

NUMS MDCAT CURRICULUM

BIOLOGY

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CELL STRUCTURE AND FUNCTION

- Cell wall,
- Plasma membranes,
- Cytoplasm and cell organelles
 - Nucleus,
 - Endoplasmic reticulum,
 - Mitochondria,
 - Golgi apparatus,
 - Lysozyme,
 - Plastid,
 - Vacuoles,
 - Peroxisomes,
 - Glyoxysome
- Prokaryote and eukaryote
- Fluid mosaic model

Learning Outcomes

- Compare the structure of typical animal and plant cell
- Compare and contrast the structure of Prokaryotic cell with Eukaryotic cells)
- Outline the structure and function of the following organelles: Nucleus, Endoplasmic reticulum, Golgi apparatus, Mitochondria)
- Discuss fluid mosaic model of cell membrane and transportation (diffusion, facilitated diffusion, active and passive transport), endocytosis and exocytosis.

BIOLOGICAL MOLECULES

- Introduction to biological molecules
- Water
- Carbohydrates
- Proteins
- Lipids
- Nucleic acids
- Conjugated molecules

Learning Outcomes

- Introduce biochemistry and chemical composition of protoplasm.
- Describe biologically important properties of water (heat of vaporization, polarity, hydrolysis, specific heat, solvent, density, ionization, cohesion)
- Discuss carbohydrates: Monosaccharides (Glucose), Oligosaccharides (Cane sugar, sucrose, lactose), Polysaccharides (Starches, cellulose, glycogen)
- Describe Proteins: Amino acids, structure of proteins
- Describe Lipids: Acylglycerol, waxes, Phospholipids, Terpenoids
- Describe the structure along its back bone composition and function of DNA as hereditary material, double helical model.
- Give an account on the structure and types of RNA (mRNA, rRNA, tRNA)
- Introduce and discuss conjugated molecules (glycolipids, lipoproteins, nucleoproteins)

ENZYMES

- Characteristics of enzymes
- Mechanism of action of enzymes
- Factors effecting rate of action
- Enzyme inhibition
- Feedback inhibition.

Learning Outcomes

- Distinguish characteristics of enzymes
- Explain mechanism of action of enzyme
- Describe effects of factor on enzyme action (temperature, pH, concentration)
- Distinguish enzyme inhibitors and activators
- Define feedback inhibition

BIOENERGETICS

- Photosynthesis,
- Role of light, water, CO₂ and photosynthetic pigments,
- Electron transport,
- Production of ATP,
- Light dependent and light independent phases,
- Cellular respiration,
- Glycolysis,
- Oxidative phosphorylation,
- Aerobic and anaerobic respiration

Learning Outcomes

- Explain the role of light in Photosynthesis
- Describe role of Chlorophyll and other pigments
- Explain the role of CO₂, water and light in photosynthesis
- Describe electron transport chain
- Distinguish and explain light dependent and independent phases
- Explain ATP production process.
- Describe cellular respiration, oxidative phosphorylation, aerobic and anaerobic respiration

BIODIVERSITY (ACELLULAR LIFE/ VARIETY OF LIFE)

- Discovery of viruses,
- Structure of viruses,
- Classification of viruses,
- life cycle of bacteriophages(lytic and lysogenic)
- Viral diseases (influenza, AIDS, Hepatitis A,B,C, MEASELS),
- Viroids and Prions

Learning Outcomes

- Trace the discovery of virus
- Classify viruses on basis of their structure.
- Describe the lytic and lysogenic life cycle of viruses
- Identify symptoms, mode of transmission and causes of viral diseases.
- Differentiate viroids and prions

PROKARYOTES (KINGDOM MONERA)

- Cellular Structure of bacteria
- Shape and size of bacteria,
- Locomotion in bacteria
- Nutrition in bacteria (autotrophic, saprotrophic, symbiotic, parasitic)
- Respiration in plants
- Reproduction (Fission and spore formation)
- Growth in bacteria,
- Cyanobacteria,
- Importance and control of bacteria

Learning Outcomes

- Describe cellular structures of bacteria and composition of cell wall
- List the major groups of bacteria on basis of nutrition.
- Explain diversity in shape and size found in bacteria
- Explain respiration and locomotion in bacteria
- Describe types of reproduction in bacteria
- Justify the role and importance of cyanobacteria
- Describe bacteria as recyclers of nature
- Highlight the importance of bacteria and control of harmful bacteria

PROTISTS AND FUNGI (KINGDOM PROTOCTISTA AND KINGDOM FUNGI)

- Major groups among Protists (algae, primitive fungi, slime mold, water mold) protozoa),
- Reproduction among Protists,
- Locomotion in Protists
- Characteristics of fungi
- Classification of fungi
- Reproduction in fungi
- Useful and harmful fungi

Learning Outcomes

- Describe salient features of protists
- Differentiate among different types of protists with examples
- Describe the mode of reproduction among protists and fungi
- List the characteristic features of fungi
- Explain the beneficial and harmful (pathogenic) effects of fungi

DIVERSITY AMONG PLANTS (THE KINGDOM PLANTAE)

- General introduction of plants,
- Characteristics of bryophytes
- Adaptation to land habitat
- Water absorption and conservation
- CO₂ absorption
- Embryo formation
- Heterogamy,
- Protection of reproductive cell,
- Life cycle of moss,
- Tracheophytes (seedless vascular plants)
- Psilopsida, Lycopsida, Sphenopsida, Pteropsida,
- Life cycle of ferns, spermatophytes (seed plants)
- Evolution of seed,
- Evolution of leaf,
- Gymnosperms,
- Angiosperms,
- Inflorescence,

Learning Outcomes

- Outline the evolutionary origin of plants
- Describe the general characteristics of bryophytes
- Outline life cycle of moss
- Explain land adaptations of bryophytes
- List general characteristics of tracheophytes (vascular plants)
- Define CO₂ absorption, water absorption and conservation.
- Outline process of embryo formation
- Outline life cycle of ferns
- Describe characteristic features of vascular plants (seedless and seed plants)
- Explain evolution of seed
- Explain evolution of leaf

- Differentiate gymnosperms and angiosperms
- Define inflorescence and heterogamy

DIVERSITY AMONG ANIMALS (THE KINGDOM ANIMALIA)

- Characteristics and diversity among the kingdom,
- Classification of animals,
- Diploblastic and triploblastic organization,
- Classification according to coelom (body cavity),
- Protostomes, deuterostomes,
- Phylum Porifera,(habitat, importance of sponge, body types),
- Phylum Cnidaria, (polymorphism, body types, nematocytes)
- Evolutionary adaptation and alterations of generation
- Coral reef,
- Phylum Platyhelminthes (parasitic adaptation, body types),
- Phylum Aschelminthes (nematodes and round worms),
- Phylum Mollusca (body types, economic importance),
- Phylum Annelida (locomotion, reproduction, economic importance),
- Phylum Arthropoda (locomotion, skeleton, evolutionary adaptations, economic importance,
- Insects
- Phylum Echinodermata (structure with examples),
- Phylum Chordata (structure, general characteristics, classification,
- Subphylum/ classes,
- General characteristics of class fish,
- Amphibian,
- Reptilia,
- Aves,
- Mammalia.

Learning Outcomes

- Describe general characteristic of animals
- Describe classification of animal kingdom
- Differentiate between diploblastic and triploblastic level of organization
- Distinguish the classification according to coelom

- Explain general characteristics of phylum of animal kingdom
- Define alteration of generations and importance of coral reef
- Highlight economic importance of phyla
- Describe characteristics of invertebrates(chordates) and vertebrates
- Highlight evolutionary adaptations in concerned phyla
- Discuss characteristics with examples in each class of phylum chordata.
- Highlight general characteristics of each subclass among phylum chordata with examples

LIFE PROCESSES IN ANIMALS AND PLANTS (NUTRITION/ GASEOUS EXCHANGE/TRANSPORT)

- Nutrition in plants,
- Mineral nutrition in plants with deficiency systems,
- Carnivorous plants,
- Photosynthesis,
- Gaseous exchange in plants,
- Role and structure of stomata,
- Uptake and transport of water,
- Ascent of sap,
- Osmotic pressure,
- Translocation of organic solutes,
- Transpiration and factors effecting it,
- Water and mineral uptake by roots,
- Concept of digestion and absorption,
 - oral cavity,
 - esophagus,
 - stomach,
 - intestine,
 - liver and pancreas,
 - disorders of digestive tract,
- Human heart structure,
- Blood vessels,
- Blood flow,
- Lymphatic system,
- Immune system

Learning Outcomes

- List the nutrients of plants with their specific role and mode of deficiency
- Discuss the examples of carnivorous plants
- State the role and structure of stomata along with structural details

- Explain the process of photosynthesis
- Explain the gaseous exchange
- Explain process of ascent of sap
- Describe mechanism of opening and closing of stomata
- Describe pathways of uptake and transport of water
- Explain translocation of organic solutes
- List all the factors effecting transpiration
- Describe water and minerals uptake by roots
- Explain all structural parts of human alimentary canal
- List GIT related disorders (dyspepsia, ulcer, obesity, ulcers, bulimia nervosa, anorexia nervosa,
- List down general structure of human heart
- List the differences and functions of capillaries, arteries and veins.
- Describe lymphatic system (organs, nodules, vessels)
- Define and introduce immune system (general definition, its need and importance)

HOMEOSTASIS

- Mechanism of Homeostasis
 - Receptors
 - Control center
 - Effector
 - Positive feedback
 - Negative feed back
- Osmoregulation
 - Osmoregulators
 - Osmoconformers
- Osmoregulation in Animals of different Environment
 - Freshwater Animals
 - Marine Animals
 - Terrestrial Environments
- Excretion
- Various nitrogenous compounds excreted during the process of excretion.
- Excretory System of Human
- Structure and Function of Kidney
- Disorders of Urinary Tract
 - Urinary Tract Infections
 - Kidney Stones
 - Kidney Failure
 - Renal Dialysis
 - Kidney Transplant
- Thermoregulation
- Ectotherms and Endotherms
- Poikilotherms and Homeotherms
- Thermoregulation in Human

Learning Outcomes

- Describe the three elements i.e. receptors, control center and effector

- Differentiate between osmoconformers and osmoregulatory
- Define osmoregulation
- Explain the nature of excretory products in relation to habitat
- Explain urinary system
- Explain kidney structure and function
- List urinary tract infections
- Define the thermo regulation and its need

SUPPORT AND MOVEMENT

- Human Skeleton
- Cartilage
- Bone
 - Osteoblasts
 - Steoclasts
 - Steocytes
- Comparison between bone and cartilage
- Main division of Human skeletal
 - Axial Skeleton
 - Appendicular Skeleton
- Joints Types/ structural classification of joints
 - Fibrous joints
 - Cartilaginous joints
 - Synovial joints
- Disorders of Skeleton
- Disorders of human skeleton
 - Disc slip
 - Spondylosis
 - Sciatica
 - Arthritis
- Bone Fractures
 - Simple Fracture
 - Compound Fracture

- Joint injuries
- Muscles
- Types of muscles

- Skeletal Muscles
- Cardiac Muscles
- Smooth Muscles
- Structure of Skeletal Muscles
- Muscles problems

Learning Outcomes

- Describe the structure of bone and compare it with that of cartilage.
- Explain the functions of osteoblasts, osteoclasts and osteocytes.
- Identify the main divisions of human skeleton.
- List the bones of appendicular and axial skeleton of man.
- Describe three types of joints i.e. fibrous joints, cartilaginous joints and synovial joints and give example of each.
- Describe the disorders of human skeleton (disc-slip, spondylosis, sciatica, arthritis) and their causes.
- State different types of fractures (simple, compound and complicated)
- Describe the repair process of simple fractures
- Define muscle
- Compare smooth muscles, cardiac muscles and skeletal muscles
- Explain the Ultra-structure of Skeletal Muscles
- Antagonistic Arrangement of Skeletal Muscles

COORDINATION AND CONTROL / NERVOUS & CHEMICAL COORDINATION

- Nervous System of Man
 - Nerve Impulse
 - Steps involved in nervous coordination
 - Neurons (Structure and Types)
- Transmission of Action Potential between Cells – Synapse
 - Electrical synapses
 - Chemical synapses
 - Transmission of nerve impulse across synapse
- Basic Organization of human nervous system
 - Central Nervous System (CNS)
 - Peripheral Nervous System (PNS)
- Major division of Human brain
- Sensory Receptors and their working
- Hormones- The chemical messengers
- Endocrine System of Man
 - Pituitary gland
 - Thyroid gland
 - Parathyroid
 - Pancreas
 - Adrenal gland
 - Gonads
- Feedback Mechanism
 - Positive Feedback Mechanism
 - Negative Feedback Mechanism

Learning Outcomes

- Steps involved in nervous coordination
- Recognize receptors as transducers sensitive to various stimuli.
- Trace the path of a message transmitted to the CNS for processing.
- Identify muscles and glands as the effectors.

- Define Neurons and explain its structure (Cell body, dendrites, axon and myelin sheath and Schwann cells)
- Define nerve impulse.
- The main components of the nervous system.
- Explain briefly the functions of major divisions of brain.
- Describe the architecture of human brain and compare its sectional view with that of the spinal cord.
- Describe the chemical nature of hormones and correlate it with important hormones.
- Outline the concept of Feedback mechanism of hormones.

REPRODUCTION

- Human Reproductive System
 - Male Reproductive System and its Hormonal Regulation
 - Female Reproductive System and its Hormonal Regulation
 - Menstrual cycle
- Disorders of Reproductive System
 - Male Infertility
 - In vitro fertilization (IVF)
 - Miscarriage
- Sexually Transmitted Diseases
 - Syphilis
 - Gonorrhoea
 - AIDS

Learning Outcomes

- Describe the structures of male reproductive system identifying their functions.
- Explain the principal reproductive hormones of human male and explain their role in the maintenance and functioning of reproductive system
- Explain the structures of female reproductive system and describe their functions.
- Describe the menstrual cycle (female reproductive cycle) emphasizing the role of hormones.
- Describe the causes of female and male infertility
- Explain that in-vitro fertilization (test tube babies) is one of the methods to solve the problem of infertility.
- Define miscarriage and state its causes.
- Relate miscarriage with abortion.
- Describe the causes, symptoms and treatment of gonorrhoea and syphilis
- Explain AIDS as a worldwide sexually transmitted disease.

GROWTH AND DEVELOPMENT/ DEVELOPMENT AND AGING

- Embryonic development
- Cleavage and blastocyst formation
- Gastrulation
- Neurulation
- Control of development
- Role of nucleus in development
- Role of cytoplasm
- Mechanism of cellular determination
- Embryonic induction and its mechanism
- Aging
- Genetic mutation
- Regeneration
- Abnormal development

Learning Outcomes

- Describe cleavage
- Explain the events of gastrulation
- List the tissues and organs formed from the three germ layers
- Define organogenesis
- State the events of neurulation
- Describe the formation of neural crest and list the structures that are derived from neural crest cells.
- Through experimental narration, describe the role of the nucleus and cytoplasm in controlling development
- Define the term aging.
- List the genetic and extrinsic factors responsible for aging
- State the changes (graying, thinning hair, pigmented patches of skin, slowed movements, fading vision, impaired hearing, reduced ability to adapt to stress and decreased resistance to infections) as primary aging.

VARIATION AND GENETICS / INHERITANCE

- Mendel's law of inheritance
 - Gregor John Mendel and his work
 - Mendel's experiment
 - Inheritance of single trait
 - Mendel's principles of inheritance
 - Inheritance of two traits
 - Law of independent assortment
 - Scope of independent assortment in variation
 - Statistics and probability relevant to genetics
- Exceptions to Mendelian inheritance
 - Complete dominance
 - Incomplete dominance
 - Co-dominance
 - Over dominance
- ABO blood group system
 - Multiple alleles
 - ABO blood group
 - Genetic basis of ABO blood group
 - Occurrence of some other blood group systems
- Rh blood group system
 - Genetic basis of blood group system
 - Maternal foetal Rh incompatibility
 - Epistasis
 - Bombay phenotype
 - Polygenic inheritance
 - Wheat grain color
 - Human skin color
- Gene linkages and crossing over
 - Gene linkages

- Detection of gene linkages
- Crossing over
- Recombination frequency and genetic map of chromosome
- Sex determination
 - Patterns of sex determinations
 - Comparison of chromosomal determination of sex between drosophila and humans
- Sex linkages
 - Sex linkage in drosophila
 - Types of sex linked traits
 - Sex linkage in human
 - Genetics of haemophilia
 - Genetics of colour blindness
 - Sex related traits

Learning Outcomes

- Associate inheritance with the laws of Mendel.
- Explain the law of independent assortment, using a suitable example.
- Explain incomplete dominance and exemplify it through the inheritance of flower color in 4 O' clock plant.
- Differentiate between incomplete dominance and co-dominance.
- Describe multiple alleles and state the alleles responsible for the trait of ABO blood groups.
- Associate multiple alleles with the ABO blood group system.
- Associate the positive and negative blood groups with the presence and absence of Rh factor
- Justify why Rh incompatibility could be a danger to the developing foetus and mother.
- Describe the terms gene linkage and crossing over
- Exemplify the concept of gene linkage by quoting the example of wing length and width of abdomen in *Drosophila melanogaster*.

- Explain how gene linkage counters independent assortment and crossing-over modifies the progeny
- Suggest why linkage could be observed / evaluated only if the number of progeny is quite large.
- Identify male and female individuals from the karyotype of *Drosophila* and man.
- Describe the concept of sex-linkage.
- Explain the inheritance of sex-linked traits (eye color) in *Drosophila*.
- Describe the sex-linked inheritance of male characters due to Y-chromosome and the effect of holandric genes.
- Critically analyze the inheritance of Haemophilia, colour blindness and muscular dystrophy
- Describe sex-influenced and sex-limited traits with common examples from human genetics.
- Describe the X- linked disorders with reference to the patterns of inheritance.

CHROMOSOME AND DNA / NUCLEIC ACID

- Chromosomes
 - Number of chromosomes
 - Structure of chromosomes
 - Composition and organization of chromosomes
- Concept of gene
 - Historical background
 - Modern concept of gene
 - Where do genes reside
 - Structure gene
- Chromosome theory of inheritance
 - DNA as heredity material
 - Griffiths experiment
 - Avery's experiment
 - Hershey and chase experiment
- DNA replication
 - Semi conservative model
 - Conservative model
 - Dispersive model
 - Meselson stahlexperiment
 - Process of DNA replication
- Gene expression
 - Central dogma of gene expression
 - Post transcriptional modification of mRNA
 - Genetic code
 - Translation
- Gene Mutation
 - Origin of mutation
 - Types of mutation

Learning Outcomes

- Analyze the history of chromosomal theory with reference to Correns' work, experiments of T. H. Morgan, history of chromosomal theory with reference to Fleming and Wldeyer, chromosomal theory with reference to Walter Sutton and Theodor Boveri
- Annotate the detailed structure, composition and Organization of a chromosome.
- Describe the concept of gene and gene locus.
- Explain the concept of alleles as the alternative forms of a gene.
- Narrate the experimental work of Griffith and Hershey-Chase, which proved that DNA is the hereditary material.
- Describe the three models proposed about the mechanism of DNA replication.
- Describe the events of the process of DNA replication. Mechanism of DNA Replication)
- Describe the central dogma of gene expression.
- Explain the mechanism of transcription
- Explain why the length of transcribed m-RNA molecule (in Eukaryotes) shortens as it enters the cytoplasm for translation (post transcriptional modification of in RNA)
- Define gene and genetic code.
- Describe the characteristics of genetic code (universal, triplet, non-overlapping, degenerate, punctuated).
- Describe the mechanism of protein synthesis (Translation)
- State the importance of the regulation of gene expression
- Relate gene expression with introns and exons
- Define mutation and identify various sources of mutation.

EVOLUTION

- The Evolution of the Concepts of Evolution
- Evolution from eukaryotes from prokaryotes
 - Endosymbiosis
 - Membrane infolding
- Lamarckism
- Darwinisms
 - Darwin's voyage of HMS Beagle and his observations
 - Darwin's theory evolution
- Neo-darwinism's
 - Evidence of evolution

Learning Outcomes

- Describe creationism and the theory of evolution as two contradictory ideas.
- Explain origin of life according to concept of evolution
- Describe the theories that have been put forwarded about the mechanism of evolution of eukaryotes from prokaryotes.
- Describe the theory of inheritance of acquired characters, as proposed by Lamarck.
- Outline the steps of the evolution of the giraffe, as illustrated in Lamarckism.
- State the drawbacks in Lamarckism.
- Briefly describe the observations Darwin made during his voyage on HMS Beagle.
- Explain the theory of natural selection as proposed by Darwin

BIOTECHNOLOGY / GENETIC TECHNOLOGY

- Cloning of gene
 - Recombinant DNA technology
 - Selection and isolation of desired gene
 - Molecular scissors
 - Molecular carriers or vectors
 - Small size example of vectors
 - Molecular glue (DNA Ligase)
 - Expression system
- Procedure of recombinant DNA technology
 - Formation of recombinant DNA
 - Transformation of expression system
 - Identification of transformed clone
- Polymerase chain reaction
 - Components of PCR technique
 - Mechanism of PCR reaction
 - Application of PCR
- Genomic Library
 - Construction of Genomic Library
- DNA sequencing
 - Sanger's Method
 - Gel Electrophoresis
 - Automated DNA sequencing
- Genome Maps
 - Genome Maps
 - Genome analysis
 - Human Genome project
- Tissue culture
 - Procedure of tissue culture
 - Types of tissue culture

- Animal cell culture
- Transgenic organisms
 - Transgenic bacteria
 - Transgenic plants biotechnology technology
 - Transgenic animals
- Biotechnology and healthcare
 - Development of vaccine in Biotechnology
 - Role of Biotechnology in Diagnosis of diseases
 - Gene therapy
 - Cystic fibrosis
- Scope and importance of biotechnology
 - Biochips and biological computers
 - Mycorrhiza
 - Biofertilizers
 - Nanotechnology

Learning Outcomes

- Define gene cloning and state the steps in gene cloning.
- Describe the techniques of gene cloning through recombinant DNA technology.
- Describe the steps involved in gene amplification through polymerase chain reaction.
- Describe the procedure for the construction of genomic library.
- Describe the principles of Gel Electrophoresis as being used in gene sequencing.
- Explain the Sanger-Coulson method of DNA sequencing.
- Define DNA profiling/DNA testing/DNA typing/genetic fingerprinting.
- Describe the purposes and mechanism of DNA analysis.
- Describe the terms of genome analysis, genome map and genetic markers.
- State the history of the human genome project admiring James Watson as its first director.
- Describe the goals of the human genome project.
- Define following terms related to tissue culture; cell culture or organ culture.

- Define genetically modified/ genetically engineered/ transgenic organism
- State the objectives of the production of transgenic bacteria, transgenic plants and transgenic animals.
- Explain with example gene therapies in the detection and treatment of some genetic diseases.
- Explain the scope and importance of biotechnology in promoting human welfare.

MEN AND HIS ENVIRONMENT

- Biogeochemical Cycle
 - Water Cycle
 - Nitrogen Cycle
- Population Dynamics
 - Characteristics of population
 - Carrying capacity
 - Problems related to rapid growth in human population
 - Pakistan population planning policies and problems
- Human Impacts on Environment
 - Global Warming
 - Acid Rain

Learning Outcomes

- Define biogeochemical cycles and locate the primary reservoirs of the chemicals in oxygen, nitrogen cycles.
- Explain population dynamics and list factors that regulate population size.
- Describe characteristics of a population, such as growth, density, distribution, carrying capacity, minimum/ viable size.
- Describe the causes of the increasing concentration of carbon dioxide in the world's atmosphere
- Correlate the increasing CO₂ concentration with the global warming and describe its long-term effects.
- Explain the causes and effects of acid rain.