiple dynamic equilibrium adjustments, controlled by interrelated regulation mechanisms. The mechanism of homeostasis is through a negative feedback response. Normally a threshold is set for triggering certain response. The sensor senses the change and transmits the change via a signal transduction pathway, reaching effectors to bring back the balance. Regulation on blood glucose level is an example.

Tutorial 20: Animal Function

Chapter Summary

Animals take in food and digest it into smaller unit for absorption and building. Digestion and absorption of food occurs in digestive systems, main site for chemical digestion is small intestine. Animals take oxygen and eliminate carbon dioxide through respiration. Gas exchange occurs in lung through diffusion mechanism. Capillaries in lung take in oxygen and release carbon dioxide. Animals can defense against pathogens. The body defense can be categorized into nonspecific defense and immune response. An inflammatory response is the major component of nonspecific response. It is initiated by tissue injury, and then chemical signals are released and trigger local blood vessels dilation, and migration of phagocytes to the infected area. Phagocytes consume bacteria and cell debris and the wound is repaired. Resistance to specific invaders is called an immune response, which contains the humoral immune response (B cell antibodies) and the cellular immune response (T cells). Animal embryo development involves three stages: cleavage, gastrulation and organ formation. Animal sensory system involves a sensory receptor which converts the stimuli to an electrical signal, and the sensory neurons then transmit the signal to the central nerve system, which is processed and passed to a motor neuron and finally reach an effector to cause an action. There are three types of neurons playing important roles in this process: sensory neurons, interneuron and motor neurons.

Tutorial Features

- Concept map to explain the interaction of each function of animals.
- Detailed organ structure and how the structure is related to its function
- Graphic scheme explanation of antibody production and secondary response
- Summary map to describe the relationship and interaction within defense system
- Stop-and-thinking questions for easy review

Key Concepts

Energy Source
- Animal nutrition
- Food process
- Food digestion
- Respiration
- Oxygen and carbon dioxide transport

Circulation and Defense
- Cardiovascular system
- Blood circulation
- Cardiac cycle
- Body defense--introduction
- Inflammatory response
- Immune response
- Antibodies and B cell
- Cell-mediated response
- Summary

Development and Reproduction
- Overview
- Sperm and Ova formation
- Embryo development

Sense and Nervous System

- Introduction
- Sensory receptors
- Neuron potentials
- Synapse
- Spinal Cord
- Brain

Chapter Review

Food Ingestion and Digestion

Animals require nutrients, including major ones such as organic carbon and nitrogen, vitamin, minerals and certain amino acids that cannot be synthesized in vivo. The nutrients are taken in the form of food. Food processing include ingestion**--**taking the food, digestion**--**breaking down the food into small unit that can be absorbed, absorption**--** nutrient molecules are absorbed into body and blood stream, and elimination**--**undigested waste is passed out of the digestive tract. Chemical digestion (breaking down macromolecules into its smaller building units) and absorption mainly occurs in small intestine.

Respiration

Respiration is a process inhaling oxygen and exhaling carbon dioxide. Gas exchange occurs in lung through diffusion mechanism. Capillaries in lung take in oxygen and release carbon dioxide.

Circulation

Cardiovascular system contains heart, vein, artery and capillary. Blood Circulation is divided into two parts: pulmonary circuit and system circuit. In pulmonary circuit, Heart pumps CO_2-riched blood to lung, then the blood releases CO_2 and uptakes O_2 in the lung, the O_2-riched blood returned back to heart eventually. In systemic circuit, Heart pumps O_2-riched blood to tissues, the blood releases O_2 for tissue to use and uptakes CO_2 generated by the tissue and send the CO_2-riched blood returns back to heart. A cardiac cycle includes three steps of alternating relaxing and contraction of heart: diastole, atria systole and ventricular systole.

Body Defense

Blood carries nonspecific defense proteins (interferon and complete) and cells (neutrophils, monocytes, macrophages, Natural killer cells). The body defense can be categorized into nonspecific defense and immune response. An inflammatory response is the major component of nonspecific response. It is initiated by tissue injury, then chemical signals such as histamine is released, histamine triggers local blood vessels dilation, and migration of phagocytes to the infected area, exhibiting swelling and redness phenotype. Phagocytes consume bacteria and cell debris and the wound is repaired. Resistance to specific invaders is called an immune response, which contains two interactive immune responses: **The humoral immune response:** antibodies in blood system, it involves B cells and antibodies, which recognize antigens; some antibodies are soluble proteins that travel free in blood and lymph, others are integral membrane proteins on B cells. When a pathogen invades the body, it may be detected by and bind to an antibody on B cell. This binding and other system component activates the B cell, which makes multiple soluble copies of an antibody with the same specificity. The antibody then attacks the invaders and kills them. **The cellular immune response:** detect antigens that reside within or on cells. Main component is T cells which destroy virus-infected or mutated cells. T cell receptors recognize and bind specific antigens on cell surface and lyse the infected cells.

Development and Reproduction

The reproductive and development process involves the following steps: sperm and ova formation via meiosis, zygote formation, embryo development, and child born process and growth stages. Once becoming an adult, one can produce more offspring by same procedure. There are three important steps for embryo development: cleavage, gastrulation and organ formation. During cleavage, cells divide rapidly and form a ball-like structure called blastula. During gastrulation, three layers are formed, ectoderm, endoderm and mesoderm. Then the embryo continues to develop to form organs. From Endoderm form the following organs/tissues: digestive tract, liver, pancreas, thyroid, parathyroid, thymus, lining of bladder. Ectoderm forms the skin and central nervous system. Mesoderm forms internal organs, skeletal/muscular system.

Sense and Nervous System

The sensory process is a process in which a stimuli from outside becomes a signal to the body. Briefly it involves a sensory receptor which converts the stimuli to an electrical signal, and the sensory neurons then transmit the signal to the central nerve system, which is processed and passed to a motor neuron and finally reach an effector to cause an action. There are three types of neurons playing important roles in this process: **Sensory Neurons** - Send impulses towards the CNS, away from the peripheral system. **Interneurons** - Neurons lying entirely within the CNS. **Motor Neurons** - These nerve cells carry signals from the CNS to the cells in the peripheral system. Neurons communicate at synapse. Action potential can regenerate itself along the neuron. The potential arrives at the synaptic cleft and release neurotransmitter; Neurotransmitter then binds to receptor on the receive neuron. The binding opens ion channel in the receive neuron and generates new action potential.

Tutorial 21: Introduction to Ecology and Biosphere

Chapter Summary

Ecology is the study of how organisms with their environments. It gives an idea of distribution and abundance of organisms. Biosphere is the entire portion of the earth which is inhabited by life. The environment of an organism can be divided into two: Abiotic and biotic environment. Biosphere is thin, life supporting skin consisting of seas, lakes, stream, land and atmosphere. Biosphere is a mosaic of habitats differing in abiotic factors such as temperature, rainfall and light. These affect the distribution of biotic factors such as the type of vegetation. Environments change in time as well as space. Individual organisms can respond to changing environments by mechanisms that are behavioral, physiological or morphological. The world's major communities like deserts, tropical rain forests, grasslands and the like are known as Biomes. The aquatic communities can be divided as fresh water and marine. Rivers and streams are bodies of water continuously moving in one direction.

Tutorial Features

- General concept map of ecology is depicted
- Flow charts of biotic and abiotic factors are shown
- Concept maps of terrestrial biomes and aquatic communities are described
- Pictorial description for each type of terrestrial biomes

Key Concepts

Scope of Ecology
- Introduction
- Abiotic Factors
- Ecology

Changing Environments in the Biosphere
- Biosphere: Introduction
- Effect of Abiotic Factors
- Temperature, Water, Light, Soil and Wind
- Fire and Other Disturbances

Responses of Organisms to Environmental Change
- Introduction
- Behavioral Responses
- Physiological Responses
- Morphological Responses

Terrestrial Biomes
- Introduction
- Forests
- Desert
- Grasslands

Aquatic Communities
- Introduction
- Fresh Water Communities
- Marine Communities

Scope of Ecology

Ecology is the study of how organisms with their environments. It gives an idea of distribution and abundance of organisms. Biosphere is the entire portion of the earth which is inhabited by life. The environment of an organism can be divided into two: Abiotic and biotic environment. Abiotic factors include temperature, light, topography, pH, soil and water. Biotic factors include plants and animals. Ecological niche of a species refers to its 'lifestyle' – how it lives, what it does, how it interacts with other members of its ecosystem. The habitat is where the species is found.

Changing Environments of the Biosphere

Biosphere is thin, life supporting skin consisting of seas, lakes, stream, land and atmosphere. Biosphere is a mosaic of habitats differing in abiotic factors such as temperature, rainfall and light. These affect the distribution of biotic factors such as the type of vegetation. On the basis of extremes of temperature, light and other abiotic factors, organisms have diverse adaptations in the biosphere. Endotherms maintain internal temperature. Water is essential to life. All ecosystems are driven by solar energy and plants are directly dependent on it. Tropical forests are resulted due to low light levels. Physical structure, pH and mineral composition of soil limit the distribution of plants and hence of the animals that feed on those plants. Wind amplifies the effects of environmental temperature on organisms by increasing heat loss due to evaporation and convection. Catastrophic events such as fires, hurricanes, typhoons, and volcanic eruptions can devastate biological communities.

Responses of Organisms to Environmental Change

Environments change in time as well as space. Individual organisms can respond to changing environments by mechanisms that are behavioral, physiological or morphological. Response such as migration of animals and birds in response to change in temperature is an example for behavioral response. Physiological responses are slower than behavioral responses. Morphological responses are the slowest. Internal anatomy of the body maybe changed due to change in the environment.

Terrestrial Biomes

The world's major communities like deserts, tropical rain forests, grasslands and the like are known as Biomes. Tropical forests are found near the equator. Savanna is tropical or semi tropical grassland with scattered individual trees. Desert is the harshest of all biomes. Chaparral consists of dense, spiny shrubs with tough ever green leaves. Temperate grasslands are found in regions of relatively cold temperature. Temperate forests grow in the regions where there is sufficient moisture to support the growth of large trees. Taiga is also known as coniferous forest. Tundra has plants which form shrubby or mat like vegetation.

Aquatic Communities

The aquatic communities can be divided as fresh water and marine. Rivers and streams are bodies of water continuously moving in one direction. These communities are dynamic, changing significantly from the source to the point at which they empty into an ocean or lake. Estuaries are the areas at which a fresh water river or stream meets the ocean. The end points of many rivers and streams are ponds and lakes. Phytoplanktons and zooplanktons thrive in them. Marine environment is made up of photic and aphotic zones. Marine communities are based on depth – Littoral zone, neritic zone and oceanic zone.

Tutorial 22: Population Ecology

Chapter Summary

Population ecology is the study of population fluctuations as well as of the factors that regulate population size. Population density is the number of individuals per unit area or volume. It is impractical to count all individuals in a population. Population size and density reflect the relative rates of processes that add individuals to the population and processes that eliminate individuals from the population. Mortality and natality are essential factors in population dynamics. Population size is regulated through density-dependent and density-independent factors. Some populations of birds, mammals and insects fluctuate in density with remarkable regularity which is called population cycles. Demography is the study of the vital statistics that affect population growth. It is concerned with births and deaths: Events that most directly determine population density. Different countries have different rates of growth for various reasons. Environmental, cultural and historical reasons are some of them. Although technology has increased our carrying capacity, the human population can not grow indefinitely. R-selected population refers to a type of population which produces large quantities of offspring with a relatively low probability of individual success. K-selected population refers to those whose life history is centered on producing relatively few offspring that have a good chance of survival.

Tutorial Features

- General concept of population ecology is depicted
- Chart of evolution of life history is described
- Animated explanations with suitable examples
- Flow charts with colorful blocks for easy understanding of the topics

Key Concepts

Density and Dispersion
- Introduction
- Measurement of Density
- Patterns of Dispersion

Models of Population Growth
- Introduction
- Exponential Growth
- Logistic Growth

Regulation of Populations
- Density-Dependent Factors
- Density-Independent Factors
- Applications
- Population Cycles

Demographic Statistics
- Introduction
- Age Structure
- Life Tables
- Survivorship Curves
- Net Reproductive Rate

Human Population Growth
- Introduction
- Baby Boom

Evolution of Life Histories
- Life History Characteristics
- R-Selection
- K-Selection

Chapter Review

Density and Dispersion
Population ecology is the study of population fluctuations as well as of the factors that regulate population size. Population density is the number of individuals per unit area or volume. It is impractical to count all individuals in a population, a variety of sampling techniques are used to estimate densities and total population sizes. Dispersion is a pattern of spacing for individuals within the boundaries of the population.

Models of Population Growth
Population size and density reflect the relative rates of processes that add individuals to the population and processes that eliminate individuals from the population. Mortality and natality are essential factors in population dynamics. Generation time is the average age when females of a population begin reproducing which greatly impacts on the intrinsic rate of increase. Carrying capacity is the maximum population size that can be supported by the available resources, symbolized as K. No population can grow indefinitely.

Regulation of Populations
Population size is regulated through density-dependent and density-independent factors. Any factor influencing population regulation that has a greater impact as population density increases is a density-dependent factor. Any population influencing population regulation that acts to reduce population size by the same fraction whether the population is large or small is called density-independent factor. Population density may change with temperature. Some populations of birds, mammals and insects fluctuate in density with remarkable regularity which is called population cycles. Stress resulting from high population density may alter hormonal balance and reduce fertility.

Demographic Statistics
Demography is the study of the vital statistics that affect population growth. It is concerned with births and deaths: Events that most directly determine population density. Age structure is a relative number of individuals of each age in a population. Mortality is one of the factors that determine population density. Life tables can be constructed by following the fate of a group of new born organisms throughout their lives until all are dead. Survivorship curve is the plot of the number of the number of members of a cohort those are still alive at each age which is one way to represent age specific mortality. Birth rates also vary with age. Net reproductive rate is the expected number of female offspring that will be produced during the average lifetime of a female member of a population.

Human Population Growth
Different countries have different rates of growth for various reasons. Environmental, cultural and historical reasons are some of them. Although technology has increased our carrying capacity, the human population can not grow indefinitely.

Evolution of Life Histories
Life history contains birth, reproduction and death – the personal episodes of organisms. Three life history characteristics influence birth rates and death rates: Clutch size, age at first reproduction and number of reproductive episodes per life time. R-selected population

refers to a type of population which produces large quantities of offspring with a relatively low probability of individual success. K-selection population refers to those whose life history is centered on producing relatively few offspring that have a good chance of survival.

Tutorial 23: Community Ecology and Ecosystem

Chapter Summary

Community is an assemblage of species living close enough together for potential interaction. Species diversity or richness is the number of species that make up a community which include relative abundance. Some species are quite rare in a community where as other species are plentiful. Coevolution is an interspecific phenomenon which is of great importance in community ecology. Interspecific competition for limited resources determines species diversity in some communities. Closely related species can coexist if there are one or more significant differences in their niches. Succession involves changes in species composition of a community over ecological time. Biogeography is the study of the past and the present distribution of species, deals with species diversity and composition in realms that have boundaries, ultimately associated with the patterns of continental drift. Ecosystem is the level of ecological study that includes all the organisms in a given area along with the abiotic factors with which they interact. . Biogeochemical cycles are the various nutrient circuits which involve both biotic and abiotic components of ecosystems. Three important chemical cycles are carbon, nitrogen and phosphorus cycles.

Tutorial Features

- General concept maps of community ecology
- Concept maps of community interactions and ecosystem interactions
- Colorful flow chart of chemical cycling
- Colorful flowchart of human intrusions in ecosystem dynamics

Key Concepts

Views of Communities
- Introduction
- Two Views

Properties of Communities & Coevolution
- Species Diversity
- Relative Abundance and Dominance
- Prevalent Form of Vegetation
- Trophic Structure
- Stability
- Coevolution

Community Interactions
- Competition between Species
- Predation
- Symbiosis
- Complex effects of community interactions on species diversity

Succession
- Introduction
- Causes
- Disturbance

- Equilibrium

Geographic Aspects of Diversity
- Limits of Species
- Island Biogeography

Ecosystem
- Trophic Levels and Food Webs
- Energy Flow
- Chemical Cycling
- Human Intrusions in Ecosystem Dynamics
- Superorganism

Topical Review

Views of Communities
Community is an assemblage of species living close enough together for potential interaction. Community structure emerges from an interaction of many environmental variables that permits species to exist in certain places. There are two views to discuss why certain species are found together in communities.

Properties of Communities & Coevolution
Species diversity or richness is the number of species that make up a community which include relative abundance. Some species are quite rare in a community where as other species are plentiful. Dominant species are those which are abundant and have major impact on the community as a whole. Grouping of communities according to similarities in overall form without regard to the actual species is the basis for the biomes. Various feeding relationships of a community determine the flow of energy and cycling of nutrients from plants to herbivores and then to carnivores. Community stability is the ability of the community to bounce back to its original composition in the wake of some disturbance such as a fire or a disease that kills most individuals of a dominant species. Coevolution is an interspecific phenomenon which is of great importance in community ecology.

Community Interactions
Interspecific competition for limited resources determines species diversity in some communities. Closely related species can coexist if there are one or more significant differences in their niches. Predation has important roles in the evolution of defensive adaptations in the prey species. Symbiosis has different impacts on a community. Parasitism resembles the predator-prey relationship but does not kill the host. It shows coevolution. Dynamic multiple interactions of organisms with both biotic and abiotic aspects of their environment results in a complex community property, the composition of species.

Succession
Succession involves changes in species composition of a community over ecological time. Primary succession occurs where no organisms previously existed whereas secondary succession occurs after disturbance of an existing community. Facilitation, inhibition and tolerance are the causes of succession.

Geographic Aspects of Diversity
Biogeography is the study of the past and the present distribution of species, deals with species diversity and composition in realms that have boundaries, ultimately associated with the patterns of continental drift. Islands are instructive in studying the role of dispersal in determining the species composition of communities.

Ecosystem

Ecosystem is the level of ecological study that includes all the organisms in a given area along with the abiotic factors with which they interact. Most ecosystems are driven by energy from sunlight. Energy flow and chemical cycling are two inter related processes that occur by transfer of substances through the feeding levels of ecosystems. Trophic levels begin with producers, autotrophic organisms that support all other components of the community. The main producers in photosystems are photosynthetic autotrophs. Primary productivity is the rate at which light energy is converted to the chemical energy of organic compounds by autotrophs in an ecosystem. Biogeochemical cycles are the various nutrient circuits which involve both biotic and abiotic components of ecosystems. Three important chemical cycles are carbon, nitrogen and phosphorus cycles. The biosphere is a kind of superorganism with a self regulated metabolism that helps counter fluctuation in the physical environment. Processes occurring at one location can have far reaching effects and consequences.

Tutorial 24: Conservation Biology

Chapter Summary

Air, water, energy, minerals, soil, land, plants and animal wealth are the natural resources since they are all part of nature. There are three types of resources: Continuous, renewable and non-renewable. Sustainability is the enhancing of community resources so that the ecosystems on which ultimately depends are not damaged. Every developmental issue takes into consideration social, ecological and economic factors. Conservation is the safeguarding, maintaining or protecting and wise management of natural resources. Water consuming human activities put a great strain on our water resources. Fresh water is the ground water stored in spaces in the soil and cracks in the rocks. Fertile upper part of the soil is the most productive, rich in organic content with adequate moisture with a rich biodiversity. Soil erosion occurring now is the result of manmade disasters. Forests are natural ecosystems with a multi species composition. Wildlife is a state of life in the wild or in its natural habitat which includes both plants and animals. Habitat is a physical place in the environment where a certain type of organism lives. Two types of habitats: Terrestrial and aquatic.

Tutorial Features

- Concept map of conservation biology for clear understanding
- Flowchart for resources
- Animated flowchart for techniques to conserve forest
- Examples for each category with pictorial description

Key Concepts

Natural Resources
- Introduction
- Continuous Resources
- Renewable Resources
- Non-Renewable Resources

Concept of Sustainability
- Introduction
- Sustainability

Conservation
- Introduction
- Traditional Ecological Knowledge

Conservation of Water
- Need for Water Conservation
- Conservation and Management
- Rainwater and Harvesting
- Watershed Management

Conservation of Soil
- Topsoil and its Loss
- Maintenance of Soil Fertility
- Soil Erosion Control

Conservation of Forests
- Introduction
- Maintenance of Biosphere Reserves

Conservation of Wildlife
- Introduction
- Objectives
- Methods

Habitat Improvement
- Introduction
- Improvement Methods

Chapter Review

Natural Resources
Air, water, energy, minerals, soil, land, plants and animal wealth are the natural resources since they are all part of nature. There are three types of resources: Continuous, renewable and non-renewable. Solar energy, wind energy, gravity, tidal energy and geothermal energy are the continuous resources. Water, flora and fauna and biodiversity in general are renewable resources. Minerals, ground water, oil and gas are non-renewable resources.

Concept of Sustainability
Sustainable development meets the needs of present generation without compromising the ability of future generations to meet their own needs. Desertification, deforestation, biodiversity depletion adversely affect future generations. Sustainability is the enhancing of community resources so that the ecosystems on which ultimately depends are not damaged. Every developmental issue takes into consideration social, ecological and economic factors.

Conservation
Conservation is the safeguarding, maintaining or protecting and wise management of natural resources. Biodiversity remains conserved because of traditional ecological knowledge. The practices of tribal communities have maintained soil fertility, soil moisture and water regimes.

Conservation of Water
Water consuming human activities put a great strain on our water resources. Fresh water is the ground water stored in spaces in the soil and cracks in the rocks. Collecting and using rain water which normally runs off on natural or man made catchment areas. Homes, farms, parks, forests are all components of the water shed.

Conservation of Soil
Fertile upper part of the soil is the most productive, rich in organic content with adequate moisture with a rich biodiversity. Soil erosion occurring now is the result of manmade disasters. Healthy soil is a key to sustainability. Soil health depends on its nutrient content and moisture. Animal manuring, farming with diversity, growing legumes, green manuring are the techniques used to maintain soil fertility. Contour farming, strip cropping and terracing, wind brakes, mulching are the various methods which keep the soil covered with vegetation and thus control soil erosion.

Conservation of Forests
Forests are natural ecosystems with a multi species composition. Restrained felling, control of disasters, reforestation, recycling forest produce, block and selective

cutting are some of the various techniques to harvest forest trees. Biosphere reserve is the undisturbed natural area where everything is protected in its totality.

Conservation of Wildlife

Wildlife is a state of life in the wild or in its natural habitat which includes both plants and animals. Objectives are: enforcing wild life laws, manipulating wild life population, preservation and perpetuation of endangered plants and animals. Methods of conservation of wildlife are in situ and ex situ conservation.

Habitat Improvement

Habitat is a physical place in the environment where a certain type of organism lives. Two types of habitats: Terrestrial and aquatic. Reforestations, reclamation of waste land, conservation of wet lands, controlling wild life trade, expansion of protected area network are the methods for habitat improvement.