

CURRICULUM

OF

PHYSIOLOGY

BS/MS

&

PhD

(Revised 2012)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum of subject is described as a throbbing pulse of a nation. By viewing curriculum one can judge the stage of development and its pace of socio-economic development of a nation. With the advent of new technology, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like of a stream of fresh water, making it imperative to update the curricula after regular intervals, for introducing latest development and innovation in the relevant field of knowledge.

In exercise of the powers conferred under Section 3 Sub-Section 2 (ii) of Act of Parliament No. X of 1976 titled “**Supervision of Curricula and Textbooks and Maintenance of Standard of Education**” the erstwhile University Grants Commission was designated as competent authority to develop, review and revise curricula beyond Class-XII. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis working in universities and R&D institutions of technically advanced countries are also invited to contribute and their views are incorporated where considered appropriate by the National Curriculum Revision Committee (NCRC).

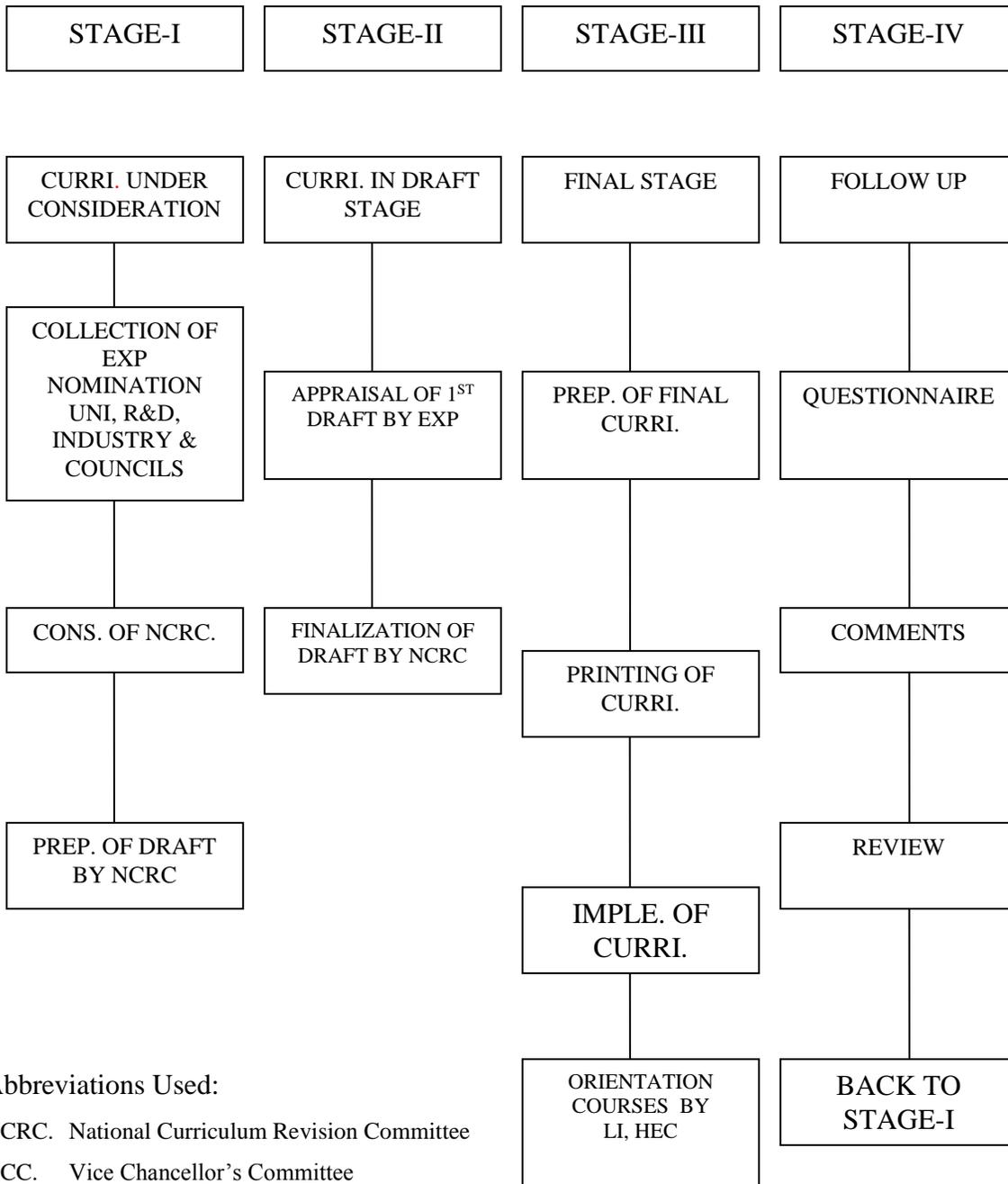
A committee of experts comprising of conveners from the National Curriculum Revision Committees of HEC in the disciplines of Basic, Applied, Social Sciences, Agriculture and Engineering met in 2007 & 2009 and developed the unified templates to standardize degree programs in the country so as to bring the national curriculum at par with international standards, and to fulfill the national needs. It also aimed to give a basic, broad based knowledge to the students to ensure the quality of education.

In line with above, NCRC comprising senior university faculty and experts from various stakeholders has finalized the curriculum for Physiology. The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

**Talat Khursheed
Adviser (Academics)**

May, 2012

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

- NCRC. National Curriculum Revision Committee
- VCC. Vice Chancellor's Committee
- EXP. Experts
- COL. Colleges
- UNI. Universities
- PREP. Preparation
- REC. Recommendations
- LI Learning Innovation
- R&D Research & Development Organization
- HEC Higher Education Commission

MISSION STATEMENT

To equip the students in the discipline of Physiology, by imparting knowledge and understanding of structure and function of human and biological systems. Thus, to foster the development of professional skills through well designed curriculum; based on experiments, training and research. It will ultimately mentor graduate and post-graduate students of Physiology for teaching and research in the disciplines of medicine and allied health sciences.

Introduction

The final meeting of National Curriculum Revision Committee on physiology was held at HEC Regional Center, Lahore from May 09-11, 2012 to finalize the draft BS (4 years) and MS in Physiology curriculum. The following attended the meeting:

Prof. Dr. Muhammad Abdul Azeem, Former Chairman, Department of Physiology, University of Karachi, Karachi.	Convener
Prof. Dr. Sadiqa Syed Head of the Department (Physiology), Bahria University Medical & Dental College, 13-National Stadium Road, Karachi-75260.	Member
Dr. Farman Ullah Wazir Professor, Department of Physiology Khyber Medical University, Institute of Medical Sciences (KIMS) KDA Hospital, Kohat.	Member
Dr. Muhammad Arshad Professor, Department of Biological Sciences, University of Sargodha, Sargodha.	Member
Dr. Nabila Roohi Associate Professor, Department of Zoology, University of the Punjab, Quaid-e-Azam Campus, Lahore.	Member
Dr. Irfan Zia Qureshi Associate Professor, Department of Animal Science, Quaid-i-Azam University, Islamabad.	Member
Dr. Saleema Bashir Shams Associate Professor, Department of Zoology, Kinnaird College for Women, 93, Jail Road, Lahore.	Member
Dr. Faqir Muhammad Assistant Professor, Department of Physiology Pharmacology, University of Agriculture, Faisalabad.	Member

Dr. Taseer Ahmed Khan
Assistant Professor,
Department of Physiology,
University of Karachi, Karachi

Member/Secretary

The meeting started with recitation from the Holy Quran by Dr. Muhammad Abdul Azeem. Prof. Talat Khurshed, Adviser (Academics) briefed about the importance of the subject of Physiology. He briefed the participants about the aim and objectives of the meeting with a particular focus on revising the course outlines of BS (4 years program) and MS in Physiology to make them compatible with the international standards and demands of the 21st Century and as well as ensuring the uniformity of academic standards within the country. Mr. Muhammad Raza Chohan, Director, HEC, Regional Centre, Lahore was also present on the occasion and he welcomed the participants.

Dr. Muhammad Abdul Azeem and Dr. Taseer Ahmed Khan were requested to chair the meeting, who were selected by the committee as Convener and Secretary respectively in the last meeting held on January 4-6, 2012.

On the request of the Convener all the members gave their detailed comments on the preliminary draft of the physiology curriculum. The committee during its deliberation considered the following objectives:

1. To finalize the curriculum in the discipline of Physiology and to bring it at par with international standards.
2. To incorporate latest reading & writing material against each course.
3. To bring uniformity and develop minimum baseline courses in each and every course of study.
4. To make recommendation for promotion /development of the discipline.

At the end the committee unanimously approved final draft of the curriculum of the BS (4-year) and MS in Physiology degree Programs. Malik Arshad Mahmood , Director (Curriculum), HEC Islamabad thanked the Convener, Secretary and all the members of Committee for sparing their valuable time and for their quality contribution towards preparation of the final curriculum of the BS (4-year) and MS Physiology Programmes. He acknowledged that their efforts will go long way in developing workable, useful and comprehensive degree programs in Physiology.

The Committee highly admired the efforts made by the officials of HEC Regional Centre, Lahore and Malik Arshed Mahmood, Director Curriculum for making excellent arrangements and their accommodation at Lahore.

The meeting ended with the vote of thanks to the HEC officials for providing ideal environment for proceeding. The Convener of the NCRC also thanked the members for their in depth inputs for preparation and improvement of curriculum in the discipline of Physiology.

After thorough and having three days long deliberations, the committee unanimously approved the draft curricula of the BS (4-year program) and Schemes for MS & PhD Physiology degree programmes along with

recommendations given at the end of this booklet, by keeping the following aims & objectives into consideration:

Aims & Objectives:

- To develop international standard of Physiology curriculum for 4-year BS and 2-year MS curriculum so that it can be uniformly adopted by the public and private sector institutions throughout the country.
- To impart up to date knowledge and practical skills amongst Physiology graduates through teaching and experimentation. .
- To discuss and propose possibilities for the induction of 4-year BS, 2-year MS & PhD Physiology curriculum for human, animal & plant Physiology for the first time at National level.

BS Physiology **(Duration 4 years and 8 semesters)**

Entry Requirement: 12 years (Pre Medical/ Pre-Engineering)

Credit requirement: 124 – 136

Objectives:

1. Study of normal Physiology/Physiological functions in Human/Plant/Animal at the level of cells, tissues, organs, systems and body as whole.
2. Application of the above knowledge in the understanding of disease process taking few selected examples.
3. To provide fundamental knowledge in statistical concepts and regulatory approach in Physiology.
4. To adopt multidisciplinary approach to equip the students for multidimensional carrier opportunities.
5. Experiments to demonstrate some of the important physiological concepts.
6. Training the students to demonstrate few clinical signs and laboratory work.
7. Encourage the students capacity for self learning by:
 - Project work
 - Seminars
 - Research Work
 - Internship

Learning Outcome:

A student holding a degree of BS will be able to:

1. Understand the physiological functions of cells, tissues, organs, systems and body as a whole.
2. Student will be able to apply physiological knowledge with respect to the understanding of the diseases associated with various systems.
3. Student will be able to integrate all the systems with respect to the regulatory aspects of whole body.
4. Student's concepts will mature for the physiological phenomenon with the performance of experiments on animal models and human subject using non-invasive techniques.
5. The student will develop confidence in communication, research protocols and career identification due to capacity building during studies.

This is only a model and every University may adjust the general, major and elective courses according to their needs and resources.

The course number should be assigned as 300,400,500 and 600 levels from 1st to 4th year respectively.

LAYOUT FOR BS (4 YEAR) IN PHYSIOLOGY

Compulsory Requirements (the student has no choice)		General Courses to be chosen from other departments	
9 courses		7-8 courses	
25 Credit hours		21-24 Cr. Hours	
Subject	Cr. hr	Subject	Cr. hr
1. English I	3	1. Biochemistry I	2+1
2. English II	3	2. Biochemistry II	2+1
3. English III	3	3. Sociology	2+0
4. English IV /Univ. optional *	3	4. Introduction to Bioinformatics	0+3
5. Pakistan studies	2	5. Microbial Physiology	2+1
6. Islamic studies / Ethics	2	6. Principles of immunology	2+1
7. Mathematics I/ Biology I	3	7. Biotechnology	2+1
8. Mathematics II/ Biology II/ Univ. optional **	3	8. Pharmacology	3+1
9. Introduction and application to computer	3	OR Any other course depending upon the expertise available.	
	25		24

Discipline Specific Foundation Courses		Major courses including research project/internship		Elective Courses within the major	
8-10 courses		11-13 courses		4 courses	
30-33 Credit hours		36-42 Credit hours		12 Credit Hours	
Subject	Cr.hr	Subject	Cr.hr	Subject	Cr.hr
1. Cell and molecular biology I	2+1	1. Cardiovascular physiology	3+1	1. Toxicology	2+1
2. Cell and molecular biology II	2+1	2. Neurophysiology	3+1	2. Pathophysiology	3+1
3. Functional Anatomy and Physiology I	3+1	3. Pulmonary physiology	2+1	3. Clinical endocrinology	3+1
4. Functional Anatomy and Physiology II	3+1	4. Renal physiology	2+1	Note: Elective courses are to be chosen from the given list.	
5. Physiology of blood and ECF	2+1	5. Gastrointestinal physiology	2+1		
6. Nerve and muscle physiology	2+1	6. Endocrinology	3+1	OR Any other course depending upon the expertise available.	
7. Physiological techniques	1+2	7. Reproductive physiology	3+1		
8. Biostatistics	1+2	8. Physiology of sensory system	2+1		
9. Human and animal behavior	2+1	9. Physiology of health, fitness and exercise	2+1		
		10. Ergonomics	2+1		
		11. Electrophysiology	2+1		
		12. Research methodology	2+1		
		13. Internship	0		
	29		40		11

Total Credit Hours = 129

* University has the option to recommend any other course in lieu of English IV

** University may recommend any other course in lieu of Mathematics II

Following is the year wise and Semester wise outline of BS 4 year Program in Physiology:

SCHEME OF STUDIES

YEAR I Semester I	YEAR I Semester II
English-I 3	English-II 3
Islamic studies 2	Pak Studies 2
Mathematics-I / Biology-I 3	Mathematics-II / Biology-II 3
Biochemistry-I* 3(2+1)	Biochemistry-II* 3(2+1)
Cell and Molecular Biology-I 3(2+1)	Cell and Molecular Biology-II 3(2+1)
Functional Anatomy and Physiology-I 4(3+1)	Functional Anatomy and Physiology-II 4(3+1)
Total 18 credits	Total 18 credits
YEAR 2 Semester III	YEAR 2 Semester IV
English-III 3	English-IV (Communication Skills) 3
Introduction and Application to Computer 3(0+3)	Introduction to Bioinformatics * 3(0+3)
Sociology * 2	Cardiovascular Physiology 4(3+1)
Physiology of blood and ECF 3(2+1)	Nerve and Muscle Physiology 3(2+1)
Physiological Techniques 3(1+2)	Principles of Immunology* 3(2+1)
Microbial Physiology* 3(2+1)	
Total 17 credits	Total 16 credits
YEAR 3 Semester V	YEAR 3 Semester VI
Biostatistics 3(1+2)	Human and Animal Behavior 3(2+1)
<u>Neurophysiology 4(3+1)</u>	<u>Endocrinology 4(3+1)</u>
<u>Pulmonary Physiology 3(2+1)</u>	<u>Reproductive Physiology 4(3+1)</u>
<u>Renal Physiology 3(2+1)</u>	<u>Physiology of Sensory system 3(2+1)</u>
<u>Gastrointestinal Physiology 3(2+1)</u>	
Total 16 credits	Total 14 credits
YEAR 4 Semester VII	YEAR 4 Semester VIII
<u>Physiology of health, fitness and exercise 3(2+1)</u>	Biotechnology* 3(2+1)
Ergonomics* 3(2+1)	Toxicology 3(2+1)
<u>Electrophysiology 3(2+1)</u>	<i>Clinical Endocrinology 4(3+1)</i>
<u>Research Methodology 3(2+1)</u>	Pharmacology* 4(3+1)
<i>Pathophysiology 4(3+1)</i>	Internship 0
Total 16 credits	Total 14 credits

Note: Legend used for above courses: Compulsory: without tag/mark; General: Asterisk; Foundation: Bold; Major: Underline; Electives: Italics

Following is the list of electives courses for BS Program in Physiology. A total of 12 credits can be selected for final year:

Course Title	Cr. Hrs
Pathophysiology	3+0
Dietetics and Nutrition	2+1
Biosafety and Bioethics	3+0
Fertility regulation	3+0
General biophysics	2+1
Human reproduction	3+0
Neuroendocrinology	2+1
Applied physiology and biophysics	2+1
Biophysical and molecular cell physiology	2+1
Biophysical basis of inflammation and atherosclerosis	3+0
Cardiovascular and neurovascular disorders	2+1
Clinical and molecular basis of ischemic disorders	2+1
Clinical endocrinology	2+1
Clinical hematology	2+1
Clinical nutrition physiology	2+1
Clinical pharmacology	2+1
Clinical physiology and biophysics	2+1
Clinical reproductive endocrinology	2+1
Comparative Animal Physiology	2+1
Comparative structure and function of muscle	2+1
Diseased muscle	2+1
Environmental endocrinology	3+0
Experimental and clinical diabetes mellitus	2+1
General hematology	2+1
General pathophysiology	2+1
Genetic basis of hematology	2+1
Immunology	2+1
Laboratory techniques in physiology and biophysics	2+1
Molecular biology and biochemistry of coagulation factors	2+1
Molecular physiology and biophysics of ion channels	3+0
Muscle structure and function	2+1
Neurological and psychiatric disorders	2+1
Pathophysiology of neuromuscular system	2+1
Physiology of cardiac muscle	2+1
Physiology of excitable cells	3+0
Physiology of smooth muscle	2+1
Systemic pathophysiology	2+1
Project with internship	3+0
Thesis without internship	6+0

DETAIL OF COURSES

YEAR I

SEMESTER I

English-I 3

Islamiat 2

Mathematics-I / Biology-I 3

Note: The details of the above mentioned compulsory courses will be adopted through standard curriculum designed from them in their respective faculties.

Biochemistry-I

3 (2 + 1)

Objectives:

To provide an understating of

- biomolecules (lipids, protein and carbohydrates).
- the organization of biomolecules.
- basic knowledge of enzymes and their functions.
- nucleic acid structure and function.

Proteins: Peptides and Amino Acids, the Covalent and 3-D structure of proteins, sequences and evolution.

Carbohydrates: Monosaccharaides; oligosaccharides; polysaccharides. Glycoconjugates: Glycosaminoglycans; Proteoglycans; Glycoproteins; Carbohydrates as informational molecules.

Lipids: Storage Lipids, Fatty acids and their types, Triacylglycerols, Structural Lipids, Glycerophospholipids, Sphingolipids, Glycolipids, Steroles and Isoprenoids.

Vitamins and Minerals: Basic concepts and types.

Enzymes: Mechanism of enzyme action and enzyme kinetics; regulatory enzyme precursors and associates for enzyme production *in vitro*.

Nucleic Acids: Structure and function of bases, nucleosides and nucleotides; DNA double helical structure.

Practicals:

1. Test for the hydrolysis of starch by using mineral acids
2. Qualitative tests for monosaccharaides, oligosaccharides and polysaccharides
3. Preparation of calibration curve for glucose
4. Estimation of serum glucose by using calibration curve
5. Detection of reducing sugars in the presence of non-reducing sugars
6. Qualitative tests for different lipids
7. Fractionation of brain lipids and their analysis by thin-layer chromatography
8. Various qualitative tests for amino acids
9. Paper and thin-layer chromatography of sugars
10. Paper chromatography of various amino acids
11. Determination of pKa values of amino acids (Glycine, Alanine) by preparation of titration curves.
12. Qualitative and quantitative analysis of proteins by colorimetric methods (Biuret and Lowry's)

Recommended Books:

- Nelson, D. L. and Cox, M. M., Lehninger Principles of Biochemistry, 5th ed; W. H. Freeman and Company, New York, 2005 (**Recommended Textbook**).
- Voet, D., Voet, J.G. and Pratt, C. W., Fundamentals of Biochemistry; John Wiley and Sons. Inc., New York, 2002.
- Berg, J. M., Tymoczko, J. L. and Stryer, L., Biochemistry 5th ed; W.H. Freeman and Company, New York, 2002.
- Devlin, T. M., Textbook of Biochemistry with Clinical Correlations 5th ed; John Wiley and Sons. Inc., New York, 2002.
- Zubay, G., Biochemistry 4th ed; W. C. Brown Publishers, Inc., Oxford England, 1995.
- Plummer, D. T., An Introduction to Practical Biochemistry 4th ed; McGraw-Hill Book Company, London, 1990.
- Wilson, K. and Walker, J., Practical Biochemistry: Principles and Techniques, 4th ed; Cambridge Univ. Press, London 1994

Cell and Molecular Biology-I

3 (2 + 1)

Objectives:

- To impart knowledge about the cell and its origin.
- To understand its differentiation into complex organization and its unified physiological role.
- To study various ultrastructural, molecular and functional aspects of the cells.

Ultrastructure of cell: Brief recapitulation, function of various cellular organelles with special emphasis on: the relationship of membrane structure, Cytoskeleton, microfilaments and microtubules; receptor proteins.

Role of organelles: The role of mitochondria and chloroplast in cellular metabolism and energy transformation, role of ribosomes and endoplasmic reticulum in protein synthesis and protein transduction, the role of endoplasmic reticulum in drug metabolism, Golgi apparatus and cell secretions, role of lysosomes and metabolic disorders due to defects of lysosomal function.

Cellular processes: Membrane permeability, transport, endocytosis, phagocytosis, pinocytosis and cell to cell interaction.

Practicals:

1. To demonstrate the process of osmosis and diffusion using cell membranes.
2. To prepare osmotic fragility curve of different cells.
3. Preparation of temporary slides of various cell types.
4. To study different cell types through permanent slides.
5. Staining and study of budding in yeast cell
6. Counting of prokaryotic cells (bacteria) and blood cells by using hemocytometer.
7. To measure the cell size with the calibrated ocular micrometer.

Recommended Books:

- Karp, G., Cell and Molecular Biology: Concepts and Experiments, 5th ed; John Wiley and Sons, Inc., 2008 (**Recommended Textbook**).
- Lodish H, Bresk A., Matsumura, P., Kaiser, C. A., Kriger, M., Scott, M. P., Zipursky, S. L. and Darnel J., Molecular Cell Biology, 5th ed;. W. H. Freeman and Co., New York. 2004.
- Roberties, E. D.P. and Roberties, E. M. F. Cell and Molecular Biology, 8th ed. Lippin Cott William and Willkins, New York, 2001.

Functional Anatomy and Physiology-I

4 (3 + 1)

Objectives:

- To provide understanding of the human tissues, organs and systems with respect to their basic functions.
- To provide the knowledge of the components of individual systems and their role in body functions.
- To inculcate the concept of regulation of physiological functions through different body systems.
- To understand the mechanism of various physiological processes related with individual systems.

Introduction: Organization of the human body including chemical and cellular levels, Basic anatomical terminologies, body planes and cavities. Homeostatic principles.

Tissue: Structure and function, Epithelial, Connective, Muscle and Nervous tissues. Bone and Cartilage, Adaptive cellular and tissue behavior: Hyperplasia, Hypertrophy, Atrophy, Genetic abnormalities.

Blood: Physical characteristics and components of blood, origin and development of blood cells, structure and function of RBC, WBC, and platelets, blood groups, and hemostasis.

Cardiovascular System: Structure and function of heart, Cardiac cycle, heart sounds, cardiac conduction system. Structure and function of blood vessels, Blood pressure and its regulatory factors.

Lymphatic System: Overview of Lymph. Structure and function of lymphatic tissues and organs. Antibodies and Immune cells. Specific and non specific immune reactions.

Respiratory System: Overview of structure and function of the Respiratory organs: Nose, pharynx, larynx, trachea, Bronchial tree and alveoli. Pleural cavity and Pleural fluid. Lung volumes and capacities. Non-respiratory function. Alveolar ventilation: mechanism of alveolar gas exchange.

Digestive System: Overview of structure and function of the digestive organs: mouth, esophagus, stomach, small intestine and large intestine. Phenomenon of deglutition. Secretion of digestive and accessory glands. Digestion, absorption and movements of GIT. Defecation.

Excretory system: Overview of structure and function of Kidneys: Gross and microscopic anatomy. Nephron: Structure and blood supply. Urine formation: Glomerular filtration, Processes of tubular reabsorption and secretion. Urine transportation, storage and micturition.

Practicals:

1. Study the organization of human body at cells, tissues, organs, and systems level through charts, models and human torso.
2. Demonstrate methods of obtaining blood sample; determine the specific gravity and viscosity of blood and plasma.
3. To record the human blood pressure by using Palpatory and Auscultatory methods.
4. To observe and record normal heart activity from exposed frog heart by Kymography.
5. To record and relate the changes in circumference of chest during normal breathing with activity of respiratory muscles.
6. To observe respiratory movement and determination of respiratory rate by Kymography.
7. To determine the normal chemical composition of human saliva.
8. To observe and discussion gastro-intestinal movements in exposed abdomen of anesthetized animal.
9. To observe and determine the normal physical and chemical properties of urine sample.
10. Microscope examination of urinary sediments.
11. To determine blood urea nitrogen, calcium and phosphate.

Recommended Books:

- Tortora, G. J. and Grabowski, S. R., Principles of Anatomy and Physiology, 11th ed; John Wiley and Sons, 2006 (**Recommended Textbook**).
- Marieb, E. N., *Human Anatomy and Physiology*, 7th ed; Benjamin/Cummings Science Publishing.
- William Henry Howell, *A Textbook of Physiology for Medical Students and Physicians*. General Books, 2010.
- Shier, Hole's Essentials of Human Anatomy & Physiology 10/e. McGraw-Hills, 2008
- Guyton, A. C. and Hall, J. E. *Textbook of Medical Physiology*, 12th ed; W. B Saunders, 2005.
- Shier, D., Butler, J., Lewis, R., Hole's Essentials of Human Anatomy and Physiology, 8th ed; McGraw-Hill, 2003.
- Waugh, A., Grant, A., Ross and Wilson *Anatomy and Physiology in Health and Illness*, 9th ed; Churchill Livingstone, 2002.

SEMESTER II

English-II	3
Pak Studies	2
Mathematics-II / Biology-II	3

Note: The details of the above mentioned compulsory courses will be adopted through standard curriculum designed from them in their respective faculties.

Biochemistry-II*

3 (2 + 1)

Objectives:

- To provide the understanding of energy production and consumption in living cells.
- To provide the basic understanding of bioenergetics and thermodynamics of biomolecule (carbohydrate, protein, lipids).

Carbohydrate metabolism: Glycolysis; Gluconeogenesis and pentose phosphate pathways and their regulation. Biosynthesis and breakdown of glycogen in animals; regulation of glycogen metabolism. Citric acid cycle: production of acetyl-CoA; citric acid cycle reactions and its regulations. The glyoxylate cycle; electron transport chain reactions and oxidative phosphorylation in mitochondria and its relationship with energy production in the cell.

Protein metabolism: Biosynthesis of amino acids. Integration and hormonal regulation of mammalian metabolism.

Lipid metabolism: Digestion, mobilization and transport of fats; oxidation pathways of fatty acids; ketone bodies. Biosynthesis of fatty acids, eicosanoids, triacylglycerols, membrane phospholipids, cholesterol and steroids.

Vitamin and mineral metabolism: Role of vitamins and minerals as cofactors in various metabolic pathways.

Practicals:

1. Glycogen isolation from liver and study of its hydrolysis.
2. Enzymatic determination of glucose.
3. Extraction and salting out of proteins.
4. Demonstration of advance chromatographic techniques.
5. Separation of pigments, lipids and amino acids through various chromatographic techniques (paper and thin layer).
6. Demonstration of SDS-PAGE technique to determine molecular size of proteins.
7. Quantitative analysis of proteins by UV spectrophotometry
8. Extraction and quantitative analysis of amino acids.

Recommended Books:

- Nelson, D. L. and Cox, M. M., Lehninger Principles of Biochemistry, 5th ed; W.H. Freeman and Company, New York, 2005 (**Recommended text book**).
- Voet, D., Voet, J.G. and Pratt, C. W., Fundamentals of Biochemistry; John Wiley and Sons. Inc., New York, 2002.
- Berg, J. M., Tymoczko, J. L. and Stryer, L., Biochemistry 5th ed; W.H. Freeman and Company, New York, 2002.

- Devlin, T. M., Textbook of Biochemistry with Clinical Correlations 5th ed; John Wiley and Sons. Inc., New York, 2002.
- Zubay, G., Biochemistry 4th ed; W. C. Brown Publishers, Inc., Oxford England, 1995.
- Plummer, D. T., An Introduction to Practical Biochemistry 4th ed; McGraw-Hill Book Company, London, 1990.
- Wilson, K. and Walker, J., Practical Biochemistry: Principles and Techniques, 4th ed; Cambridge Univ. Press, London 1994.

Cell and Molecular Biology-II

3 (2 + 1)

Objectives

- To provide the understanding of normal and abnormal gene functions.
- Cell regulation at gene level.
- To introduce with the applications of genetic engineering.

Molecular structure: Prokaryotic and eukaryotic genetic material, role of histones and high mobility group proteins in the packing of chromosomes and gene expression.

Cell cycle: Replication of DNA, mechanism in prokaryotes and eukaryotes. DNA polymerase, other replication enzymes and DNA binding proteins involved in replication. DNA repair mechanisms.

Protein synthesis: Transcription, RNA polymerases, transcriptional control in prokaryotes and eukaryotes. Post-transcriptional processing of RNAs (mRNA, rRNA and tRNA). RNA splicing, ribozymes. Genetic code, genetic code in mitochondrial DNA. Translation and post-translational modification of proteins. Mutations and inborn errors.

Genetic engineering: Gene expression, Lac operon, Try operon, recombinant DNA, cloning vectors, restriction endonucleases, constructions and screening of gene libraries. cDNA cloning. DNA sequencing, site-specific mutagenesis.

Practicals:

1. Extraction and quantitative determination of DNA by diphenylamine/protein kinase method from mammalian liver.
2. Extraction and quantitative determination of RNA by orcinol method
3. Quantitative analysis of DNA and RNA by UV spectrophotometry.
4. Separation of different sized DNA fragments by agarose gel electrophoresis.
5. Demonstration of RNA/DNA/protein through northern/southern/western blotting procedures.
6. To prepare transformed bacteria.
7. To study antibiotic resistance in transformed bacteria.

Recommended Books:

- Karp, G., Cell and Molecular Biology: Concepts and Experiments, 5th ed; John Wiley and Sons, Inc., 2008 (**Recommended Textbook**).
- Lodish H, Bresk A., Matsumura, P., Kaiser, C.A., Kriger, M., Scott, M.P., Zipursky, S.L. and Darnel J., Molecular Cell Biology, 5th ed;. W. H. Freeman and Co., New York, 2004.
- Roberties, E. D. P. and Roberties, E. M. F. Cell and Molecular Biology, 8th ed. Lippin Cott William and Willkins, New York, 2001.

Functional Anatomy and Physiology-II

4 (3 + 1)

Objectives:

- To provide understanding of the human tissues, organs and systems with respect to their basic functions.
- To provide the knowledge of the components of individual systems and their role in body functions.
- To inculcate the concept of two basic regulatory mechanisms in body.
- To understand the mechanism of various physiological processes related with individual system.

Endocrine System: Types, structure and function of endocrine glands and their secretions. Mechanism of hormone action. Control of hormone secretion by Hypothalamo-pituitary axis.

Reproductive System: Gross anatomy, histology and hormonal regulation, menstrual/estrous cycle, Overview of secondary sex characters, accessory sex glands. Oogenesis, spermatogenesis and composition of semen.

Musculo-skeletal System:

Skeletal organization: Axial and Appendicular skeleton. Structure of Bone. Anatomy and classification of joints. Overview of structure and function of muscle, ligaments and tendons. Neuromuscular junction and chemical transmission.

Nervous System: Structure and function of neuron, neuroglial cells and their classification. Membrane potential, generation and propagation of nerve impulse. Synaptic transmission.

Organization of CNS: Sensory and motor system. Anatomy and Physiology, Protective structures, meninges, formation and regulation of cerebrospinal fluid, cerebral blood flow and blood brain barrier. Nerve pathways: Sensory and motor tracts and cranial and Spinal nerves. Reflexes and reflex arc. Anatomical divisions and functional areas of brain. Receptors and their classification.

Special Sensory organs: Overview of structure and Function of Ear, Eye, Nose and Tongue.

Integumentary system: Accessory structures of skin, hair and nails. Overview of skin and exocrine glands.

Practicals:

1. Identification and isolation of endocrine glands in dissected frog/uromastix.
2. To study the gross structure of male and female reproductive organs and their functions in animal models.
3. Comparison of health and disease states of different body tissues and organs with the help of slides or charts
4. The microscopic examination of cartilaginous and bone matrix in prepared slides.
5. Study of cranial and spinal nerves and their functions with the help of charts.
6. To study the spinal reflexes in animal model (frog).
7. Isolation of nerve and muscle (Sciatic and Gastrocnemius) in frog and to observe irritability on mechanical and electrical stimulation.
8. To locate cold, warm, pain and pressure spots on human skin.
9. Study of special sense organs with the help of chart and multimedia presentations.

10. Study of brain through sheep brain and learning of protective coverings with the help of illustrated charts.

Recommended Books:

- Tortora, G. J. and Grabowski, S. R., Principles of Anatomy and Physiology, 11th ed; John Wiley and Sons, 2006 (**Recommended Textbook**).
- Shier, D., Butler, J., Lewis, R., Hole's Essentials of Human Anatomy and Physiology, 8th ed; McGraw-Hill, 2003.
- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology, 12th ed; W. B Saunders, 2005.
- Waugh, A., Grant, A., Ross and Wilson Anatomy and Physiology in Health and Illness, 9th ed; Churchill Livingstone, 2002.
- Marieb, E. N., Human Anatomy and Physiology, 4th ed; Benjamin/Cummings Science Publishing, 1997.

YEAR 2

Semester III

English-III	3
Introduction and Application to Computer	3(0 +3)
Sociology	2

Note: The details of the above mentioned compulsory courses will be adopted through standard curriculum designed from them in their respective faculties.

Physiology of Blood and ECF

3 (2 + 1)

Objectives

- To provide the understanding of different body fluid compartments and their role in maintaining homeostasis.
- To provide the concept of hemopoiesis and blood group systems.
- To understand the mechanisms of hemostasis.

Body fluid Compartments: Classification, composition of body fluids, regulation of fluid composition and volume, regulation of fluid exchange and osmotic equilibrium between intra and extra cellular fluid, interstitial fluid, colloidal osmotic pressure.

Blood: Hemopoiesis, stem and progenitor cells, differentiation of blood cells. Composition and function, synthesis of plasma proteins, protease inhibitors and colloid osmotic pressure.

Erythropoiesis: Overview, regulation of erythropoiesis, development of erythroid lineage. Red blood cell development, Hemoglobin synthesis, structure and function, iron metabolism, transport and storage. Destruction of RBCs. Diseases; anemia, polycythemia and thalassemia.

Leukopoiesis: Development, morphology and functions of granulocytes and agranulocytes, macrophages, distribution, functions and fate. Leucopenia, leukemia and leucocytosis.

Megakaryopoiesis: Megakaryocytes Morphology, synthesis, distribution. Functions of platelet and its role of platelets in hemostasis.

Hemostasis: Coagulation factors, Natural Inhibitors. The blood coagulation cascade. The contact activation system. Fibrinolytic system and Anticoagulation system.

ABO system: Introduction, Principles of ABO Group determination. The Rh system, Hemolytic disease of the newborn.

Lymph: Lymph nodes and channels, capillaries and their permeability, rate of lymph flow. Composition and function, effect of interstitial fluid on lymph flow.

Cerebrospinal Fluid: Formation, flow, pressure, absorption and function. Brain edema, blood brain barrier and blood CSF barrier.

Sweat: Glands, formation, volume regulation.

Ocular fluids: Overview, production and turnover of Tears, Aqueous and Vitreous humor.

Synovial fluid: Composition and regulation of volume and function.

Body Cavity Fluids: Overview of Pleural, Pericardial fluid, peritoneal fluid and surfactant

Practicals:

1. To determine the packed cell volume (PCV) or Hematocrit ratio by Wintrobe's method.
2. Determination of erythrocyte count in a sample of blood.
3. Determination of absolute red cell Indices by calculations.
4. Determination of blood groups
5. Estimation of hemoglobin concentration by Sahli's method.
6. To determine the erythrocyte sedimentation rate (ESR) by Westergren's method.
7. Determination of total leukocyte count in a sample of blood.
8. Determination of differential leukocytes count.
9. Determination of platelet count.
10. Determination of bleeding time and clotting time.

Recommended Books:

- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology, 12th ed; W. B Saunders, 2011 (**Recommended textbook**).
- Pallister, C., Blood Physiology and Pathophysiology. Butterworth — Heinemann Ltd., 1994.
- Schmaier A. H. and Petruzelli L. M., Hematology: Lippincott Williams and Wilkins, 2003.
- Talib V. H. and Khurana S. K., Hematology For students (Clinical and Practical Approach).. CBS Publishers and Distributors, 1995.
- Ogsten, D., The Physiology of Hemostasis: Biddies Ltd, Guildford and King's Lynn, 1983.
- Ganong, W. F., Review of Medical Physiology: International ed. McGraw-Hill. 2005.

Physiological Techniques

3(1 + 2)

Objectives:

- To introduce the students with latest physiological techniques/tools
- To familiarize with the uses/applications of instruments/techniques in the field of physiology.

Power Lab in various Physiology experiments: measurement of blood pressure, pulse rate, heart rate, electrocardiography, electroencephalography, electromyography, nerve conduction velocity, respiratory rate, respiratory volumes and capacities. Power Lab experiments with isolated heart, uterus, ilium, nerve-muscle preparations.

Microtomy: tissue sectioning and staining

Microscopy: types of microscopy such as confocal, transmission electron microscopy and scanning electron microscopy, Immuno-histochemistry.

Imaging Techniques: Radiography; X-ray microanalysis. Ultrasonography, CT scanning and MRI (magnetic resonance imaging),

Spectrophotometry: (visible, ultraviolet, atomic absorption, infra-red, mass spectrophotometry).

Flamephotometry: Principles and use in electrolyte estimations.

Immunoassay Techniques: Principles and use of immune assays; radioactive substances; radio immunoassays (RIA), immune histochemistry (IHC).

Chromatography: (High Performance Liquid Chromatography, Gas Chromatography etc.). Electrophoresis, Polymerase chain reactions

Surgical techniques: used in physiological experiments. Anesthesia techniques for experimental animals.

Practicals:

1. To demonstrate the use of power lab and its components for the recording of physiological experiments.
2. Measurement of physiological parameters using power lab.
3. Preparation of tissue specimen for microtomy and staining
4. Demonstration of the use of electron microscopy.
5. Identification of slow and fast muscles by using histochemical methods.
6. Demonstration of imaging techniques for diagnostic purpose.
7. Demonstration of different spectroscopic techniques.
8. To perform different immunoassays e.g. ELISA, Hemagglutination Inhibition
9. To demonstrate RIA and IHC
10. To demonstrate the use of High Performance Liquid Chromatography.

Recommended Books:

1. Tharp, G., and D. Woodman. 2007. Experiments in Physiology. 9th ed. Prentice Hall, London, UK.
2. Zia-ur-Rahman, B. Aslam and T. Khaliq, 2011. Physiology I and II, 4th Ed. Department of Physiology and Pharmacology, University of Agriculture Faisalabad., Pakistan.
3. ADInstruments manual Data Acquisition system
www.adinstruments.com/downloads/manuals/

Microbial Physiology

3 (2 + 1)

Objectives

- To provide basic knowledge about bacteria, viruses and related microbes.
- To give an understanding of metabolism and transport systems in bacterial cells.
- To gain concepts about probiotics and protozoans.

Bacteria: Properties and behavior of bacteria with respect to their chemical and physical requirements for sustainability and reproduction; Metabolic pathways; Protein export; Chemiosmosis and multiple transport system; Functions of bacterial membrane and antibiotic resistance mechanism; Principles of enzyme action; Fermentation respiration; Novel bacteria pathways and biotransformation. Probiotics and their Importance.

Virus: Structure and classification of virus; Status and nature of virus in life system; Multiplication, lysogeny, episomy, and transducing bacteriophages, Interference with viral multiplication. Physiology of prions.

Protozoa: Kinds and their medical importance.

Fungi: Medically important fungi, fungal spores and diseases.

Practicals:

1. To culture bacterial cells.
2. To identify types of bacteria through staining.
3. To study applied aspects of microbial physiology.
4. Microscopic examination of stool for identification of parasites.
5. To culture protozoa and study their medical importance.
6. To perform haemagglutination assay.
7. Identification of fungi through prepared slides.

Recommended Books:

- Albert G. Moat, John Watkins Foster, Michael P. Spector. Microbial Physiology. John Wiley & Sons. 2002. (**Recommended Textbook**).
- White, D. The Physiology and Biochemistry of Prokaryotes. Oxford University Press, Oxford. 1999.
- Caldwell, D. R. Microbial Physiology and Metabolism. Star Bop. Co. 1999.

SEMESTER IV

English-IV (Communication Skills)

3

Note: The details of the above mentioned compulsory courses will be adopted through standard curriculum designed from them in their respective faculties.

Introduction to Bioinformatics

3(0 + 3)

Objectives:

The students will be able to:

- Access, retrieve, and analyze bioinformatics data available from several bioinformatics databases;
- Assess the quality of bioinformatics data available from the Internet;
- Use standard bioinformatics tools to answer specific biological questions;
- Understand the theories used to build the tools and their relationship to biology;
- Critically assess solutions to bioinformatics problems.

Overview of Bioinformatics: The scope of Bioinformatics, Bioinformatics and internet, Useful Bioinformatics sites on the internet.

Basic Principles of Computing in Bioinformatics: Running computer software, Computer operating systems, Software downloading and installation, Database management

Data Acquisition: Sequencing DNA, RNA and proteins, Determination of protein structure, Gene and protein expression data, Protein interaction data.

Databases: Contents, Structure and Annotation: File formats, Annotated sequence databases, Genome and organism-specific databases, Miscellaneous databases.

Retrieval of Biological Data: Data retrieval with Entrez and DBGET/LinkDB, Data retrieval with SRS (sequence retrieval system).

Searching Sequence: Databases by Sequence Similarity Criteria: Sequence similarity searches, Amino acid substitution matrices, Database searches (FAST and BLAST), Sequence filters, Iterative database searches and PSI-BLAST.

Multiple Sequence: Alignment-Genes and Protein Families: Multiple sequence alignment and family relationships, Protein families and pattern databases, Protein domain families.

Phylogenetics: Phylogenetics, cladistics and ontology, Building phylogenetic trees, Evolution of macromolecular sequences.

Sequence Annotation: Principles of genome annotation, Annotation tools and resources.

Structural Bioinformatics: Conceptual models of protein structure, relationship of protein three-dimensional structure to protein function, The evolution of protein structure and function, Obtaining, viewing and analyzing structural data, Structural alignment, Classification of proteins of known three-dimensional structure: CATH and SCOP, Introduction to protein structure prediction by comparative modeling, Secondary structure prediction, Advanced protein structure prediction and prediction strategies.

Microarray Data Analysis: Analysis methods, tools and resources, Sequence sampling and SAGE.

Proteomic Data Analysis: Analyzing data from 2D-PAGE gels, Analyzing protein spectrometry data.

Recommended Books and Web Sites:

- Lesk, A. M. Introduction to Bioinformatics. Oxford University Press, Oxford. 2002 (**Recommended Textbook**).
- Gibas, C. and Jambeck, P. Developing Bioinformatics Computer Skills. O'Reilly Publishers. 2001.
- Westhead, D. R., Parish, J. H. and Twyman, R. M. Instant Notes on Bioinformatics. Viva Books Private Limited. 2003.
- Baxevanis, A. D. and Ouellette, B. F. F. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd ed. O'Reilly Publishers. 2004.
- Krane, D. E. and Raymer, M. L. Fundamental Concepts of Bioinformatics. Benjamin Cummings. 2002.
- Moody, G. Digital Code of Life: How Bioinformatics is Revolutionizing Science, Medicine, and Business. John Wiley and Sons. 2004.

- Orengo, C. A., Jones, D. T. and Thornton, J. M. Bioinformatics: Genes, Proteins and Computers (Advanced Text). Routledge. 2003.
- <http://www.ncbi.nlm.nih.gov>
- <http://www.ebi.ac.uk>
- <http://foldoc.doc.ic.ac.uk/foldoc/index.html>

Cardiovascular Physiology

Objectives:

4(3 + 1)

- To understand the organization and components of cardiovascular system
- To understand the excitability and contractility in heart with respect to its role in pumping of blood in circulatory system.
- To understand various phases of the cardiac cycle along with variation in blood volume and pressures in ventricles aorta and atria.
- To understand ECG with respect to its recording and analysis for cardiac functions.
- To understand the regulation of cardiac activity and blood pressure in arterial tree.
- To know the role of vascular bed and importance of coronary circulation.

Introduction: Organization of circulatory system

Structure of Heart: Specialized cells and functional anatomy of heart

Electrical Properties of Heart: Pace makers, mechanism of self-excitation, rhythmicity, types of cardiac potentials and excitation of ventricular fibers

Cardiac Cycle: Cardiac cycle and output, atria as primer pump, Ventricle as pump work output of heart and pressure volume curves

ECG and its Analysis: characteristics of normal ECG; methods of recording, ECG leads, principles of vectorial analysis of normal ECG. Electrical analysis of ventricular QRS, abnormal voltages of QRS (causes)

Regulation of Cardiac Activity: Control of rhythmicity by autonomic innervations, myocardial performance and its neural and hormonal control

Vascular Bed: Arrangements of vessels, routes from arterial to venous system, volume of blood in different vessels, architecture of the terminal vascular bed, volume distensibility, mean velocity of flow, circulation time and flow in capillaries (starling forces), measurement and meaning of circulation time, shunts and AV-Anastomoses

Blood Vessels: Elastic nature of vessels (Hooke's and Laplace Law).

The Arterial System: Arterial blood pressure, relationship between flow and pressure in capillaries, importance of transmural pressures, Pressure gradients (Ohm's Law, Poiseuille's law), viscosity and blood flow, peripheral resistance, regulation of blood pressure

Control of Cardiac Output: Relationship between cardiac output and venous return, influence of various factors

Coronary Circulation: Functional anatomy of coronary vessels, Factors influencing coronary blood flow. Cutaneous, Skeletal muscle, Cerebral, Pulmonary,

Special Circulation: Renal and splanchnic circulation, Peripheral circulation and Intrinsic and extrinsic control of peripheral blood flow and its control central and peripheral factors (Exercise and Hemorrhage)

Practicals:

1. To record normal cardiogram and observe the effect of temperature on frog's heart
2. Effect of Stannius ligature on the heart of frog/uromastix
3. To observe the effect of Vagal stimulation on heart
4. To observe the effect of various factors (1) posture, (2) breath holding, (3) exercise, (4) over ventilation and (5) stress on blood pressure
5. To record and study ECG
6. To observe the microcirculation in the frog's web.
7. Studies on capillary circulation in human volunteers on reactive hyperemia
8. To evaluate the cardiac efficiency after exercise through scoring chart.

Recommended Books:

- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology. 12th ed. W. B. Saunders, 2005 (**Recommended Textbook**).
- Lauralee Sherwood, Cengage Learning (Firm). Human Physiology: From Cells to Systems, 7th edition.
- Berne, R. M., Matthew, N., M. D. Levy and Levy, M. N. Cardiovascular Physiology. Mosby, Inc. St. Louis. 2001.
- Mohrman, D. E. and Heller, L. J., Cardiovascular Physiology. McGraw-Hill, Boston, 2002.
- Katz, A. M. Physiology of the Heart. Raven Press, New York, 1992.
- Timmis, A. Essentials of Cardiology. Blackwell Scientific Publications. 1989.

Nerve and Muscle Physiology:

3 (2 + 1)

Objectives:

To understand the:

- Significance of nerve-muscle relation with respect to their role in various systems of human body.
- Types of neurons, nerves & muscles with respect to their gross & ultrastructures and physiological functions.
- Classification of nerves & skeletal muscles with respect to their functions.
- Excitability, contractility & mechanics of skeletal, cardiac and smooth muscles & their importance.

Introduction: Significance of nerve-muscle physiology related to various systems (CVS, Respiration and Special senses) Characteristics of nerve & muscle, functions and types.

Neuron & synapse: Classification, structure & functions of neurons, synapse and synaptic transmission, role of neurotransmitters. Classification of nerves.

Skeletal Muscle: Gross Structure, Covering, Connective tissue layer, Aponeurosis, tendon sheath. Classification: On the basis of direction, location, origin, insertion, Color,

Fiber types, nerve and blood supply to muscle and various actions. Skeletal muscle Movements: muscular actions; individual and group, role of skeleton and muscle in various movements, Neuromuscular Junction: Motor unit, and mechanism of impulse transmission through NMJ, Synthesis of neurotransmitter and its secretion. Electrical activity: Resting membrane potential, Ionic channels, conductance and generation of action potential. Microanatomy: Sarcolemma, Sarcoplasm, Nuclei, Sarcoplasmic Reticulum, Mitochondria, Transverse tubules, Myoglobin, Myofilaments, Molecular structure of contractile proteins, Excitation contraction coupling. Mechanism of Contraction: Theories of contraction (Sliding filament, ratchet) and their molecular aspects. Muscle Mechanics: Twitch, tetanus, summation, staircase, fatigue, isotonic and isometric contraction, tone. Relationships: Length Tension, force velocity & strength duration relationships. Muscle heat: efficiency of muscle, sources of energy, Location and function of Muscle proprioceptors.

Smooth Muscles: Microanatomy: Sarcoplasm, Mitochondria, Caveolea, sub surface, cisterns, Sarcolemma, cell to cell contacts, cyto-skeleton, dense bodies, intermediate filaments, myo-filaments, classification, excitation, contraction and regulation, Neuronal and hormonal influence, excitation and inhibition at NMJ, electrical activity (membrane & action potentials), E-C coupling, contractile process & its regulation (latch mechanism).

Cardiac Muscles: Microanatomy, Fiber types, Mechanism of excitation and contraction, types of action potential.

Practicals:

1. To dissect out nerve and muscle from Frog's leg and fixation for recording of muscle mechanics (Twitch & summation).
2. To study the ultra-structure & functions of neuron, synapse using illustrated charts and multimedia presentation.
3. To record the effect of tetanization on muscle contractility.
4. To record the effect of repeated direct and indirect stimulation on the muscle to observe its transmission & contraction fatigue.
5. To record the Stair case effect in muscle contraction
6. Experiment to demonstrate muscle tone, tension, isometric and isotonic contractions and fatigue in human muscles.
7. To demonstrate the preparation of isolated intestinal strip and its use for the recording of rhythmic activity on kymograph/chart recorder/power lab.
8. To demonstrate the rhythmic contraction and relaxation in isolated heart of mammal using kymograph/power lab/chart recorder.
9. To record EMG during voluntary contraction of human muscle.
10. To determine the work performed by human muscles, using an Ergograph.

Recommended Books:

- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology, 12th ed. W. B. Saunders, 2005 (**Recommended Textbook**).
- Richard D. Keynes, David J. Aidley & Christopher L. H, Huang. Nerve & Muscle, Cambridge, 2011
- Berney, R. M. and Levy, M. N. Physiology. Mosby Air book, 1992.
- Berney, R. M. and Levy, M. N. The Structure and Function of Muscle. Academic Press, 1968.
- West, J. B. Physiological Basis of Medical Practice. Williams and Wilkins. 1990.

- Davidson, B. and Smith, E. Textbook of Physiology and Biochemistry. W. B. Saunders.
- Philip F. Gardiner Advance neuromuscular exercise physiology, e-book, Publisher: Human Kinetics, 2011.
- Brain MacIntosh, Philip Gardiner, Alan McComas, Skeletal Muscle 2nd ed. Human Kinetics pubs. 2006.
- Ganong's Review of Medical Physiology, 23rd Edition (LANGE Basic Science) by Kim E. Barrett, Susan M. Barman, Scott Boitano and Heddwen Brooks (Jul 24, 2009).

Principles of Immunology

3 (2 + 1)

Objectives:

1. To understand the development, function and regulation of cells of the immune system.
2. To provide understanding of molecular and cellular basis of T cell recognition.
3. To understand relationship between structure and function of antibodies.

Introduction to immune system: Adaptive and innate immunity, cells and organs of immune system, soluble mediators of immunity, antigens, immune responses, inflammation, defenses against intracellular and extracellular pathogens, immunopathology, and vaccination.

Cells, tissues and organs of immune system: Cells of innate and adaptive immune system, lymphoid tissue and lymphocytes traffic.

Cell migration and inflammation: Mechanism and pattern of cell migration, mechanism and steps in inflammation.

Complement system: Introduction, components and importance of complement system in immune system

Antibodies: Immunoglobulins, interaction of antibodies with antigens, function of antibodies, antibodies diversity, immunoglobulins gene recombinations, somatic mutations.

T-cell receptors and major histocompatibility molecules complex: T-cells receptors, genes of T-cell antigen receptors, Major histocompatibility complex molecules (MCH), interaction of MCH molecules with antigenic peptides, interaction of T-cells receptors with MCH and antigens.

Antigen presentation: Antigen presenting cells, antigen processing and presentation, T-cell activation.

Cytokines: Cytokines and cytokines receptors families, cytokine production by T-cells subset.

Cell cooperation in antibody response: Development of B-cells, activation of B-cells by T-dependent and independent antigens.

Mononuclear phagocytes in immune defense. Concepts in immunological tolerance; immunodeficiency, hypersensitivity type 1-4; transplantation and rejection; autoimmunity. Immunological techniques.

Practicals:

1. Identification of blood cells and their functions in immunological processes.
2. Experiments in antigen-antibody interactions: precipitation reactions; haemagglutination etc.

3. Preparation of various immunogens.
4. Separation of gamma globulins by salt precipitation method
5. Demonstrations of immunoassays
6. To demonstrate the procedure of immunoblotting and immunoprecipitation.
7. To demonstrate the procedure of monoclonal antibody production.

Recommended Books:

- Goldsby, R. A., Kindt, T. J., Osborne, B. A. and Kuby, J. Immunology, W. H. Freeman and Co Ltd., London, 2006 (**Recommended Textbook**).
- Roitt, I., Brostoff, J. and Male, D. Immunology, Mosby, Edinburgh, 2005
- Kindt, T. J., Osborne, B. A. and Goldsby, R. A. Immunology, W. H. Freeman and Co Ltd., London, 2006.
- Lydyard, P. M., Whelan, A. and Fanger, M. W. Instant Notes on Immunology, Bios Scientific Publisher Ltd., 2003.

YEAR 3 SEMESTER V

Biostatistics

3 (1 + 2)

Objectives:

- To get the knowledge of statistical tools used in the data analysis of biological nature.
- To understand variations in the data and its measurement to reject or accept the hypothesis for a particular study.
- To apply various testing tools on two or multiple data sets for comparison.
- To develop the ability to determine association between two or more parameters available in a data.

Introduction: Study design, sampling theories, Variables, and Interference.

Frequency Distribution: Data and its analysis, Histogram, Frequency polygon, Ogives, Frequency curves

Measures of Central Tendency: Mean, Median, Mode.

Measures of Dispersion: Range, Mean deviation, the Semi interquartile range. Quartiles, deciles and percentiles. Variance and Standard deviation. Skewness and Kurtosis.

Probability: Dependent and Independent Discrete and continuous probability distribution, Permutations and Combinations, Binomial, Normal and Poisson distributions, Confidence interval.

Hypothesis Testing: Z – test, Student's t – test and Chi-Square test.

Relationships among Parameters: Correlation and Regression analysis, Spearman's and Pearson's correlation coefficients.

Analysis of Variance: One-way and two-way ANOVA, Tukey's HSD test, Kruskal-Wallis one-way analysis of Variance, The Friedman two-way analysis of Variance.

Practicals:

1. To find out class boundaries, marks and widths for the given data set.
2. To construct frequency distribution tables for given primary data.

3. Graphical presentation of data through frequency histogram, polygon, ogive and stem and leaf display.
4. To calculate various measures of central tendency of the given group and ungroup data.
5. To calculate measures of dispersion for the given group and ungroup data.
6. Graphical presentation of variations in data by constructing the box plot.
7. Estimation of Skewness and kurtosis from given distribution of data.
8. To construct the venn diagram.
9. To find out the probability of given event with the help of combination and permutation.
10. To solve different probability problems with the help of binomial, normal and Poisson distribution.
11. Use of z-test, t-test and χ^2 test to solve statistical problems.
12. To calculate correlation and regression from the given data.
13. Use of one way and two way ANOVA to compare data variables.
14. Use of computer in statistics (MS Excel/Minitab/SPSS).
15. Assignment/Population survey for the collection of data and its analysis.

Recommended Books:

- Bernard, Rosner. Fundamentals of Biostatistics. 7th ed; Books/Cole Cengage Learning. 2010 **(Recommended Text Book)**.
- Walpole, R. E., Myers, R. H, and Mayers, S. L. Probability and Statistics for Engineers and Scientists. 9th Ed; Prentice Hall International. New Jersey. 2011.
- Anthony J. Hayter. Probability and Statistics for Engineers and Scientists. 4th eds; Cengage Learning. 2010.
- Daniell, W. W. Biostatistics: A foundation for analysis in the Health Sciences, 5th ed; John Wiley and Sons. 1991.
- Dawson-Saunders, B. and Trapp, R. G. Basic and Clinical Biostatistics. Prentice Hall International, 1990. New Jersey.
- Towened, J. Practical Statistics for Environmental and Biological Scientists. John Wiley and Sons, 2003.
- Wardlaw, A. C. Practical Statistics for Experimental Biologists. 2nd ed; John Wiley and Sons. 2000.
- Feinstein, A. R. Principles of Medical Statistics. Chapman and Hall. 2002.
- Weiss, N. A. Introductory Statistics. 4th ed. Addison Wesley Publishing Company Inc. 1995.

Neurophysiology

4 (3 + 1)

Objectives:

- To inculcate understanding the role of neuron as a functional unit in neural activities.
- To provide understanding of electrical transmission and their pathways in spinal cord and brain.

- To develop ability of understanding the communication between and within the neuron along with cable and threshold properties with the help of analogous models.
- To provide understanding of the transduction of signals at receptor level and adaptation in receptors.
- To give understanding of various levels of brain with respect to their individual role in motor control and their integration for somatic, vegetative and behavioral activities.

Introduction: Introduction to Neurophysiology

Neural functions and Pathways: Anatomical and Physiological methods for identification of neuronal functions and their pathways.

Communication within neurons: Flow of electrical currents along nerves and in electrical analog models of nerve cell membrane, cyclic regeneration of action potential. Dependence of membrane potential on ionic permeability, dependence of ionic permeability on membrane potentials. Nerve conduction velocity, classification of nerves, Compound action potential. Threshold properties, Refractory period, accommodation, all or none law, neural codes, initiation of impulse.

Communication between neurons: Electrical transmission, Types of channels and their characteristics (EPSP, IPSP), Convergence and divergence theory; Receptor potential and transduction in paccinian corpuscles. Receptor adaptation and its function. Ascending pathways and analgesia system.

Local Motor Control: Motor Neurons, descending pathways, Sensory feedback from muscles; spindle reflexes, the servo hypothesis.

Control of Posture: The importance of Support, Role of Brain Stem, Vestibular and visual contribution to posture, Vestibular and visual interaction. Decerebrate rigidity, Clasp knife reaction, neck reflexes, posture as a whole

Higher functions: cerebral cortex; Integration between sensory, motor, parietal, temporal and occipital cortices.

Global Motor Control: Motor cortex, corticospinal concept, Input and Output Circuits in Cerebellum, Cerebellar connections and functions.

Basal ganglia: Functions and clinical conditions.

Physiology of Autonomic Nervous System: Sympathetic and parasympathetic control, Autonomic reflexes. Neurotransmitters, Types; Cholinergic and Adrenergic Receptors, Denervation hypersensitivity.

Recognition and Memory: Types of learning, central circuits of learning, Role of cerebellum in learning. Types and mechanism of memory.

Hypothalamus and limbic system: Physiological role of hypothalamus, Motivation, Emotion, Sleep and cortical arousal, EEG and its clinical use, Limbic system, role of amygdala and Hippocampus.

Speech and language: Sensory and motor control. Aphasia, dysphasia.

Practicals:

1. To calculate the conduction velocity of sciatic nerve in frog by the help of recorded twitches on kymograph/power lab.
2. Demonstration of various tendon reflexes in human being.
3. Demonstration of various common (daily use) examples for the understanding of spinal reflexes in human subjects.

4. Demonstration of the principle and use of oscilloscope in various neurophysiological studies.
5. Recording of extracellular action potential from Frog/Uromastix sciatic nerve on physiograph by using extracellular electrodes.
6. To observe the neurophysiological influence of vagus nerve on heart activity (Uromastix/Rabbit/Frog).
7. Elicitation of spinal reflexes in Frog.
8. Effect of strychnine on spinal reflexes in Frog.
9. Effect of acid treatment to observe withdrawal reflexes in Frog.
10. Demonstration of the recording of an action potential from sciatic nerve bundle by using intracellular glass capillary microelectrode.
11. Demonstration of somatic sensations; touch, pressure, pain, temperature

Recommended Books:

- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology. 12th ed; W. B Saunders Co. 2010 (**Recommended Textbook**).
- Carpenter, R. H. S. Neurophysiology. 4th ed; Oxford University Press, Oxford. 2002.
- Jessel, K.S. Principles of Neural Science, 4th ed; McGraw-Hill, 2000.
- West, J. B. Best and Taylor's Physiological Basis of Medical Practice. 12th ed; 1991.
- Constance Hammond. Cellular and Molecular Neurophysiology, Third Edition [Hardcover]. Elsevier. 2008.
- Eric Kandel, James Schwartz and Thomas Jessell. Principles of Neural Science. 4th ed; 2000.

Pulmonary Physiology Objectives:

3 (2 + 1)

- To understand the role of respiratory passages in conditioning of air, speech and resonance.
- To understand the mechanism of respiration.
- To understand the exchange and transport of respiratory gases
- To understand the nervous and chemical/humoral regulation of respiration.

Introduction: Anatomical and physical relationship, lung volumes and capacities.

Functions of Respiratory Passages: Air-conditioning, speech and resonance,

Respiratory Mechanism: Muscles of respiration, pressure, compliance and elasticity. Surface tension, surfactants. Work of breathing. Ventilation-Perfusion Relationship: Oxygen transport from air to tissue, Hypo and Hyperventilation, Respiratory quotient. Ventilation-perfusion ratio.

Respiratory Pigments: Hemoglobin, hemerythrin, chlorocrouirin.

Transport of Respiratory Gases: Henry's law, Dalton's law, oxygen and carbon dioxide dissociation curves and factors affecting, Bohr and Haldane effect, Hypoxia, hypercapnia, cyanosis.

Acid-Base Status: Respiratory and metabolic, acidosis and Alkalosis.

Control of Respiration: Nervous and Chemical/humoral control during normal quiet breathing and stress.

Practicals:

1. To record and relate the changes in circumference of chest (normal and maximal breathing) with activity of respiratory muscles.
2. To obtain a graphical record of normal respiration.
3. To study the effect of exercise on respiration.
4. To observe the effect of deglutition on respiration.
5. To observe the effect of rebreathing of expired air on respiratory rate.
6. To observe the effect of voluntary apnea on normal respiration.
7. To observe the effect of mental stress on respiration.
8. To measure/calculate the lung volumes and capacities by spirometer/vitalograph
9. To determine the oxygen consumption of cockroach per hour by potometer.
10. To determine respiratory gases in expired air by Douglas Bag method

Recommended Books:

- Guyton, A. C. and Hall, J. E. Text book of Medical Physiology. 12th ed. W. B. Saunders, 2005. **(Recommended Textbook).**
- West, J. B. Respiratory Physiology; The essentials, 7th ed., Williams and Wilkins, London, 2005.
- Davis, A. The Respiratory System, Basic Science and Clinical conditions. Churchill Livingstone, London. 2003.
- Levitzky, M. G. Pulmonary physiology, 6th ed., McGraw-Hill, New York, 2003.
- Leff, L. A. and Schumacker, P. T. Respiratory Physiology, Basic and Application. W. B. Saunders Company, London, 1993.
- Stuch, N. C. Basic Respiratory Physiology. Churchill Livingstone, London, 1991.
- Mines, A. H. Respiratory Physiology. 2nd ed., Raven Press, New York, 1986.

Renal Physiology

3 (2 + 1)

Objectives:

- To understand the filtration function of glomerulus and its relationship with renal blood flow.
- To understand the mechanism of early and late filtrate processing.
- To know the mechanism for the formation of dilute and concentrated urine.
- To understand the endocrine function of kidney.
- To interpret the renal function tests in health and disease.

Introduction: Structural and functional characteristics of nephrons.

Fluid Dynamics: Filtration process, Glomerular filtrate, composition and factors affecting filtration function.

Renal Blood Flow and Glomerular filtration Rate: Control and regulation of flow rate. Tubuloglomerular feedback.

Renal Clearance: Para-amino hippuric acid and Inulin based estimation of Glomerular filtration rate and renal blood flow.

Renal Tubular Functions: Reabsorption and secretion in the proximal tubule, Loop of Henle, Juxtaglomerular apparatus, distal tubules, Collecting ducts, mechanisms of dilution and concentration of urine (Counter-current system and role of vasa recta).

Renal Regulation: Body fluids Osmolarity, Volume, pH, and electrolytes. Respiratory and metabolic acidosis/alkalosis.

Dialysis: Principle, basic mechanism.

Practicals:

1. To study various procedures for collection and preservation of urine specimens for urinalysis.
2. To determine the physical and chemical properties of urine.
3. Spectrophotometric examination of the urine sample (Ascorbic acid, Iron, Glucose, Uric acid, Proteins).
4. To determine blood urea and creatinine.
5. To observe the effects of diuretics on urinary volume and pH in animal models.
6. Determination of threshold time for micturition using diuretics on animal model.
7. Microscopic examination of urinary sediments.
8. Preparation of slide to study the animal kidney histology.

Recommended Books:

- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology. 12th ed. W. B. Saunders. 2005. **(Recommended Textbook)**.
- Vander's Renal Physiology (LANGE Physiology Series) by Douglas Eaton, John Pooler and Arthur J. Vander. 2002.
- Lote, C. J. Principles of Renal Physiology, 3rd ed., Chapman and Hall, London, 1994.
- Berliner, C. W. and Giebisch, G. H. Renal Physiology. American Physiological Society, Bethesda. 1987.
- Valtin, H. Renal Function: Mechanisms Preserving Fluid and Solute Balance in Health. Little Brown and Company, Boston, 1973.
- Pitts, R. F. Physiology of Kidney and Body Fluids, An Introductory Text. Year Book Medical Publisher, Chicago. 1964.

Gastrointestinal Physiology

3 (2 + 1)

Objectives:

- To understand the organization of gastrointestinal system with respect to its functions.
- To understand the role of liver, gall bladder and pancreas in digestion.
- To provide understanding of different segments of GIT with respect to processing of food, digestion, absorption and excretion.
- To understand the physiological mechanism of secretions, regulation of secretions, movements in GIT and reflexes.

Introduction: General organization of GIT, enteric nervous system, autonomic supply, chemical mediators.

Mouth: Anatomy, mastication. Structure and function of salivary glands, composition and regulation of salivary secretions.

Esophagus: Esophageal secretions, esophageal peristalsis, swallowing, lower sphincter control.

Stomach: Structure and innervation, gastric glands and their secretions, composition and regulation of gastric secretions and motility.

Pancreas: Functional anatomy, composition, mechanism and regulation of pancreatic secretion, cellular mechanism of secretion, cholecystokinin and acetylcholine as pancreatic exocrine secretion mediators.

Liver and Gall Bladder: Structure and function, composition of bile. Mechanism and control of bile secretion. Transport and storage of Bile. Enterohepatic circulation. Gall stone formation.

Small Intestine: Epithelial cells, intestinal glands. Motility and intestinal reflex.

Assimilation: Digestion and absorption of Carbohydrates, Proteins, Fats, Iron and Electrolytes.

Large Intestine: Structure and motility. Electrolyte transport. Microflora. Defecation reflex.

Gastroenteropancreatic Hormones; Gastric, pancreatic, duodenal hormones and their roles in digestion

Practicals:

1. To observe the digestive organs in a dissected animal model (Frog, Uromastix, Rabbit)
2. To study the histology of digestive organs by slides and charts.
3. To determine the composition and normal physical and chemical properties of saliva.
4. To study the effect of enzyme concentration on enzyme activity by arbitrary method.
5. To study the effect of temperature, ionic concentration, pH and substrate concentration on enzyme activity.
6. To determine the effect of boiling on salivary amylase.
7. To observe the protein digestion by the action of pepsin.
8. To observe the effect of Renin on milk protein.
9. To observe the effect of Pancreatin on carbohydrate, protein and fat digestion.
10. To study the action of Bile on fat digestion.

Recommended Books:

- Guyton, A. C. and Hall, J. E. Text book of Medical Physiology. 12th ed. W. B Saunder. 2005. (**Recommended Textbook**).
- Leonard R. Johnson, Fayez K. Ghishan, Jonathan D. Kaunitz and Juanita L. Merchant. Physiology of the Gastrointestinal Tract, Two Volume Set, 5th ed; Academic Press. 2012.
- Johnson, L. R. and Gerwin, T. A. Gastrointestinal Physiology. Mosby Inc., 2001
- Kim E. Barrett, Fayez K. Ghishan, Juanita L. Merchant and Hamid M. Said. Physiology of the Gastrointestinal Tract, 4th ed; (v. 1-2). Elsevier. 2006.
- Sanford P. A. Digestive System Physiology, Edward Arnold. 1992.
- Moffett, D. F. and Moffett, S. B. Human Physiology Foundations and Frontiers; Mosby Company, 1993.

SEMESTER VI

Human and Animal Behavior Objectives

3 (2 + 1)

- To understand basic knowledge about behavior, behavioral theories and concepts
- To compare and contrast human versus animal behavior
- To integrate behavioral biology with nervous system and related organ systems.
- To understand basic mechanism of learning memory, sleep and emotions.

Introduction: Understanding Behavior, instinct, learning and memory. Natural Selection and Evolution in development of Behavior

Ingestive Behavior: Drinking: The Nature of Physiological Regulatory Mechanisms; Drinking and Salt Appetite; Brain Mechanisms of Thirst and Salt Appetite; Mechanisms of Satiety.

Learning and Memory: Basic Mechanisms: The Nature of Learning; Learning and Synaptic Plasticity; Perceptual Learning; Classical Conditioning; Instrumental Conditioning and Motor Learning.

Relational Learning and Amnesia: Human Anterograde Amnesia; Relational Learning in Laboratory Animals.

Sleep and Biological Rhythms: A Physiological and Behavioral Description; Why Do We Sleep; Physiological Mechanisms of Sleep and Waking; Disorders of Sleep; Biological Clocks, clock genes and zeitgebers

Reproduction Behavior: Sexual Development; Hormonal Control of Sexual Behavior; Neural Control of Sexual Behavior; Parental Behavior.

Social Organization: Social behavior in animals, mating, fighting, parenting, signaling, social relationship and organization; dominance, territoriality, development of sexes and types, theories of sexual selection and mate choice, mating systems, monogamy, polygamy and polygyny; parental care, social organization and kinship; cooperation; altruism; coalition; optimal foraging theory, foraging alone and in groups.

Emotion: Emotions as Response Patterns; Expression and Recognition of Emotions; Feelings of Emotions; Aggressive Behavior.

Human Communication: Speech Production and Comprehension: Brain Mechanisms; Disorders of Speech, Reading and Writing.

Behavioral disorders in human: Anxiety, depression

Physiology of Addiction: Drugs of abuse, addiction, smoking, alcoholism etc.

Practicals:

1. Field study of bird and mammalian behavior through visits to aviaries and zoos, nesting behavior of birds, through binoculars
2. Study of feeding and drinking behavior and social behavior in animal models
3. Basic animal models to show learning through study on snails and pigeons
4. To study reproductive and mating behavior in rats or related animals
5. To demonstrate aggression, fear and related behaviors through monkeys
6. Preparation of ethograms and presentation of data
7. Study of sleep in small animals, rats, mice and cats

8. Study of basic human emotions like fear, aggression, hate, attentiveness through questionnaires and observations.
9. Study of human facial expressions and postures in different conditions like sadness and happiness.
10. Recordings of human speech and other means of communications.
11. Study of behavioral disorders like stress, depression, anxiety and rage.

Recommended Books:

- Dugatkin, L. A. 2004. Principles of animal behavior. 1st ed. W. W. Norton & Co. Inc. **(Recommended Textbook)**
- Neil, R. Physiology of Behavior. Allyn and Bacon. 2000.
- Adkins-Regan, E. 2005. Hormones and animal social behavior. Princeton University Press.
- John Alcock. 2010. Animal behavior, an evolutionary approach. 9th Edition. Sinauer Publishers.
- Scott, G. 2009. Essential Animal Behavior. Wiley publishers.
- Drickamer, L. C; Vessey, S. H; Jakob, E. M. 2002. Animal behavior: mechanisms, ecology, evolution. 5th ed. McGraw-Hill Higher Education.
- Sherman, P. W; Alcock, J. (Editors). 2001. Exploring animal behavior. 3rd ed.
- Sinauer Associates, Inc. Huntingford, F. 1984. The study of animal behavior. Chapman and Hall.

Endocrinology

4 (3 + 1)

Objectives:

- To understand the synthesis, secretion and function of hormones.
- To understand the mechanism of action of hormone on target tissue.
- To explain the biosynthesis, actions and regulation of secretion of hormones of pituitary, thyroid, parathyroid, pancreas, adrenal cortex, adrenal medulla, gonadal hormones.
- To understand the function of hormones secreted from non-endocrine organs.

Introduction: Endocrine Glands, Functional anatomy of different endocrine glands, General account of chemical nature and biosynthesis of hormones, Transport of hormones to the site of action

Mechanism of Hormone Action: Hormonal signaling and its role in coordination of molecular, cellular and tissue functions; conceptual account of different types of signaling and transductions,

Hormone Functions: physiological actions of the hormones of hypothalamus, pituitary, thyroid, parathyroid, endocrine pancreas, adrenal cortex, adrenal medulla, gonads, corpus luteum, pineal, thymus. Endocrine secretions of heart, kidney and adipose tissue.

Invertebrate hormones. Hormones involved in molting and metamorphosis.

Control of Hormonal Secretion: Negative and positive feedback regulation.

Practicals:

1. To demonstrate the position of various endocrine glands

2. Experiments to reveal the roles of endocrine glands and their hormones in physiological functions
3. The effect of insulin on glycemic level.
4. To determine the random and fasting blood glucose level.
5. To perform oral glucose tolerance test in human/animals.
6. To determine the effect of cortisol on biochemical parameters (glucose/protein)
7. To determine the effect of MSH on skin pigmentation.

Recommended Books:

- Greenspan, F. S. and Strewler, G. J. Basic and Clinical Endocrinology. Prentice-Hall, New York, 2004. **(Recommended Textbook)**.
- Guyton, A. C. and Hall, J. E. Textbook of Medical Physiology. 12th ed. W. B. Saunders, 2005.
- Molina, P. E. Endocrine Physiology. McGraw-Hill, Boston, 2003.
- Kacsoh, B.. Endocrine Physiology. McGraw-Hill, Boston. 2000.
- Wilson, J. D., Foster, D. W., Larsen, P. R and Kronenberg, H. Williams Textbook of Endocrinology. W. B. Saunders, Philadelphia. 2002.
- Ganong, W. F. Review of Medical Physiology. 24th ed. McGraw-Hill. 2005.
- Gerald D. Tharp, David A. Woodman Experiments in physiology. 10th Edition.

Reproductive Physiology

4 (3 + 1)

Objectives:

- To know the hypothalamic control and role of FSH and LH in relations of gonadal hormones.
- To understand the stages of spermatogenesis and functions of testosterone.
- To know the phases of ovarian and uterine cycles and their correlation.
- To understand the process of fertilization, Implantation, placental function,
- To understand the process of parturition and lactation.

Introduction: Gender; identity and sexuality, role of gonadotrophic hormones in puberty and maturation of hypothalamic-pituitary gonadal axis. Reproductive states in aging.

Male Reproductive System: Hormones of testis their functions, spermatogenesis and their hormonal regulation.

Female Reproductive System: Hormones of the ovaries; Ovarian cycle, endometrial cycle; Amenorrhea, dysmenorrhea, post menopausal syndrome.

Pregnancy, Parturition and Lactation: Coitus and fertilization, Implantation, Maternal recognition of pregnancy, response and maintenance. Placental functions, Development of breast and lactation, stages of parturition.

Regulation of Reproductive hormones: Testosterone, estrogen, progesterone, HCG, somatomammotropin, oxytocin, prolactin etc.

Fertility and infertility: Azospermia, Oligospermia, impotency. polycystic ovaries, Hormonal deficiency.

Practicals:

1. To study the histology of male and female reproductive organs with the help of models/3D animation/slides.

2. Study of female reproductive cycle through vaginal smear in mice.
3. To observe the morphology of spermatogenic cells in testicular tissue.
4. To observe the motility of sperms.
5. To study different stages of the estrous cycle.
6. The study the Influence of gonadectomy on the target tissue in animal model.
7. To perform pregnancy test through strip method in urine.
8. To determine the metabolic pattern (BMR, BBT) in different stages of menstrual /estrous cycle.

Recommended Books:

- Greenspan, F. S. and Strewler, G. J. Basic and Clinical Endocrinology. Prentice-Hall, New York. 2001. **(Recommended Textbook)**
- Knobil, I. and Neill, J. The Physiology of Reproduction. Raven Press, New York, 2005.
- Molina, P. E. Endocrine Physiology. McGraw-Hill, Boston, 2003.
- Wilson, J. D., Foster, D. W., Larsen, PR and Kronenberg, H. Williams Textbook of Endocrinology. W. B. Saunders, Philadelphia, 2002.
- Kacsoh, B. Endocrine Physiology. McGraw-Hill, Boston. 2000.

Physiology of Sensory System

3 (2 + 1)

Objectives:

- To provide understanding of various sensory apparatus, their location, structure and functions.
- To inculcate the understanding of various sensory modalities their transduction, transmission and sensations.
- To understand the pathways for the transmission of sensory signals from sense organs towards brain with respect to excitation and inhibition.
- To study molecular mechanisms in generation of receptor potentials.

Introduction: Receptors and sensations, sensory coding, transduction, types of receptors, mechanism of sensory adaptation, somatic and special senses.

Somatic Sensations: Pain; types, receptors, transmission of signal to CNS and causes of pain, Headache and thermal sensations.

Tactile Sensation: Sensory modalities, types of receptors and central projections, neural responses from smaller afferents, receptive fields, lateral inhibition, central responses.

Proprioception: Muscle spindle; Golgi tendon organ, ultra structure and function, vestibular apparatus; ultra-structure and function.

Gustation: Primary sensations of taste, threshold for tastes, taste buds and their functions, transmission of taste signals, transduction mechanism and taste preference.

Olfaction: Olfactory cells; structure, mechanism of excitation and adaptation, central olfactory projections and psychophysics of smell, transduction mechanisms and olfactory pathway.

Visual System: Optics of vision: Physical principles of optics; refraction of light and application of refractive principles to lenses, optics of eye; mechanism of accommodation, image formation. Eye, photoreceptor and neural function of retina; photochemistry of vision and color vision mechanisms of adaptation and visual acuity

and factors affecting visual acuity, visual pathways; function of lateral geniculate nucleus and visual cortex, fields of vision and eye movements and their control, visual localization and, autonomic control of accommodation and pupillary aperture.

Auditory System: Structure of ear (external, middle and internal), nature of sound and sound spectra, Fourier analysis by cochlea and responses from auditory fibers, spatial localization of sound and determination of loudness, Impedance matching, functional organization of central auditory pathways.

Practicals:

1. Study of pupillary, cutaneous and kinaesthetic reflexes in human.
2. Determination of visual acuity of human subject by using Snellen's and Jagger's eyes chart.
3. Determination of visual field by perimetry.
4. To assess the colour vision by wooltest and Ishihara chart.
5. To locate Gustoreceptors present on human tongue by using chemical methods.
6. Determination of hearing ability of human subject by using air conduction, bone conduction and sound perception methods.
7. To observe various physiological phenomenon's related with the focusing of light on the retina of human eye in a simulated model.
8. Locate and plot the boundary of the blind spot of eye using the computer-simulated program.
9. To distinguish the different odors by examining various samples.
10. Experiments related to sensory adaptations.

Recommended Books:

- Guyton, A. C. and Hall, J. E Textbook of Medical Physiology. W. B. Saunders Co., 2005. **(Recommended Textbook).**
- Carpenter, R. H. S. Neurophysiology, Oxford University Press, 2000.
- Ganong. Review of Medical Physiology
- Berne, R. M. and Levy, M. N. Physiology. Mosby Yearbook, 1992.

YEAR 4

SEMESTER VII

Physiology of Health, Fitness and Exercise

3 (2 + 1)

Objectives

- To understand the importance of exercise and balanced nutrition.
- To correlate exercise with energy production and consumption.
- To understand the effect of exercise in different physiological conditions.

Introduction: The basis of human performance, macro and micronutrients.

Bioenergetics: Biological energy transformation, Mechanisms of energy transfers in body during rest and exercise, energy expenditure during walking, jogging, running and swimming, individual differences in energy requirements;

Energy Metabolism: Rest-to-exercise transition, metabolic responses, factors governing fuel selection.

Regulations during Exercise: Respiration and acid base balance, Circulatory, muscular and endocrine adaptation. Temperature regulation.

Energy Enhancement: Training for anaerobic and aerobic power, muscle strength and training; Special aids for training to enhance performance. Exercise performance and environmental stress. Exercise at high altitude, thermal stress, stress in diving and microgravity. Effects of overweight and obesity on performance, weight control.

Practicals:

1. Epidemiological surveys related to pattern of health and disease
2. Designing exercise and nutrition program.
3. Experiments to evaluate cardiorespiratory fitness.
4. Health estimation parameters in; games, strenuous exercise, climbing, swimming and jogging.
5. To measure body mass index.

Recommended Books:

- McArdle, W. D., Katch, F. I. and Katch, V. L. Exercise Physiology: Energy, Nutrition and Human Performance. Lippincott Williams and Wilkins, Baltimore. 2001. **(Recommended Textbook).**
- Powers, S. K. and Howley, E. T. Theory and applications to fitness and Performance. Brown and Benchmark. 1997.

Ergonomics

3(2+1)

Objectives

- To understand the relationship between physiology, human factor and ergonomics.
- To learn the design and ergonomics relationship using examples of various models in different work condition.
- To understand the concept of occupational health and safety in terms of ergonomics.

Introduction and concepts: Multidisciplinary nature of ergonomics, History of ergonomics.

Human factor and physiology in ergonomics:

Energy, the fuel of work; Work as output of skeletal-muscular activity; limitations of a function and emergence of health problems.

Occupational workstation Injuries/diseases: Repetitive work at workstation and injuries; common injuries/diseases. Loss of work output and remedial strategy.

Occupational workstation design and work efficiency interactions: Workstation, Sitting work design, Standing work design, Hand tools and their control design and Heavy physical work in Repetitive Strain Injury (RSI) development; Physiological indices in RSI; Modification in design.

Ergonomics in action (A few models): Computer workstation: Setting up of station, Keyboard trays, Selecting chairs, Ergonomics tips for users, Operator's risk factors. Industrial production workstation: Identity of repetitive work RSIs; Physiological stresses and effects on work output.

Role of Health & Safety Representative: Awareness of workers to workplace RSIs; Workers' information on ergonomics issues; Administrative awareness to ergonomical issues.

Practicals:

1. Making hazard data sheets of repetitive work in University laboratory and any other work site.
2. Identifying problems and developing solutions to ergonomic problems.
3. Data collection on physiological targets in heavy physical workstations.
4. Preparation of job design check-lists and workers' work behavior.
5. Study of Cumulative Trauma Disorder/Injury e.g. in garment industry.
6. Evaluation risk factors for different jobs.

Recommended Books:

- Introduction to Ergonomics. 1995. 1st ed. Bridger, R. S. McGraw-Hill Higher Education, New York, USA. **(Recommended Text Book)**.
- Ergonomics (How to design for ease and efficiency). 2000. 1st ed. Kroemer, K. H. E., Kroemer, H. B. and Kroemer-Elbert, K. E. Prentice Hall International Inc. London, UK.

Electrophysiology

3(2 + 1)

Objectives:

- To understand the basis of electrical activity produced in human body.
- To provide the knowledge of equipment's used in electrical recordings.
- To provide an understanding of various methods required for electrical recordings; by using different types of excitable tissues/cells.

Introduction: Concepts of Electricity: electric charge, electric field, electric current & Ohm's law, direct, alternating, and pulsed current.

Physiology of Excitable Cells: Passive Electrical Properties of Membranes: Resistance & Capacitance. Action Potentials: generation, propagation, stimulation by depolarizing agents, perfusion and gating. Voltage Clamp: rationale and methods, separation of currents, conductance changes, reconstruction of the action potential. Effect of Fiber Geometry: cable properties of elongated cells, determinants of conduction velocity, velocity vs. diameter, extra-cellular stimulation and recording.

Voltage Gated Channels: Na Channels: pore and selectivity, pharmacology of Na channels, gating in Na channels, the Na channel protein. Ca Channels: gating and action potentials, selectivity and block. K Channels: diversity in gating, conductance, selectivity, and block.

Receptor Mechanism: Receptors as transducers, Differential sensitivity of receptors, properties of generator potentials in different receptors, site and generation of action potential. Receptor adaptation, spike discharge, Intensity-frequency relationship and information coding mechanism of repetitive firing, Discharge of tonic & phasic receptors.

Instrumentation: Characteristics and Components of Electrotherapeutic Stimulation Systems: signal generator, types of stimulators, stimulation electrodes (placement,

orientation, size and shape). Characteristics and Components of devices used in electrophysiology: extra-cellular recording technique, surface and subcutaneous electrodes.

Electrical Stimulation of Muscles; Technique and applications: Muscle Plasticity in response to Electrical Stimulation, Instrumentation for Neuromuscular Electrical Stimulation (NMES), NMES to augment Strength and Endurance, Functional Neuromuscular Electrical Stimulation, Precautions and Contraindication for NMES

Electromyography: Introduction, Nerve Stimulation Unit, Nerve Stimulation Studies; definitions of terms, procedures, sensory, latency, H-reflex, F-wave M response, NMJ studies. Needle electromyography: technique, sites for testing, normal and abnormal potentials. Electro diagnosis: technique, normal and abnormal potentials, artifacts and source of errors.

Electroencephalography: Physiological basis of EEG, Technical requirement for EEG and its basic, Normal EEG pattern, Activation method, Spikes and sharp waves, slow activity, cerebral death studies, neonatal EEG

Polysomnography: Physiological basis of sleep & sleep disorders, Technical aspects and Interpretation of polysomnography.

Practicals:

1. To record resting membrane potential from isolated animal muscle or nerve fiber using glass capillary microelectrode on oscilloscope or power lab.
2. To understand the biophysical & cable properties of membrane using its electrical model through multimedia presentation.
3. To record action potential using extracellular electrodes from an isolated sciatic nerve of frog/rabbit/Uromastix using chart recorder or power lab.
4. To demonstrate the use of voltage clamp technique, its main equipment, and accessories using multimedia presentation.
5. To record the sodium and potassium currents using respective channel blockers (tetrodotoxin & tetra ethyl ammonium ions) through Voltage clamp technique in an electrophysiology lab or through multimedia presentation.
6. To explain the types of micropipette and their use in voltage clamping and recordings of electrical potentials from individual ionic channels, use of channel blockers; in electrophysiology lab or through multimedia presentation.
7. To understand the differences between fast adapting (Paccinian Corpuscle) and slow adapting (Muscle Spindle) receptors using multimedia presentation.
8. To demonstrate the use of electrotherapeutic stimulation devices in physiotherapy in an electrotherapy lab or through multimedia presentation.
9. To demonstrate the use of NMES devices for the recording of nerve conduction velocities, H-reflex, F-wave, M-response and electromyography (surface/needle) in a neurology laboratory.
10. To demonstrate the use of electroencephalograph for the recording of various EEG waves and their clinical importance/application with respect to sleep studies.

Recommended Books:

- Clinical Electrophysiology, Lynn Synder & Andrew J. Robbins, Williams & Wilkins, 1989. **(Recommended Textbook)**.
- Manual of Electroneuromyography, (2nd ed.), Hyman L. & Joel Brumlik, Harper & Row, 1976
- Practical Electromyography, (2nd Ed.), Ernest W. Johnson, Williams & Wilkins, 1988
- Textbook of Physiology: Excitable Cells & Neurophysiology (21st ed.), Patton, Fuchs, Hille, Scher, Steiner, W.B Saunders, 1989
- Textbook of Medical Physiology, (10th ed.), C. Guyton & J. E. Hall, W. B Saunders, 2000

Research Methodology

3 (2 + 1)

Objectives:

- To guide the students in obtaining necessary knowledge about the aspects of research.
- To guide the students in acquiring an understanding of the utilization of the resources available for Research Projects.
- To guide the students in deciding upon the topic for his/her culminating experience.

Introduction: Research profession, Understanding the research process, aims of research, the research topic, title and research problem, literature search, research design, Search, retrieve, manage information, Plagiarism and its professional consequences.

Study design: Epidemiological studies, choosing an appropriate epidemiologic approach to investigate a problem, Sample size, population and sampling types, data-collection and measuring instruments in quantitative research, types of quantitative research designs.

Statistical Analysis: Approaches for data analysis, Parametric, non-parametric and semi-parametric methods, Qualitative Methodologies and interpretation of results, validity of conclusions.

Project Report Writing: The research proposal, Community Research, Aboriginal Research, and Clinical Trials. Conflicts of interest, Principles of presentation, Communication-oral, posters, abstract and manuscript preparation, communicating your own credentials and CV writing,

Writing Grant Proposal: Development of using the grant format of national and international agencies.

Practicals:

1. Exercises on how to write abstract or summary after reading article.
2. Exercises to write result and discussion section by using data from different articles.

3. Introduction to spreadsheet application, formulas and functions, Data storing, Features for Statistical data analysis, Generating charts/graph and other features.
4. Exercise and observation of different design data procedures.
5. Development of fundamental skills in the use of bibliographic software like EndNote etc.
6. Acquire fundamental skills in the use of a Statistical Analysis Software like SPSS.
7. Introduction to presentation tool, features and functions, Creating presentation, Customizing presentation, showing presentation.
8. Web Search through advanced search techniques.

Recommended Books:

- Baumgartner, T. and Hensley, L. Conducting and Reading Research in Health and Human Performance 4th ed McGraw-Hill, New York, 2006. **(Recommended Textbook).**
- Handbook of Health Research Methods (2005), by Ann Bowling and Shah Ebrahim Open University Press, Two Penn Plaza, New York, NY.
- Qualitative Research and Evaluation Methods 3rd ed (2002), by M. Patton, Sage Publications Inc., Thousand Oakes, CA
- Community-Based Participatory Research for Health (2003), by M. Minkler and N. Walderstein, Josey Boss, San Francisco, CA
- Hully, S., Cummings, S., Browner, W., Grady, D., Hearst, N. and Neuman, T. Designing Clinical Research, 2nd ed; Lippincott Williams and Wilkins, Philadelphia, 2001.

Pathophysiology Objectives

4(3 + 1)

- To understand the physiological basis of different pathological disorders.

Introduction: Basic concepts of pathophysiology. Phenomena of alterations in human physiologic function and the resulting human response. Molecular basis of Pathophysiology. The disease process.

Disorders of Blood: Red and White Blood Cells Disorders, Disorders of Coagulation. Disorders of, Inflammation and the Immune Response, Hypersensitivity Disorders and Immune Deficiencies.

Cardiovascular Disorders: An overview on ischemic, valvular and congenital disorders. Hypertension and cardiac failure and shock.

Gastrointestinal Disorders: Disorders of GIT motility: diarrhea, constipation, intestinal obstruction, irritable bowel syndrome. Peptic ulcer disease. Vomiting & nausea.

Disorders of liver & gall bladder: Hepatitis, gallstones, jaundice, cirrhosis.

Respiratory Disorders : Obstructive and restrictive lung diseases.

Renal Disorders: Urinary tract infections, renal calculi. Renal failure, glomerulonephritis, nephrotic syndrome.

Musculoskeletal Disorders: Muscular dystrophies, kyphosis, scoliosis.

Nervous Disorders: Functional abnormalities of higher nervous system. Headache, migraine and sleep disorders. Cerebrovascular accidents and paralysis.

Skin Disorders: Dermatitis, eczema, acne, keratosis, vitiligo, skin burns.

Practicals:

1. An overview of collection, handling and preservation of pathological samples.
2. Comparison of health and disease states of different body tissues and organs with the help of slides or charts.
3. Liver function test of pathological samples.
4. Renal function test for pathological sample.
5. Detection of abnormal constituents of Urine.
6. To determine (quantitative) blood urea nitrogen in the provided pathological sample for the detection of Uremia.
7. To understand X-ray, MRI, ultrasonographic reports.

Recommended Books:

- Robbins Basic Pathology. 7th Ed., Vinay Kumar, Ramzi's Cotran, Stanley L Robbins. W. B Saunders USA, 2003. **(Recommended Textbook)**.
- Essentials of Pathophysiology. 3rd edition. Carol Porth, Kathryn J., Gaspard and Kim A., RN Noble. Lippincott.
- Review of Medical Physiology 22nd Ed., William F. Ganong. Mc Graw-Hill. USA. 2005
- General and Systemic Pathology. 2nd ed., J. C. E. Underwood. Churchill Livingstone UK.1998.
- Cecil Essential of Medicine. 6th ed., Thomas A. Andreoli, Charles C. J. Carpenter, Robber C. Griggs, Joseph Loscalzo. Saunders NOIDA U.P. 2004
- Davidson's Principles and Practice of Medicine.18th Ed., Christopher Haslett, Edwin R. Chilvers, John A. A. Hunter, Nicholas A. Boon. Churchill Livingstone Press. UK. 2001.

SEMESTER VIII

Biotechnology Objectives

3 (2 + 1)

- To provide basic concepts about biotechnology.
- To give information about recombinant DNA technology in health and disease.
- To provide an understanding of cell and organ culture techniques.
- To provide knowledge of the use of biotechnological techniques for remedial measures regarding various diseases.
- To provide information about gene knock-outs, transgenic and therapeutic biotechnology.

Introduction: Overview of principles of biochemical, biophysical, rDNA technology techniques etc. at molecular, cellular, tissue and organ levels in understanding the physiological mechanisms.

Recombinant Technology: Preparation of plasmids, cosmids. Cloning and its use in the industrial production of hormones and bioactive compounds, such as: insulin, growth hormone, interferons etc.

Bioinformatics: Use of bioinformatics and protein data bases and genomic sequences in understanding of signal proteins in various physiological diseases, mutant strain of neurofibromatosis (NF1), protein tyrosine phosphatase 1B (PTP-1B) overexpression role in insulin resistance of type 2 diabetes. The use of biotechnology, in phylogenetic relationship.

Tissue culture: Concepts of animal tissue cultures, embryonic stem cell culture, whole organ culture.

Biotechnology application in impaired fertility: Superovulation, intra cytoplasmic sperm injection, in vitro fertilization, nuclear transfer techniques.

Gene therapy: concepts of gene therapy and its applications in disease states, such cystic fibrosis. Generation of transgenic and knock out models.

Significance of ethics in the discipline of biotechnology. Animal rights and ethics for the use of experimental animals in physiological research.

Practicals:

1. Preparation of bacterial and cell culture media.
2. To perform primary and embryonic stem cell culturing using cell lines and animal models.
3. To perform plasmid extraction.
4. To perform gene cloning in bacteria.
5. To study protein and gene data bases through software.

Recommended Books:

- William J. Thieman and Michael A. Palladino. Introduction to Biotechnology. 2nd ed; 2008. **(Recommended Textbook)**.
- Colin Ratledge and Bjorn Kristiansen. Basic Biotechnology. 3rd eds; Cambridge Press. 2006.
- Colin Ratledge and Bjorn Kristiansen. Basic Biotechnology. 2nd ed; Cambridge Press. 2001.
- Lisa A. Seidman. Basic Laboratory Methods for Biotechnology. 2000.

Toxicology Objectives

3 (2 + 1)

- To understand the concepts of toxicity in different physiological systems.
- To know the toxicity level, its effects and risk assessment.
- To study bioremedial mechanism.

Introduction: Concepts in toxicology, Disposition of toxic compounds. Metabolism of foreign compounds. Dose-response relationships. Absorption of toxicants. Types of exposure and response. Distribution and storage of toxicants.

Biotransformation and Bio-detoxification: Elimination of the toxicants. Drugs as toxic substances. Toxicology and industry (heavy metals and metalloids. radionuclides). colors and preservatives).

Environmental Pollutants (petrochemicals and dioxins). Natural products. Household products. Toxicants as teratogens. Toxicity test (Lethal doses LDs Effective Doses EDs, Effective Concentration ECs. Toxicity testing and risk assessment.

Toxicity of Food and Water: Toxicity of drinking water, Toxicity of natural foods and food additives (taste enhancers, emulsifiers).

Toxicity from Pesticides and Fertilizers: Types, characteristics, bioaccumulation and bio-magnification, eutrophication, antidotes.

Practicals:

1. Case studies related to hazardous toxicity incidences in affected areas.
2. Field Trips to these particular sights
3. Concepts and determination of LD₅₀, ED₅₀ and ECs in insects / birds
4. Demonstrations of toxic effects of toxicants on fresh water protozoans.
5. Demonstrations of teratogenic effects (chick and rat models)
6. Determinations of effects of any toxic substance on biochemical and hematological parameters

Recommended Books:

- Comparative Toxicology: Cellular and Molecular Toxicology 2002 Vanden Heuel, JP., per dew, G. H and Mattes, WB (eds) Pergamon Press, New York. **(Recommended Textbook).**
- Casarett and Doulls Toxicology: The basic Science of poisons, 2007.
- Casart, LJ., Curtis D., Klissen.(editor) Doull, J. and Klaasen CD. McGraw-Hill Professional Publishing New York.

Clinical Endocrinology

4(3 + 1)

Objective

- To provide an understanding of endocrinological disorders and basic concepts.
- To develop a plan for the diagnosis, treatment and prevention of the endocrinological disorders.

Introduction: Introduction to clinical endocrinology.

Disorders of the Endocrine System: Hyperfunction & hypofunction of the glands; altered tissue response, tumors & other causes of endocrine disorders. Approach to the patient with endocrine disease: General & special features of endocrine illness: History, sign, symptoms and lab tests.

Disorders of the Hypothalamus: Etiology & clinical features of hypothalamic disorders. endocrinologic evaluation of the hypothalamic-pituitary-axis, hypothalamic syndromes.

Disorders of the Pituitary Gland:

Anterior Pituitary: Developmental, circulatory & inflammatory disorders of the pituitary gland, empty sella syndrome. Pituitary Adenomas: Classification, prevalence and the disorders related to tumors; Disorders due to abnormal secretion of anterior pituitary

hormones: hypopituitarism; hyperpituitarism: Acromegaly & gigantism, hyperprolactinemia. Disorders due to alteration in gonadotropins and corticotropin secretion.

Posterior Pituitary: Diabetes insipidus, syndrome of inappropriate secretion of ADH.

Disorders of Growth: Endocrine and non-endocrine causes of abnormal growth.

Disorders of the Thyroid Gland: Approach to a patient with thyroid disease; Adverse effects of Iodide, Goitrogens; Euthyroidism, Nontoxic goiter. Hyperthyroidism; Effects of thyrotoxicosis, Grave's disease, Hypothyroidism: Myxedema and cretinism, thyroiditis, thyroid cancer; thyroid hormone resistance syndromes.

Endocrine Disorders of Bone and Mineral Metabolism: Clinical evaluation of metabolic bone disease, biochemical markers of bone metabolism Hypercalcemic disorders: parathyroid dependent & independent. Hypocalcemic Disorders: hypoparathyroidism & other causes of hypocalcaemia; pseudohypoparathyroidism. Renal osteodystrophy; osteoporosis; rickets & osteomalacia, Paget's disease, disorders of phosphate & magnesium metabolism.

Disorders of Endocrine Pancreas: Classification, etiology, signs, symptoms and pathogenesis of Diabetes mellitus: Secondary forms of diabetes mellitus, impaired glucose tolerance, Diagnosis, control & management of Diabetes Mellitus. Syndromes of extreme insulin resistance & Metabolic X syndrome. A brief account of Diabetic complications.

Obesity: Prevalence, methods of determination of obesity, causes, endocrine & metabolic consequences of obesity.

Disorders of Adrenal Gland: Adrenocortical disorders: Cushing's Syndrome, adrenal insufficiency, congenital Adrenal Hyperplasia. corticosteroid therapy: Glucocorticoids as pharmacologic agents and their adverse effects. Disorders of mineralocorticoid excess and deficiency, Endocrine hypertension, Pheochromocytoma and others.

Ectopic Hormone Production: General concepts.

Practicals:

1. Study of endocrine glands in different pathological states with the help of prepared slides.
2. Approach to the patient with endocrine disease: Group discussion on case studies.
3. Endocrine tests of Hypothalamic- pituitary -function: Introduction to procedure, possible side effects, contraindications & Interpretation of different tests.
4. To perform an Intravenous glucose tolerance test in rabbits.
5. To perform a Tolbutamide test in rabbits.
6. To perform an impaired glucose tolerance test in humans.
7. To determine the parameters of obesity, Body Mass Index, Waist Hip ratio, Skin fold thickness
8. To Calculate the Basal Metabolic Rate in different endocrine abnormalities.
9. To perform the renal function tests in patients with long standing Diabetes mellitus. (eg: Serum urea, uric acid and creatinine, albuminuria.
10. To determine the markers of bone formation (serum alkaline phosphatase) and bone resorption (serum and urinary calcium and hydroxy proline) in patients with bone disorders such as osteoporosis & others.
11. To study the patients with goiter, cretinism, myxedema, Grave's disease, Addison's disease, Cushing syndrome, adrenogenital syndrome.

Recommended Books:

- Basic & Clinical Endocrinology, 7th Edition. Green Span & Strewter, Prentice Hall Intern, 2004. **(Recommended Textbook)**.
- Principles & Practice of Endocrinology & Metabolism, 3rd Ed. Kenneth L. Becker. Lippincot, Williams & Wilkins 2001.
- Williams Textbook of Endocrinology; 10th edition. Larson, Kronenberg, Melmed & Polonsky. Saunders.2003
- Endocrine Physiology 3rd Ed. Kacsoh. B., McGraw-Hill Boston, 2003
- Essential Endocrinology, 3rd Ed. Charles G. D Brook & Nicholas, J. Marshall. Blackwell Science. Intern Edition.
- Textbook of Endocrinology, 5th Ed., Mac E. Hadley, Pearson Education, 2005
- Molecular Endocrinology, 3rd Ed., Franklyn F. Bolander, Elsevier Publication, 2004
- Fundamentals of Clinical Endocrinology, 4th Ed, Reginald Hall & Michael Besser. Churchill Living Stone,1989
- Endocrinology, 2nd Ed. William Jubiz, McGraw-Hill International Editions, 1987.

Pharmacology Objectives

4(3 + 1)

- To understand the concepts of drug disposition, mechanism of action on human body.
- To understand the effects of drugs on various systems of body.

Introduction: Nature and sources of drugs, routes of drug administration.

Pharmacodynamics: Drug receptors, their nature and interaction. Drug abuse. Agonist and antagonist. Signalling mechanism, Receptor desensitization. Drug dose response relationship curves.

Pharmacokinetics, absorption, distribution and metabolism: Absorption and physical factors influencing absorption. Bioavailability and affecting factors, drug distribution. Metabolism and clearance of drug. Drug interactions and incompatibilities.

Drugs affecting Autonomic Nervous System: Cholinergic agonists and antagonists. Alpha and beta adrenergic agonists and antagonists.

Drugs affecting Central Nervous System: CNS stimulants, anxiolytic and hypnotic drugs. General and local anaesthetics. Neuroleptic, opioid and analgesics.

Drugs affecting Circulatory System: Antihypertensive agents, vasodilators, antiarrhythmic drugs. Haematinics, anticoagulants, thrombolytic drugs, anti-inflammatory and autacoids.

Miscellaneous Drugs: An overview of Bronchodilators, Antiemetic, Diuretics, Antimicrobial, antifungal and chemotherapeutic drugs. An overview of hormone therapy for dysfunction of Hypothalamus, Pituitary, Thyroid, Adrenal, Gonads and Pancreas.

Practicals:

1. To study the effect of Neostigmine on muscle contraction.
2. To perform the screening test for Paracetamol and Phenothiazines in urine samples.
3. To demonstrate the Duke bleeding time method in rabbit.

4. To observe the effect of Warfarin and Heparin on bleeding time in rabbit.
5. To study and compare the effect of Adrenaline, Neostigmine and Acetylcholine on the contraction of skeletal muscle.
6. To study the effects of drugs on rabbit eye pupil diameter.
7. To study the effect of Acetylcholine, Atropine and Adrenaline on cardiac muscle.
8. To observe the effect of central nervous system depressants and stimulants in animal models.
9. To study the effect of hypoglycaemic drugs in rabbit.

Recommended Books:

- Goodman & Gilman's. The Pharmacological Basis of Therapeutics, 12ed; McGraw-Hill. 2011. **(Recommended Textbook)**.
- Katzung, B. G. Basic and Clinical Pharmacology. 12th ed., Appleton and Lange. 2011.
- Harvey, R. A. and Champe, P. C. Pharmacology, 2nd ed., Lippincott Publication. 2001.

Internship

0 credits

Internship is to be offered for a period of at least 5 weeks in teaching, research, health and commercial organizations, with no credits. However, at the end of Internship a certificate will be issued to the candidate by the organization where internship was done with the submission of internship report in the degree awarding Department/ Institution.

**MS Physiology
(2 Years / 4 Semesters)
With Research Thesis**

SEMESTER – I		SEMESTER – II	
Course Title	Cr Hours	Course Title	Cr Hours
(Core Course – I)	3+0	Special/Optional Course-II	3+0
(Core Course- II)	3+0	Special/Optional Course-III	3+0
Special/Optional Course-I	3+0	Special/Optional Course – IV	3+0
SEMESTER – III		SEMESTER – IV	
Research Reading – I	3	Research Reading - II	3
Research Thesis			6

List of Core Courses:

1. Advances in Clinical Endocrinology
2. Advances in Pathologic Physiology
3. General Hematology
4. Poultry Physiology
5. Physiology of Smooth Muscle
6. Myocardial Cell
7. Electrophysiology
8. Comparative Structure & Function of Muscle
9. Reproductive Endocrinology
10. Physiological techniques

List of Specializations:

Endocrinology	Neuromuscular Physiology
Hematology	Pathophysiology
Biology	Poultry Physiology

Note: Universities may offer other specialization courses according to their resources and expertise available with them.

**MS Physiology
(2 Years / 4 Semesters)
Without Research Thesis**

SEMESTER – I		SEMESTER – II	
Course Title	Cr Hours	Course Title	Cr Hours
Systemic physiology*	3	Physiology of motor control**	3
		Advanced smooth muscle physiology**	3
Advanced cell physiology*	3	Behavioral physiology**	3
		Neurobiological and vascular physiology-i**	3
Molecular physiology*	3	Psychoneuroimmunology**	3
		Physiology and biophysics-i**	3
Approaches to laboratory Techniques*	3	Biotechniques in avian biology**	3
		Physiological aspects of poultry management**	3
		Non-malignant & malignant disorders in hematology**	3
SEMESTER – III		SEMESTER – IV	
Advanced neuroanatomy**	3	Research reading and special problems in physiology***	3
Sensory physiology**	3		
Exercise physiology**	3		
Neurobiological and vascular physiology-ii**	3		
Clinical and molecular Physiology of angiogenesis**	3		
Physiology and biophysics-ii**	3		
Advance poultry pathology**	3		
Avian immunology**	3		
Therapeutic principles of hematology**	3		

* To be opted by all students for the requirement of NON-THESIS MS in PHYSIOLOGY.

** A total of 15 credits can be opted to qualify for NON-THESIS MS in PHYSIOLOGY.

***Course requires a plan of work under a supervisor but will not require a formal committee approval and laboratory research work.

Note: Universities may offer other major and minor courses according to their resources and expertise available with them.

PhD Physiology

Student admitted in the PhD Programme will be required to complete the course work of 18 Cr hrs in addition to the Research work & defense of thesis according to the laid down criteria mentioned in the websites of HEC and respective Universities.

Below is a proposed list of courses for selection to complete the course work for PhD Programme:

Course Title	Cr Hours
Advanced poultry breeding	3
Advanced poultry nutrition	3
Advances in Clinical Endocrinology & Metabolism	3
Advances in Clinical Reproductive Endocrinology	3
Aging motor control	3
Avian diseases diagnostic techniques	3
Biomechanical aspects of Motor Control	3
Clinical Molecular Physiology & Bio-Physics	3
Experimental & Clinical Diabetes Mellitus	3
Experimental lab animal handling	3
Locomotion Neuro-mechanics	3
Molecular Basis of Diabetes Mellitus	3
Molecular biology of Cell Signaling, Apoptosis & Senescence	3
Movement disorders	3
Nerve–Muscle Integration	3
Poultry Pharmacology	3

Note: Universities may offer other courses according to their resources and expertise available with them.

Recommendations by the Committee:

On the basis of 3 days deliberations, discussions and hectic editing of physiology curriculum (2006), the committee has revised its BS & MS curriculum with the addition of Ph.D. program, along with the following recommendations for the induction, development and promotion of Physiology.

1. Induction of Physiology:

- i. At FSc & BSc level as pre-major and major course respectively.
- ii. As BS Program in all medical and non-medical institutions at undergraduate and graduate level with respect to human, animal and plant physiology.

2. Development of Physiology by:

- i. Regular feedback from stakeholders regarding advantages and disadvantages at inter curricular intra-curricular levels.
- ii. Regular self-assessment & evaluation of Physiology BS & MS Programs by concerned institutions for improvements.
- iii. Recommendations (every 5 years) from the concerned institutions for an update of physiology curriculum under the umbrella of HEC at National level.

3. Promotion of Physiology:

- i. Opening of teaching jobs for physiology graduates & post graduates in FSc/BSc Colleges and medical non-medical universities, health, research and related organizations.
- ii. Training workshops be arranged for the faculty, participation in national and international conferences on physiology.
- iii. Laboratory capacity building for procurement of basic and applied equipment and latest techniques.
- iv. Hiring of Foreign faculty
- v. Students of MS (physiology without research thesis) are required to do 6 months internship in institutes offering expertise in student's area of working.
- vi. Courses prepared by the Committee are given in the semester system format. It may be adopted by the respective university according to their own regulations in vogue.
- vii. The field trainings, visits to teaching hospitals/research institutes/RHC/Basic health units etc., may be arranged.
- viii. Teacher training Program and refresher courses should be arranged to train teachers with state of the art physiology techniques.
- ix. Teachers should be encouraged to write manuals both for theory and practical with latest knowledge from books and websites.
- x. Physiology software be made available related to the subjects and the expertise be developed in the universities.
- xi. Latest editions of textbooks and the reference books should be available in the departmental seminar library as well as main library. Special funding is to be provided by HEC.
- xii. Audio Visual Aids (multimedia) and smart boards are to be provided in every lecture hall.