B.Sc. in Biochemistry

FIRST SEMESTER

CBCS MODE

BC-1: Introduction to Biochemistry

(4 Blocks)

(Note: This SLM is developed for the reference of I Semester B.Sc. Biochemistry students of KSOU.)

BC-1: Introduction to Biochemistry

COURSE DESIGN

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Vice Chancellor
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Smt. Suprada Rao M. S. DOS in Biochemistry, Yuvaraja's College, UOM, Mysuru.	BC-1	Block-II, Block-III & Block IV	5,6,7,8,9,10,11,12,13, 14, 15, & 16.

COURSE EDITOR

Dr. Shaukath Ara Khanum Associate Prof. DOS in Chemistry, Yuvaraja's college, University of Mysore.	BC-1	Block I - IV	1 to 16.

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Dr. Niranjan Raj S. Chairperson, Department of Microbiology, KSOU, Mysore	Member
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PUBLISHER

The Registrar
Karnataka State Open University,
Mukthagangotri, Mysore-570006

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BC-1: INTRODUCTION TO BIOCHEMISTRY		
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INTRODUCTION TO BIOCHEMISTRY

Bioinorganic Chemistry is at the gate-way of inorganic chemistry and biochemistry, i.e. it describes the mutual relationship between these two sub-disciplines, with focus upon the function of inorganic substances in living systems, including the transport, speciation and, eventually, mineralisation of inorganic materials, and including the use of inorganics in

medicinal therapy and diagnosis. These substances can be metal ions (such as K+, ferrous and ferric), composite ions (e.g. molybdate), coordination compounds, or inorganic molecules such as CO, NO, O_3.

What is biophysical chemistry and why study it? As a field, biophysical chemistry is an interdisciplinary area of study in which biological systems are regarded with the somewhat quantitative and concrete eye of physical scientist. In using the intellectual paradigm of biophysical chemistry, we attempt to understand a biological phenomenon (Osmosis, acidity, viscosity, adsorption etc.,) by carefully describing the essentials of its physical nature. This gives us the advantage of using the tools of physical scientist to explore the complexities of biological system. These tools are essentially the language and formalism of mathematics, physics, and chemistry. The underlying foundation of biophysical chemistry is that application of the principles of these fields to biological systems which lead to meaningful and useful information.

The fundamental of inorganic and physical is essential prior to understanding the biochemistry and biomolecules since each of biological compound comprise of both organic and inorganic molecules. The present course comprised of four blocks which aim to introduce you to field of bioinorganic and biophysical chemistry.

The Block I & II are dedicated for biophysical chemistry, consists of 9 units. Unit 1 & 2 will introduce you to overview of Biochemistry and Concentration units used in Biochemistry. Units 3 & 4 will explain properties of Water and Colligative properties particularly Osmotic pressure. Units 5, 6 & 7 will introduce you to the basics of Adsorption, Viscosity and Distribution law respectively. Units 8 & 8b are interconnected units in terms of understanding which deals with Ionic Equilibrium, theory of acid base indicators, pH and electrodes and electrochemistry. Finally Unit-9 will introduce you to the field of Photochemistry, where you will learn about the principles governing spectrophotometer, colorimeter, fluorescence, and phosphorescence.

The Block III & IV are dedicated for bioinorganic chemistry. Unit-10 describes Describe Complex salts or Coordination compounds, Co-ordinate bond, Central metal atom or ion, Ligands in Coordination compounds, Classification of ligands, and Coordination number (CN). It also describes the Werner's theory of co-ordination compounds. The Unit-11 deals

with Porphyrin nucleus and their classification, important metallo-porphyrins occurring in nature (Heme, cytochrome, chlorophyll and Vitamin B12) their structure and biological importance. Unit-13 will introduce you to Nitrogen and Phosphorous. The topics discussed here include fixation of Nitrogen (symbiotic and non-symbiotic methods), Nitrogen cycle and environmental pollution caused by nitrogen compounds. Further Phosphorous containing compounds in biological system and phosphorous cycle in nature are detailed. Similarly, Unit-14 describes the importance of Oxygen (O), Sulphur (S) and Selenium (Se). In detail formation of ozone in atmosphere and its importance, importance of selenium compounds in biological system and importance of Sulphur as a constituent of Protein are discussed. Units 15 will detail biochemical toxicology of Lead, Mercury, Cadmium and Arsenic. Unitt-16 is totally dedicated to understanding of Radiochemistry. This includes Natural and Artificial radioactivity, detection of radioactivity, applications of radioisotopes, biological effects of radiations and safety measure in handling radio isotopes.

Happy studies,

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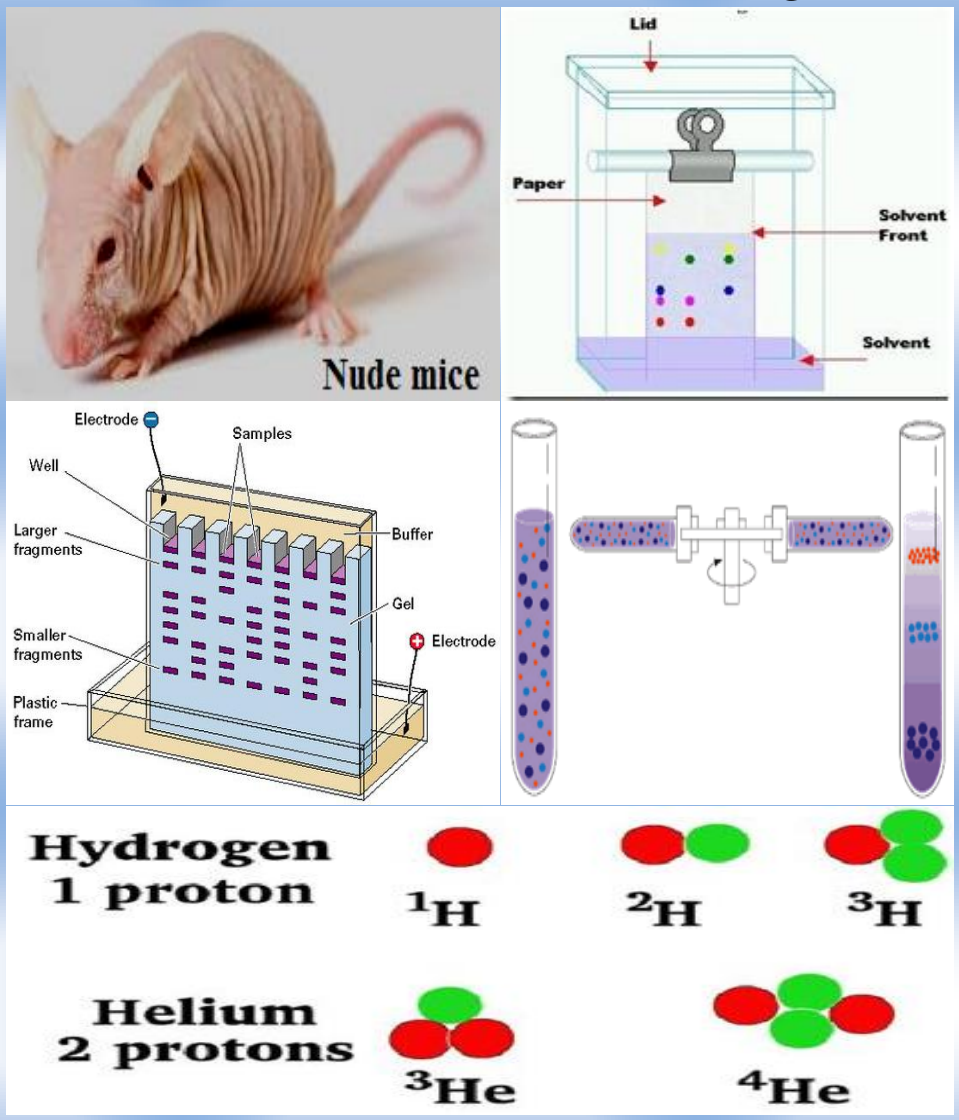
M.Sc. BIOCHEMISTRY- I SEM. (CBCS)

BC-1.2

BIOCHEMICAL TECHNIQUES



Self Learning Material

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M.Sc. in Biochemistry

FIRST SEMESTER

CBCS Mode

BC 1.2-BIOCHEMICAL TECHNIQUES

(Blocks –I, II, III & IV)

(This SLM is developed for the reference of I Semester M.Sc. Biochemistry students of KSOU.)

BC-1.2: BIOCHEMICAL TECHNIQUES

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COURSE EDITOR			
Dr. Deepti Saini Protein Design Private Limited, M.S.R. Nagara, Mathikere, Bangalore-54	BC-1.2	Block I to IV	1, 2, 3, 4, 5, 6,7,8,9, 10,11,12,13,14,15&16
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INTRODUCTION TO BIOCHEMICAL TECHNIQUES

The goal of this course is to provide an introduction to the field of Biochemical techniques. Biochemistry is the study of combination of both biology and chemistry as equal components and has immense importance today. Biochemistry gives intimate knowledge of structure and function of molecular components of living organisms. Biochemistry has undergone a colossal transformation within the past few decades due to development of new methods of research.

Progress in research depends upon development of an effective technique. A hypothesis cannot be converted into a fact unless proved experimentally with the help of adequate technique. If the technique is inadequate the results may be misleading or meaningless. As proper understanding of technique and its use in biochemical investigation is very important to get meaningful results. So the biochemical methods have become specialised and sophisticated during the recent past.

Various techniques such as electrophoresis, chromatography, centrifugation, different types of spectroscopy, radio isotopes, radilabelled elements *etc* play important role in separation and identification of particular components present in biological systems. Bio- analysis of nucleic acids has clearly shown the connection between DNA and Proteins. Artificial synthesis of DNA and transferring it to unnatural recipient with the help of Genetic Engineering has solved many hitherto unknown mechanisms and problems.

So no doubt various physical & chemical, qualitative & quantitative techniques employed by researchers have contributed a lot to the advancements in the field of biological sciences.

In the text of this course maximum attempt has been made to provide complete information on different biochemical techniques and their applications. All the units have been brought up to date by collecting information from different sources and modified in keeping pace with the learning interest and potential of Open University Students.

Each Unit begins with clearly stated learner-oriented objectives followed by terms important for thorough understanding of the text. Every unit at the end includes key words to easily remember the subject and questions to help the readers to self evaluate their grasp of the concepts. The complete format of self learning material of Biochemical techniques should definitely help in creating interest and better learning of different aspects of Biochemistry.

The content of this book is organized into 4 Blocks, each block contains 4 Units. The Block I consists of four units (1-4). Unit-1 describes the preliminary techniques in biochemistry: animal models, choice of animals, types of studies- mutant organisms, cultured cells and plants as models. The Unit-2 explains general principles of chromatography and describes different types of paper chromatography (ascending, descending and circularand two dimensional). Unit-3 describes TLC: Qualitative and quantitative, adsorption, ion exchange, gel filtration etc. Unit-4 describes affinity chromatography, GLC, chromatofocussing, HPLC and RP–HPLC in detail.

The Block II consists of four units (5-8). Unit-5 explains polyacrylamide gel electrophoresis, SDS-PAGE, 2D-electrophoresis, Agarose gel electrophoresis, separation of protein, lipoproteins and nucleic acids. The Unit-6 throughs light on **v**isualizing separated macromolecules by various staining methods such as fluorescence, PAS staining, zymogram and reverse zymogram etc. Unit-7 will explain Iso-electric focusing, pulsed field electrophoresis, high voltage electrophoresis, capillary electrophoresis and isotachophoresis. Unit-8 describes hydrogen electrode, oxygen electrode, electrode potential, oxidation and reduction potential of electrodes in connection with electrophoresis.

Block III consists of units (9-12). Unit-9 explains instrumentation of preparative and analytical ultra-centrifuge, optical system, Schliren optics and Raleigh scattering. In Unit-10 you will learn Svedberg's constant, molecular weight determination, preparation of continuous and discontinuous gradients ($CsCl_2$, Sucrose, Percol). The Unit-11 describes isolation of cell organelles, differential and density gradient centrifugation. Unit-12 explains Spectroscopic techniques, Colorimetry-Beer-Lambert's law and its limitations, determination of extinction coefficient and application of colorimetry in biological assays.

Block IV (units 13-16) is dedicated for the study of Tracer techniques. This block deals with radio isotopes, frequently used radio isotopes, how they are used in biochemistry, the instruments available for detecting the amount of radiation in a sample. This block also describe how biological samples can be labelled and what are the major advantages and disadvantages of using radio labelled chemicals in biochemistry.

Happy studies,

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M.Sc. in Biochemistry

FOURTH SEMESTER

MOLECULAR BIOLOGY - I

(BC 4.1)

(Blocks -I, II, III and IV)

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INTRODUCTION TO MOLECULAR BIOLOGY - I

The goal of this course is to provide the basics of molecular biology. Molecular biology is the study of the structure function, and makeup of the molecular building blocks of life. It focuses on the interactions between the various systems of a cell, including the interrelationship of DNA, RNA and protein synthesis and how these interactions are regulated. The youngest of the biosciences, molecular biology is closely interrelated with the fields of biochemistry, genetics and cell biology.

Maximum attempt has been made to provide complete information required for understanding the basics of molecular biology. The content in this course contains information collected from various sources and modified in keeping pace with the learning interest and potential of Open University students. The contents of this course are organized into Four Blocks, each Block consisting of Four Units.

Each Unit begins with clearly stated learner-oriented objectives followed by a brief introduction which sets up the base for understanding the unit. Every unit at the end includes key words to easily remember the subject and questions to help the readers to self evaluate their understanding of the concepts. The complete format of SLM should act as necessary tool in learning molecular biology and helping in easy understanding of different concepts of Biochemistry.

The Block I is dedicated to introducing nature and replication of DNA. Unit 1 deals with the topics such as historical perspective, central dogma of molecular biology. Unit 2 is about anti-parallel nature of DNA and the concept of nearest neighbour base frequency analysis. Unit-3 will introduce you to replication of DNA semiconservative model, Messelson and Stahl experiment, direction of replication of *E.coli*, discontinuous replication- Okazaki fragments. Finally, Unit-4 describes the DNA polymerase I, II and III of *E.coli* DNA ligase, fidelity of replication. DNA topoisomerases and gyrases. Replication in viruses single stranded DNA virus, ϕX174, rolling circle model. Role of DNA Polymerases α, β, γ, δ, ε. Replication of mitochondrial DNA is also discussed.

The Block II consists of four units. Unit-5 deals with transcription - RNA polymerase I, II and III. The Unit-6 will help you in understanding the RNA biosynthesis in prokaryotes and eukaryotes- initiation, elongation and termination. Further, Unit-7 will illustrate RNA dependent RNA synthesis - RNA replicase of Qβ virus. Unit-8 describes the processing of eukaryotic RNA cap addition, poly-A tail addition, intron splicing and RNA editing. In addition this unit will through light on processing of t-RNA and m-RNA transcripts.

Block III consists of units 9-12. Unit-9 describes the translation - Genetic code, triplet codon, universality features of the genetic code, assignment of codons, and studies of Khorana & Nirenberg. The Unit-10 describes triplet binding techniques, degeneracy of codons, wobble hypothesis, evolution of genetic code, codon usage, and variation in the codon usage. The Unit-11 describes the structure of prokaryotic and eukaryotic ribosomes. Finally the Unit-12 is dedicated to understanding the process of translation-initiation, elongation and termination in both prokaryotes and eukaryotes.

Block IV with four units (13-16) is the last block of this course dedicated towards understanding the post translational modification of proteins. Unit-13 deals with role of m-RNA and t-RNA; aminoacyl tRNA synthetase and its role in translation accuracy. Unit-14 describes the signal sequence, translational proof-reading and translational inhibitors. Unit 15 describe the post translational modifications-signal peptide cleavage, disulphide bond formation, O- and N-glycosylation. Unit-16 is the final unit of this course that covers folding of nascent protein, role of chaperones, attachment of glycosyl anchor, and other modifications.

Good luck and happy studies,

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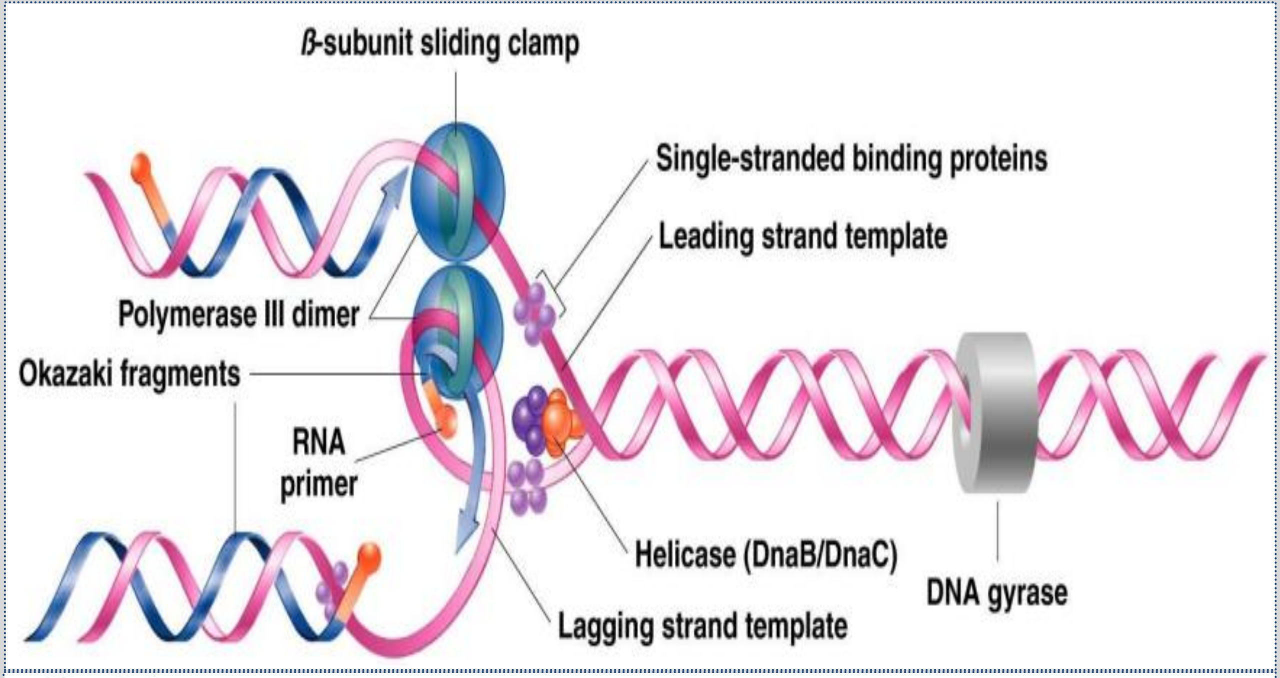
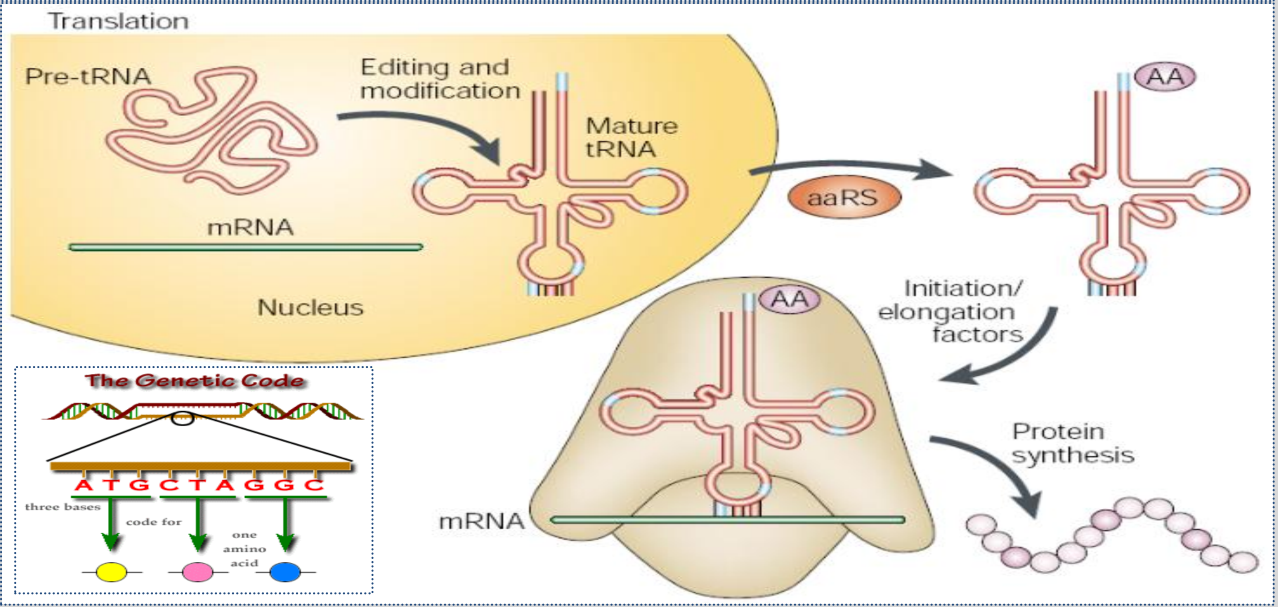
M.Sc. BIOCHEMISTRY- IV SEMESTER

BC-4.1: MOLECULAR BIOLOGY - I.





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M.Sc. in Biochemistry

FOURTH SEMESTER

MOLECULAR BIOLOGY - II

(BC 4.2)

(Blocks -I, II, III and IV)

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INTRODUCTION TO MOLECULAR BIOLOGY - II

The goal of this course is to provide the basics of molecular biology. Molecular biology is the study of the structure function, and makeup of the molecular building blocks of life. It focuses on the interactions between the various systems of a cell, including the interrelationship of DNA, RNA and protein synthesis and how these interactions are regulated. The youngest of the biosciences, molecular biology is closely interrelated with the fields of biochemistry, genetics and cell biology.

Maximum attempt has been made to provide complete information required for understanding the basics of molecular biology. The content in this course contains information collected from various sources and modified in keeping pace with the learning interest and potential of Open University students. The contents of this course are organized into Four Blocks, each Block consisting of Four Units.

Each Unit begins with clearly stated learner-oriented objectives followed by a brief introduction which sets up the base for understanding the unit. Every unit at the end includes key words to easily remember the subject and questions to help the readers to self evaluate their understanding of the concepts. The complete format of SLM should act as necessary tool in learning molecular biology and helping in easy understanding of different concepts of Biochemistry.

The Block I is dedicated to introducing prokaryotic and eukaryotic genetic information. Unit 1 deals with the topics such as fine structure of the prokaryotic and eukaryotic gene - promoters, introns, exons, other regulatory sequences, enhancers, silencers, function of introns. Unit 2 is about regulation of Gene expression in prokaryotes - Operon model - lac operon- structure and regulation; galactose operon - role of two promoters; arabinose operon - positive control; tryptophan operon- attenuation control. Unit-3 will introduce you to regulation of gene expression at the level of DNA structure - Super coiling, DNA methylation, role of nucleosome. Structure of eukaryotic DNA in gene expression taking examples of glucocorticoid gene, chromatin remodelling. Finally, Unit-4 describes the regulation at the level of transcription - Transcription factors, TF II, NFκB. Regulation of NFkB and its activation, formation of initiation complex and the role of enhancers.

The Block II consists of four units. Unit-5 deals with regulation at the level of RNA processing- RNA export and RNA stability. Factors affecting RNA stability and degradation. The Unit-6 will help you in understanding the regulation at the level of translation - Secondary structure in the 5' and 3' untranslated region - eg. Regulation of Ferritin and Transformation of m-RNA. Further, Unit-7 will illustrate the allocating genes to chromosomes -chromosome walking, RFLP and RAPD. Unit-8 describes the Role of upstream AUG codons. (eg. GCN 4 gene regulation), transplicing and translational introns, protein splicing introns.

Block III consists of units 9-12. Unit-9 describes role of aminoacyl t-RNA synthetase in the regulation of translation- proof-reading mechanism. The Unit-10 describes ribosomal optimization of translation and regulation at the level of ribosome assembly. The Unit-11 describes role of DNA binding protein motifs. Finally the Unit-12 is dedicated to understanding the regulation at the level of post-translational modification, protein stability, N-end rule, PEST and other sequences.

Block IV with four units (13-16) is the last block of this course dedicated towards understanding the concepts of Genetic engineering. Unit-13 deals with Genetic engineering - Extraction and purification of nucleic acids (DNA and RNA) from biological sources. Unit-14 describes the Gene cloning-genomic cloning, c-DNA cloning. Vectors, plasmids, phage, cosmids and phagemid. Unit 15 describe the yeast cloning vectors, plant vectors, bacterial artificial chromosome, SV40, shuttle vectors construction of expression vectors. Unit-16 is the final unit of this course that covers restriction endo-nucleases - blunt end and staggered cut and isochizomers.

Happy studies,

Dr. Nataraju Angaswamy
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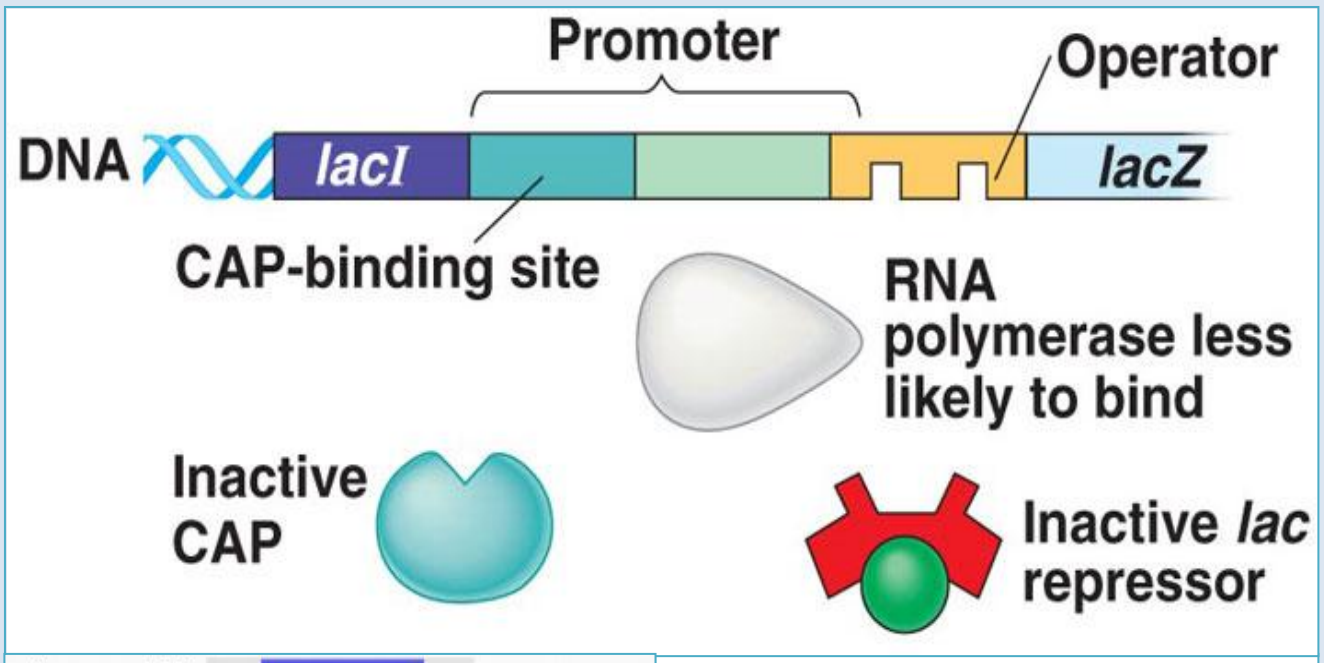
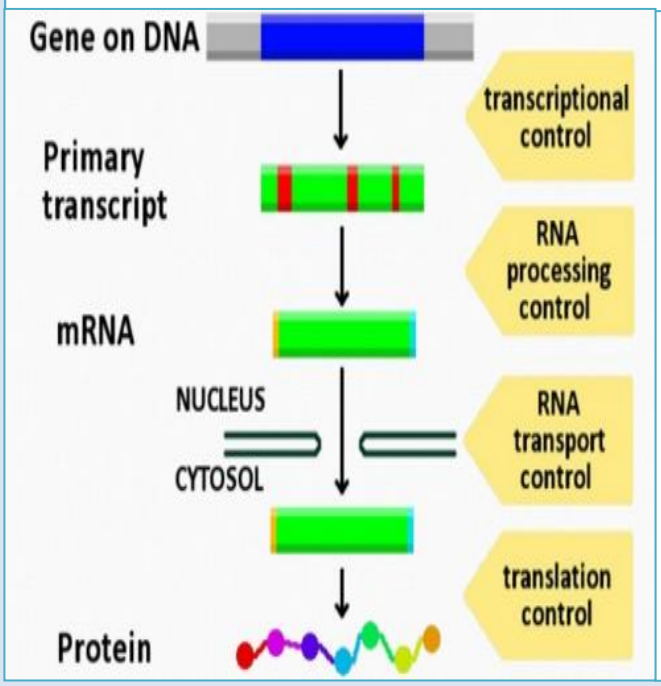
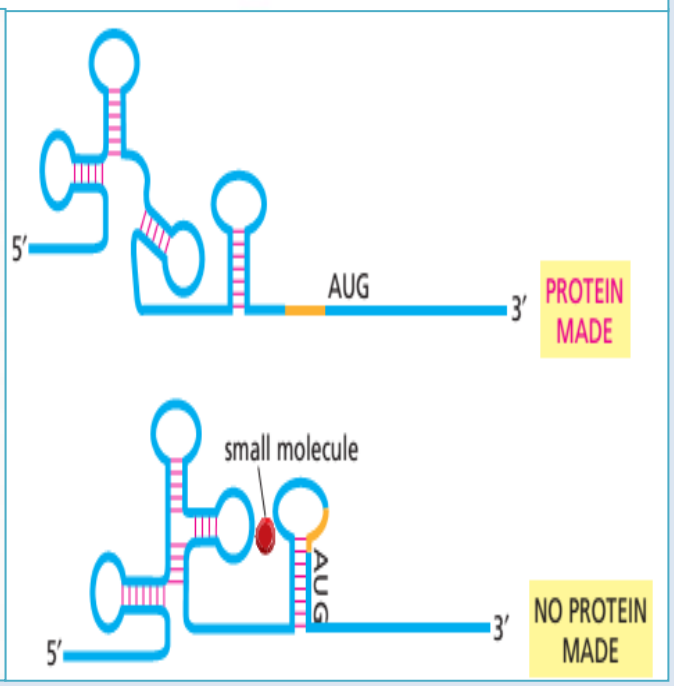
M.Sc. BIOCHEMISTRY- IV SEMESTER

BC-4.2: MOLECULAR BIOLOGY - II.







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M.Sc. in Biochemistry

FOURTH SEMESTER

BIOCHEMISTRY OF HORMONES

(BC 4.3)

(Blocks -I, II, III and IV)

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INTRODUCTION TO BIOCHEMISTRY OF HORMONES

The goal of this course is to provide the basics of biochemistry of hormones. What are hormones? You have most likely heard of hormones at your bachelor degree classes or some point in your lifetime and may think you know what they do. Well, the truth of the matter is that hormones and their function within the endocrine system are extremely complex. There are multiple glands throughout the body, and each gland produces specific hormones designed to carry out certain functions. The whole process is actually quite amazing! It also has the potential to be very overwhelming at times. Never fear, because you are about to learn a general overview of this highly important system in this course material.

Hormones are actually tiny chemical messengers located inside one's body. They are unable to be seen with the human eye and travel throughout the internal superhighway - otherwise known as the bloodstream - to all of our body's organs and tissues. Different hormones perform specific roles inside. Some of these hormones work quickly to start or stop a process, and some will continually work over the course of a long period of time to perform their necessary jobs. Some of these jobs include the body's growth and development, metabolism (or production of energy), sexual function and reproduction.

Hormones are produced and secreted by endocrine glands. The endocrine glands are a highly specialized group of cells responsible for making hormones. Each gland plays a specific role in the production of a particular hormone or group of hormones needed to carry out the necessary duties required to help the body remain in a state of homeostasis, or continual balance. The body requires a continual state of balance in order to function at its maximum level of efficiency.

This self learning material (SLM) provides a practical overview of the biochemistry of hormones, and describes how these hormones function during both health and illness. Maximum attempt has been made to provide complete information required for understanding the biochemistry of hormones. The content in this course contains information collected from various sources and modified in keeping pace with the learning interest and potential of Open University students. The contents of this course are organized into Four Blocks, each Block consisting of Four Units. Each Unit begins with clearly stated learner-oriented objectives followed by a brief introduction which sets up the base for understanding the unit. Every unit at the end includes key words to easily remember the subject and questions to help the readers to self evaluate their understanding of the concepts. The

complete format of SLM should act as necessary tool in learning biochemistry of hormones and helping in easy understanding of different concepts of biochemistry.

The Block I is dedicated to introducing Endocrine system and basics. Unit 1 deals with the topics such as mammalian endocrine system, location, structure and functions of different endocrine glands and their disorders. Unit 2 is about the general classes of chemical messengers (paracrine, autocrine & exocrine) and also deals with peptide and amino acid derivatives. Unit-3 will introduce you to Steroid hormones and various growth stimulating factors. Finally, Unit-4 describes the chalones, eicosanoids, pheromones and the cell regulators.

The Block II consists of four units. Unit-5 deals with mechanism of hormone action at cellular and molecular levels with special reference to hormone receptors – surface and intracellular. The Unit-6 will help you in understanding the mechanism mediated by secondary messengers- G-protein, cAMP, IP3, DAG and Ca2+. Further, Unit-7 will illustrate the mechanism mediated by receptor- tyrosine kinase; and genomic transcription (steroid hormones). Unit-8 describes the biomedical applications of hormones: Chemical / bio-technological, synthesis by recombinant technology- Thyroxin, catecholamine, insulin, and growth hormone.

Block III consists of units 9-12. Unit-9 describes the biosynthesis of steroid hormones and their applications in human diseases and anabolic steroids and their abuse. The Unit-10 describes hormones in contraception, treating infertility with special reference to IVF and test tube baby. The Unit-11 describes commercial application of hormones and pheromones (use of hormones in poultry, dairy and agriculture). Finally the Unit-12 is dedicated to understanding insect hormones and pheromones in pest control and commercial production of pheromones.

Block IV with four units (13-16) is the last block of this course. Unit-13 deals with hormones in plants and their applications (auxins, gibberellins). Unit-14 describes the cytokinins, Abscisic acid, ethylene and jasmonates. Unit 15 describe the growth promoting factors- role in agriculture and plant tissue culture. Unit-16 is the final unit of this course that covers formulation of media (dehydrated) commercial production of plant hormones.

Happy studies,

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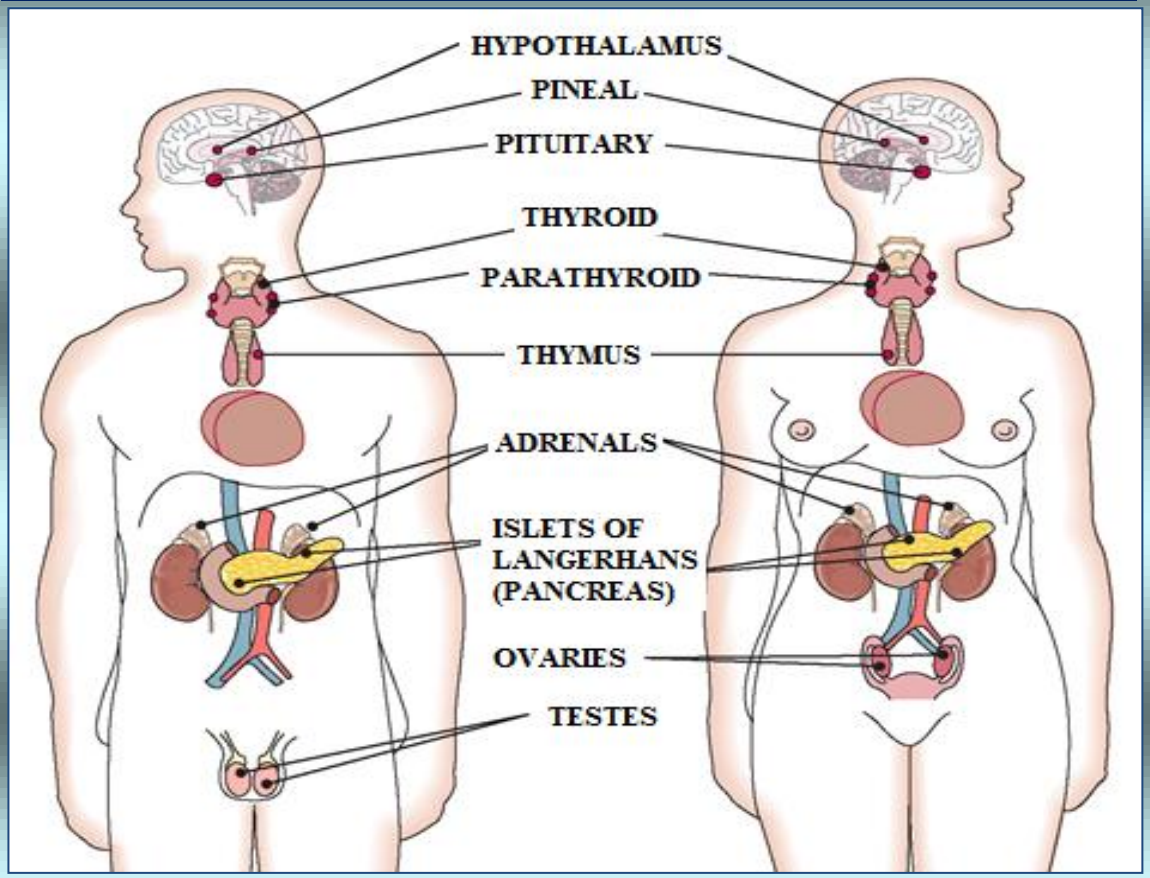
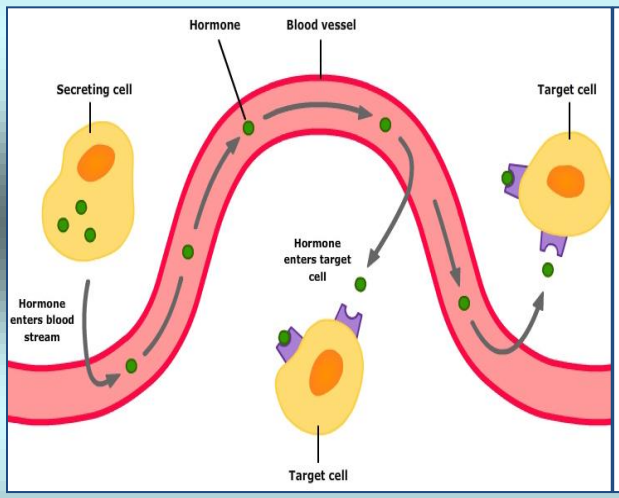
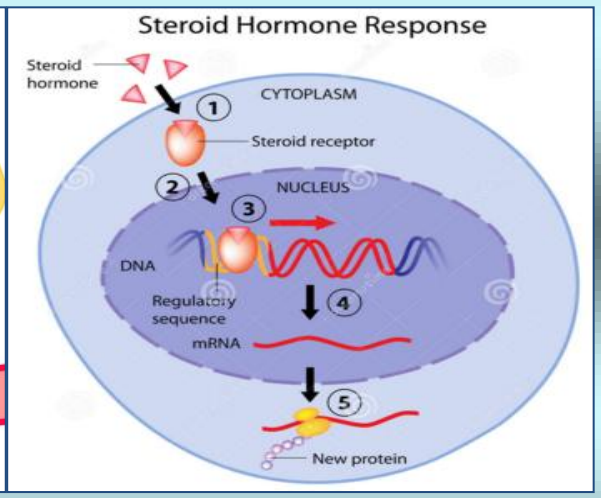
M.Sc. BIOCHEMISTRY- IV SEMESTER

BC-4.3: BIOCHEMISTRY OF HORMONES







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M.Sc. in Biochemistry

FOURTH SEMESTER

CLINICAL BIOCHEMISTRY

(BC 4.4)

(Blocks -I, II, III and IV)

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INTRODUCTION TO CLINICAL BIOCHEMISTRY

The goal of this course is to provide the basics of **CLINICAL BIOCHEMISTRY**. Clinical biochemistry is a specialization in which you could help diagnose and manage disease, through analysis of blood, urine and other body fluids. Clinical biochemistry" is for most purposes synonymous with "clinical chemistry" and "chemical pathology". Here one studies the changes that occur in disease in the chemical composition and biochemical mechanisms of the body. Clinical biochemistry can also be defined as a special branch of medicine dealing with measurement and interpretation of the physicochemical condition and dynamics in healthy and diseased humans, thus contributing to a pathophysiological understanding and thereby to prophylaxis, diagnosis, therapy, prognostication and research of disease. By studying clinical biochemistry, you will know the diseases and the reason for the development of the disease. In addition, the clinical diagnosis and treatment options will also be discussed.

Maximum attempt has been made to provide complete information required for understanding the basics of clinical biochemistry. The content in this course contains information collected from various sources and modified in keeping pace with the learning interest and potential of Open University students. The contents of this course are organized into Four Blocks, each Block consisting of Four Units.

Each Unit begins with clearly stated learner-oriented objectives followed by a brief introduction which sets up the base for understanding the unit. Every unit at the end includes key words to easily remember the subject and questions to help the readers to self evaluate their understanding of the concepts. The complete format of SLM should act as necessary tool in learning clinical biochemistry and helping in easy understanding of different concepts of Biochemistry.

The Block I is dedicated to introducing health and disease. Unit 1 deals with the topics such as basic concepts of health and disease, normal and pathological changes affecting cells in the body- cell death and the physiological causes - physical, chemical and biological agents. Nutritional deficiency is also discussed in brief. Unit 2 deals with diagnostic enzymology- mechanisms of elevated enzyme activities, some important enzymes - alkaline phosphatase, creatine kinase, LDH, AST, ALT - isoenzyme changes. Unit-3 will introduce you to blood - disorders of hemoglobin- Thalassemia, sickle cell anemia. Anemias - microcytic, normocytic,

and macrocytic. Finally, Unit-4 describes the kidney - Assessment of renal function - creatine clearance, renal calculi, uremia, and laboratory investigation of kidney disorders.

The Block II consists of four units. Unit-5 deals with Liver- Biochemical indices of hepatobiliary diseases. Bile pigments - formation of bilirubin, urobilinogen and bile acids. The Unit-6 will help you in understanding Jaundice – pre-hepatic, hepatic and post-hepatic, diagnosis- liver function tests, diseases of the liver – hepatitis, cholestasis, cirrhosis and formation of gall stones. Further, Unit-7 will illustrate the Cardiovasuilar disorders- Atheroschrosis - risk factors, pathogenesis, diagnosis and prognosis. Unit-8 describes the gastrointestinal disorders - Fractional gastric analysis, hypo- and hyper- acidity, gastric ulcers, malabsorption syndrome, steatorrhea and diarrhea.

Block III consists of units 9-12. Unit-9 describes the endocrine disorders- laboratory diagnosis of function of pituitary, thyroid, adrenals and gonads. The Unit-10 describes Disorders of hormones such as Graves disease, Addison's disease, hypo- and hyper- secretion of hormones of the pituitary gland. The Unit-11 describes metabolic disorders- disorders of carbohydrate metabolism- Diabetes mellitus, classification, etiology, management, laboratory investigations such as GTT, HbA_{lc}, and diabetic complications. Finally the Unit-12 is dedicated to understanding the inborn errors of carbohydrate metabolism- galactosemia, lactose intolerance, fructosuria and pentosuria.

Block IV with four units (13-16) is the last block of this course dedicated towards understanding some metabolic disorders, cancer, AIDS and autoimmune diseases. Unit-13 deals with disorders of lipid metabolism- hyper lipoprotenemia- types of modification of lipoproteins - glycation, oxidation, consequences on metabolism- foam cell formation. Unit-14 describes the autoimmune diseases: Myasthenia gravis and Hosimato syndrome. Unit 15 describe the disease caused by retrovirus- AIDS, HIV its transmission and regulation. Unit-16 is the final unit of this course that covers cancer-etiology, diagnosis, management and prognosis.

Good luck and happy studies,

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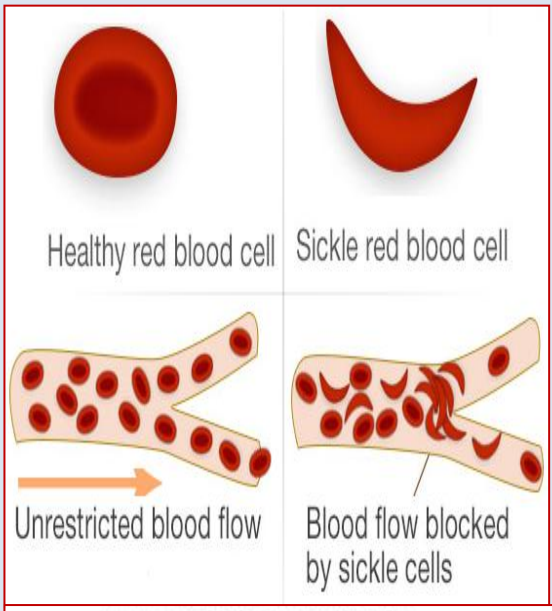
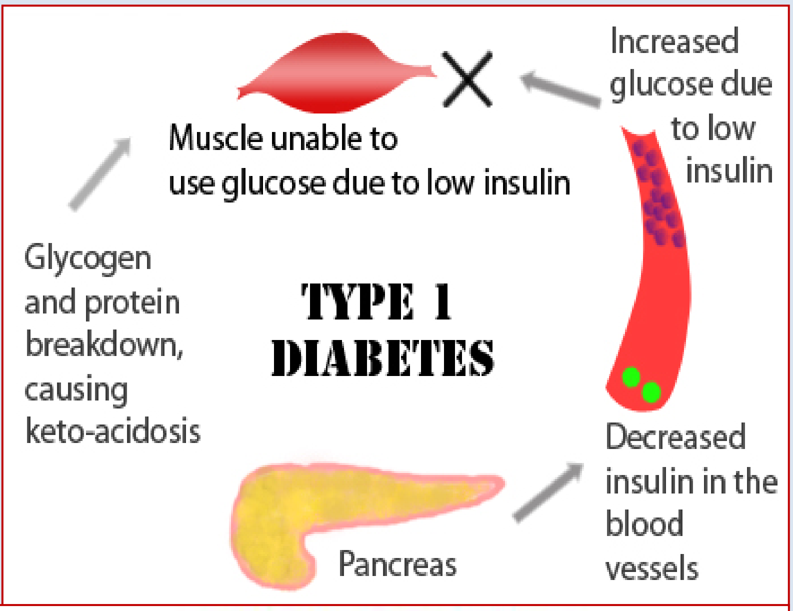
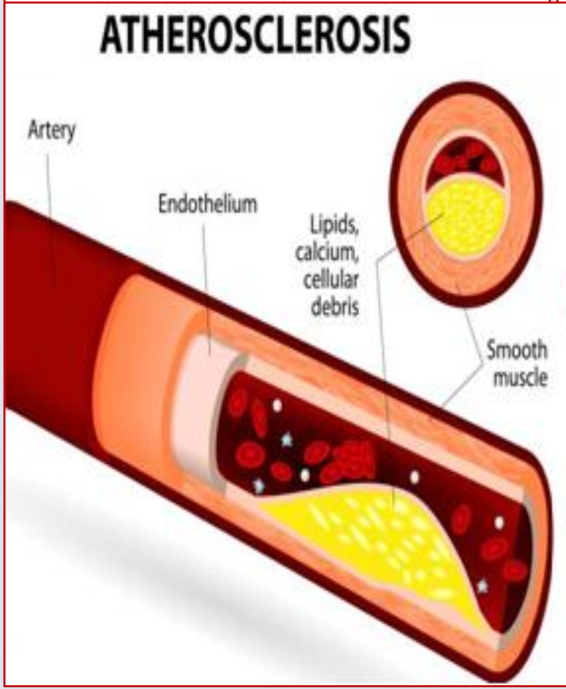
M.Sc. BIOCHEMISTRY- IV SEMESTER

BC-4.4: CLINICAL BIOCHEMISTRY.







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