UNIVERSITY OF THE PUNJAB

NOTIFICATION

The Syndicate at its meeting held on 15-11-2021 has approved the recommendations of the Academic Council dated 07-10-2021 regarding approval of the revised Scheme of Studies for M.Phil. and Ph.D. Programs, Biological Sciences at the School of Biological Sciences w.e.f. the Academic Session, 2021 and onwards.

The Scheme of Studies for M.Phil. and Ph.D. Programs are enclosed herewith, vide Annexure-'A&B'

Sd/-
Muhammad Rauf Nawaz
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.
No. D/ 142 /Acad.

Dated: 12-01-/2022.

Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean,
   Faculty of Life Sciences
2. The Director General, School of Biological Sciences
3. Chairperson, DPCC
4. Controller of Examinations.
5. The Director, Quality Enhancement Cell
6. Admin. Officer (Statutes)
7. Secretary to the Vice-Chancellor
8. Ps to Pro-Vice-Chancellor
9. PS to the Registrar.
10. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

School of Biological Sciences, University of the Punjab

Curriculum/ Syllabus M.Phil. Program

Curricula/Syllabi of M.Phil. Program

Program Title: M.Phil. /M.S. Program

Department: School of Biological Sciences, University of the Punjab, Lahore

Faculty: Life Sciences

1. Department Mission

There is a dearth of researchers in universities/R&D institutes who are well versed in molecular biology techniques especially recombinant DNA technology and proteomics. A few who are familiar with the techniques are handicapped due to ill equipped laboratories. With this background our mission is to:

- Develop human resource in the areas of Molecular Biology, Recombinant DNA Technology, Plant and Animal Biotechnology, Protein Chemistry and Enzymology to our own students and researchers from other departments of the university/other universities of the country.
- Establish linkage between R&D and industry.
- Develop sustainable indigenous technology for the preparation and application of therapeutic proteins and enzymes of commercial importance.

2. Introduction

Establishment of the School of Biological Sciences at the University of the Punjab, Lahore, Pakistan was conceptualized in 2002. Coincidently around the same time Prof. Dr. Muhammad Akhtar, then the only FRS of Pakistani origin, had retired from University of Southampton, UK, after an illustrious career. Mr. Akhtar Saeed, the then Education Minister, Government of the Punjab, took an unprecedented personal initiative to pursue Dr. Akhtar to come to Lahore and contribute to a national cause. Thus started the Punjab Government-Punjab University joint project for the establishment of the School of Biological Sciences, subsequently approved by the University of the Punjab Syndicate, as a part of the university, within the provisions of the University of the Punjab. The principal objective of the School was to generate high quality work force in the wider range of biological sciences. Qualitative and quantitative achievements of high merit, made during the 19 years of existence of the School, bear testimony of the potential it has displayed.

3. Program Introduction

School of Biological Sciences offers only Post Graduate Programs (M.Phil./M.S. and Ph.D.) For the award of M.Phil. /M.S./Equivalent degree, candidates need to complete 24 credit hours of course work along with a minimum of 6 credit hours for research work/thesis.

6 credit hours of research is mandatory for M.Phil. Research is offered in the following principal research areas of biological sciences; Biochemistry, Biotechnology, Molecular Biology, Zoology, Botany, Microbiology, Genetics, Cell Biology, Virology, and Food Biotechnology.

4. Program Objectives

School of Biological Sciences offers the post graduate programs (M.Phil./M.S. and Ph.D.) with the following objectives.

1. Train manpower for contributing to education, health and industry.
2. Develop sustainable indigenous technology.
3. Establish linkages with industry.

5. Market Need / Rationale of the Program

The M.Phil./M.S. Biological Sciences is a previously approved academic program. It was initiated since there is a scarcity of trained manpower in areas of molecular biology, recombinant DNA technology and enzymology in the country. Therefore, it makes scientists with these skills in high demand. All major universities have established departments/institutes/centres in biotechnology and furnished them with relevant equipment. However, most of these centres are devoid of trained personnel.

Our human resource development program not only fills this gap but also provides talented young scientists to bio-tech related industries in the country. This sustained effect will eventually lead to a positive socio-economic impact on the society.

The program was offered and is continued based on the needs as below:

a) ***Potential Students for the Program.*** There is a high degree of interest in students to attain M.S./M.Phil. degree in Biological Sciences, since almost 500 apply every year for admission against the 25 seats. The students use these degrees for subsequent careers in the universities, colleges, hospitals, research institutes and industrial sectors.

b) ***Potential Employers.*** The employers respect the degree offered by School of Biological Sciences and currently our students are employed at different universities, institutes, colleges and, health, agriculture and industrial sectors. The future prospects for the graduates are bright as there is a dearth of highly trained biologists.

c) ***Academic Projections.*** School of Biological Sciences is one of very few departments in Pakistan which offers a degree in Biological Sciences. Internationally, there are a number of universities in the UK and other countries which offer a degree in Biological Sciences. Our curricula have been designed keeping the international syllabus in mind.

d) ***Faculty***. School of Biological Sciences has a trained faculty with 23 Ph.D. who are well respected in their fields of studies. Reflecting the diverse nature of biology, these include biochemists, molecular biologists, zoologists, botanists, microbiologists, geneticists and cell biologists. All are highly trained and also have acquired postdoctoral training.

e) ***Physical Facilities.*** The School of Biological Sciences has state of the art laboratory facilities for research which are available to all students admitted to the department. These include Mass Spectrometry Labs, Cell Biology Labs, Plant Cell Culture Facility, Sanger sequencing Facility and many other sophisticated and routine Molecular Biology Labs. The library has all pertinent books required for help in studies as well as laboratory procedures. Some important journals which are not freely available via HEC or PU, are also subscribed to separately.

6. Admission Eligibility Criteria

The School of Biological Sciences strictly follows the "Minimum quality criteria for M.Phil./ Ph.D. Programs", as outlined by the HEC.

- **Years of studies completed.** Sixteen years of schooling or education; 130 credit hours following matriculation/F.Sc. or equivalent will be required in any field of Biological Sciences. B.S., M.Sc. and equivalent.
- **Study Program/Subject.** Candidates must have completed their last terminal degree in any field of Biological Sciences (Biological Sciences, Botany, Zoology, Molecular Biology, Microbiology, Genetics, Biochemistry or equivalent).
- **Percentage/CGPA:** Either M.Sc. or B.S./B.Sc. (hons 4 years) semester system, at least 2.5 CGPA is required to be eligible for M.Phil. admission (http://pu.edu.pk/dpcc/rule_eligibility.htm).
- **Entry test.** The candidates must secure 50% marks each in the entry test and the interview. The candidates must obtain greater than 19.1 out of 40 marks in academic merit (according to the formula available at http://pu.edu.pk/dpcc/rule_eligibility.htm) to be eligible for taking the written test.

7. Duration of the Program

4 semesters/ 2years/30 credit hours. Please see below for details

Name of Program	Duration	No. of Modules	Total Credit Hrs
M.Phil./M.S. Program	2 Years	4 Semesters	24 + 6 credit hour research

8. Categorization of Courses as per HEC Recommendation and Difference

Semester	Courses	Category (Credit Hours)					
		Core Courses	**Basic Courses**	**Major Electives**	**Minor Electives**	**Any others**	**Semester load**
1	6	2	2	1	1	0	12
2	9	2	3	2	2	0	12
3	None/Research						Full time
4	None/Research						Full time
PU	Same						
HEC guidelines	Same						
Differences HEC and PU	None						

**Core: Compulsory, Basic: Foundation, Major Electives: Professional Minor Electives: Specialization*

Note: The course/column heads are customizable according to nature and level of the program.

9. Scheme of Studies / Semester-wise workload

#	Code	Course Title	Course Type	Prerequisite	Credit hours
Semester I					
1.	SBS 501	Biomolecules and their Physicochemical Properties	Core	B.S./M.Sc. in life/allied sciences	2
2	SBS 502	Physicochemical Principles of Proteins and Enzymes	Basic	-do-	2
3	SBS 503	Frontiers in Molecular Biology I	Core	-do-	1
4	SBS 505	Molecular Biology Lab	Basic	-do-	2
5	SBS 510	General & Medical Genetics	Major Elective	-do-	3
6	SBS 513	Research Ethics	Minor Elective	-do-	2
Total credit hours: 10 (without Minor Elective)-12 mandatory					
Semester II					

1.	SBS 504	Molecular Biology	Core	B.S./M.Sc. in life/allied sciences	2
2	SBS 506	Cell Biology	Basic	-do-	2 +1
3	SBS 507	Metabolic Pathways and their Integration	Basic	-do-	2
4	SBS 508	Analytical & Mechanistic Enzymology	Basic	-do-	1
5	SBS 509	Frontiers in Molecular Biology 2	Core	-do-	1
6	SBS 511	Fundamentals of Virology	Major Elective	-do-	2
7	SBS 512	Cancer Biology	Minor Elective	-do-	2
8	SBS 514	Genomics	Major Elective	-do-	2
9	SBS 515	Advanced Food Microbiology	Minor Elective	-do-	2+1
Total credit hours: 9 (excluding Electives)-12 mandatory					
Semester III and IV					
1.	SBS 516	Research Thesis	Core/ Compulsory	-do-	6
Total credit hours: 6					

1. Type of course may be core (Compulsory), basic (Foundation), major Elective (Professional), minor Elective (Specialization) etc.

Research Thesis

Comprised of two semesters (semester III and IV) of 6 credit hours

10. Award of Degree

Areas of specialization in M.Phil./Ph.D. degree in Biological Sciences:

As recommended by Board of Faculty of Life Sciences in a meeting held on 21st January, 2020, following areas of specialization in M.Phil./M.S./Ph.D. degrees in Biological Sciences, are proposed:

1. Biochemistry
2. Biotechnology
3. Molecular Biology
4. Zoology
5. Botany
6. Microbiology
7. Genetics
8. Cell Biology
9. Virology
10. Food Biotechnology

Degree awarding criteria:

CGPA required to qualify

(According to the rules given at http://pu.edu.pk/dpcc/rule_examination.htm)

CGPA requirement: 2.5 cGPA is required to be awarded M.S./M.Phil. degree and subject wise GPA not less than 2.3.

Thesis/Project/internship:

Thesis project of 6 credit hours in semester 3 and 4. No comprehensive examination in M.Phil./M.S. according to HEC rules

11. NOC from Professional Councils (if applicable)

Not applicable

12. Faculty Strength

Degree	Area/Specialization	Total
Ph.D.	1. Biochemistry= 3 2. Biotechnology=1 3. Botany/Plant Sciences = 2 4. Zoology/ Cell and Molecular Biology/Molecular and Cellular Biology=3 5. Molecular Biology=4 6. Protein Chemistry and Enzymology=1 7. Biomolecular Sciences=1 8. Biology= 1 9. Biological Sciences= 6 10. Molecular Genetics and Genomics=1	23
-----	Veterinary sciences: Clinical Medicine and Surgery=01	01
Total		**24**

Sr. No.	Faculty Name	Designation	Area of specialization
1.	Prof. Dr. Naeem Rashid	Professor (Acting Director General)	Biotechnology
2.	Prof. Dr. Javed Iqbal	Professor Emeritus	Botany
3.	Prof. Dr. M. Waheed Akhtar	Professor Emeritus	Biochemistry
4.	Prof. Dr. A. R. Shakoori	Professor Emeritus	Biochemistry/Cell and Molecular Biology
5.	Prof. Dr. Sadaf Naz	Professor	Molecular Biology
6.	Prof. Dr. Moaz ur Rehman	Professor	Biochemistry
7.	Dr. Q.A. Gardner	Associate Professor	Biological Sciences (Biochemistry)
8.	Dr. Qamar Bashir	Associate Professor	Protein Chemistry & Enzymology
9.	Dr. Muhammad Saleem	Associate Professor	Biomolecular Sciences
10.	Dr. Uzma Qaisar	Associate Professor	Molecular Biology
11.	Dr. Hafiz Naveed Shahzad	Associate Professor	Cell and Molecular Biology
12.	Dr. Bushra Tabassum	Associate Professor	Plant Sciences
13.	Dr. Asima Tayyab	Assistant Professor	Biology
14.	Dr. Soumble Zulfiqar	Assistant Professor	Biological Sciences
15.	Dr. Nasir Ahmad	Assistant Professor	Biological Sciences
16.	Dr. Mehwish Aslam	Assistant Professor	Molecular Biology
17.	Dr. Ayesha Imtiaz	Assistant Professor	Biological Sciences (Human Genetics)
18.	Dr. Farhan-ul-Haq	Assistant Professor	Molecular and Cellular Biology
19.	Dr. Muhmmad Sajjad	Assistant Professor	Biological Sciences
20.	Dr. Muhammad Akhtar Ali	Assistant Professor	Molecular Genetics and Genomics
21.	Dr. Saima Iftikhar	Principal Experimental Officer	Biological Sciences/ Molecular Biology

22.	Dr. Munir Ahmad	Experimental Officer	Biological Sciences
23.	Dr. Naseema Azim	Senior Research Officer	Biological Sciences
24.	Dr. Muhammad Ali	Senior Research Officer/ Veterinary Doctor	Clinical Medicine and Surgery
1 to 23; Ph.D., 24 Veterinary doctor			

13. Present Student Teacher Ratio in the Department

Ph.D./M.Phil. Students: Faculty: Ratio = ~2:1

14. Course Outlines separately for each course

Attached below (Pages 10-43 M.Phil. syllabus)

School of Biological Sciences, University of the Punjab

M.Phil. Syllabus Content files

Pages 10-43

+ Annexure I

Pages 44-69

M.Phil. Semester 1 Syllabus

Course Title: Structures and Physico-chemical Properties of Biomolecules

Course Code: SBS 501

Semester: 1st

Credit Hours: 2 (2+0)

- **Pre-requisites course requirements/ skills**

Students taking this course should have a graduate degree in any of the biological sciences. They should have the basic knowledge that life exists of an array of biomolecules, the structural, physical and chemical properties of which are responsible for all life.

- **Learning Outcomes**

  After studying this course, the students will:

1. Understand the chemical and physical principles involved in the living systems
2. Understand the nature, properties and functions of the biomolecules.
3. Understand the structure and processes in the living systems at molecular level in order to make their foundation strong.

- **Contents**

  Units I-II

  Unit-I Thermodynamics and Reaction States

  1.1 Thermodynamics

  1.2 Kinetics

  1.3 Redox states

  1.4 pH, acid-base reactions, and buffers, aqueous solutions

  1.5 Equilibria catalysis and reaction mechanisms

Unit-II Structure and Interaction

2.1 Structure, assembly and organization of macromolecules (for example, nucleic acids, polysaccharides, proteins, and complex lipids)

2.2 Biochemical aspects of supramolecular complexes (for example, membranes, ribosomes, and multi-enzyme complexes)

2.3 Ligand-protein interactions (for example, between hormones and receptors, antigens and antibodies, transport proteins and their effectors)

- **Teaching-learning Strategies**

The course contents shall be covered using two methods.

1. One section of the course contents shall be covered in regular class lectures.
2. A section of the course contents shall be covered in a combination of in-class tutorials and class presentations.

- **Assignments-Types and number with calendar**

A single assignment comprising individual topics for all students shall be given before the mid of the semester. Each student will prepare a power point presentation on these topics including the latest advancements on the topic as well. The presentation should be of 10-15 min duration. Each student will be assessed on delivery and command of the topic.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written test comprising of short questions, and multiple choice questions based quiz
2.	Formative Assessment	25%	Assignments and presentations
3.	Final Assessment	40%	Written test comprising of short questions, and multiple choice questions based quiz

- **Books Recommended/ Suggested Readings**

1. Berg JM, Tymoczko JL, Gatto Jr GJ, Stryer L. 2015. Biochemistry. 8th ed. San Francisco: W.H. Freeman, USA.
2. Ferrier DR. 2017. Lippincott's Illustrated Reviews: Biochemistry. 7th ed. Philadelphia: Wolters Kluwer, USA.
3. Nelson DL, Cox MM. 2017. Lehninger’s Principles of Biochemistry. 7th ed. San Francisco: W.H. Freeman, USA.
4. Voet D, Voet JG, Pratt CW. 2017. Fundamentals of Biochemistry: Life at the Molecular Level. 5th ed. New Jersey: John Wiley & Sons, USA.

Course Title: Physicochemical Principles of Proteins and Enzymes

Course Code: SBS 502

Semester: 1st

Credit Hours: 2 (0 + 2)

- **Pre-requisites course requirements/ skills**

M.Sc./B.S. in biological/life and allied sciences (plant sciences, animal sciences, molecular biology, microbiology, biochemistry)

- **Learning Outcomes**

This course will provide students, intensive hands-on training on how to:

1. Study and interpret the physical and chemical properties of proteins.
2. Isolate enzymes from biological sources and determine their biochemical parameters.

- **Contents**

Units I-III

Unit-I Basic Protein Chemistry

1.1 Quantification of various samples using UV-visible spectrophotometry and its application in studying proteins and enzymes.

Unit-II Enzyme Kinetics

2.1 Kinetics studies of a standard enzyme and determining its kinetic parameters.

Unit-III Isolation and Purification of Enzymes

3.1 Isolation and purification of enzymes like malate dehydrogenase, transaminases, trypsin, chymotrypsin, *etc*. from biological sample

3.2 Each student shall study kinetics experimentally of at least one enzyme

- **Teaching-learning Strategies**

1. The objective of this course is to provide students a practical know-how of physicochemical principles and properties of proteins, enzymes, kinetics and large scale production of some enzymes of commercial importance.
2. Hand-outs/Lab instructions will be provided by the instructor.
3. The students will be assigned to review their results in comparison to fellow students so to promote interactive sessions among class.

- **Assignments- Types and number with calendar**

Students will be asked to write a review on a particular enzyme, its discovery, functioning and the kinetic parameters after midterm examination.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It will be comprised of short test/written quiz which encompasses theoretical and numerical-based studies involved in this course.
2.	Formative Assessment	25%	It is comprised of presentation, written assignments and data note book record of experiments.
3.	Final Assessment	40%	Since it is a laboratory course work and daily performance of each student on a bench is very important for the assessment. Therefore, it will be judged on the basis of punctuality and day-to-day performance of the student in laboratory, and class participation Practical tests.

- **Books Recommended/ Suggested Readings**
  - **Books**

1. Berg JM, Tymoczko JL, Gatto Jr GJ, Stryer L. 2015. Biochemistry. 8th ed. San Francisco: W.H. Freeman, USA.
2. Nelson DL, Cox MM. 2013. Lehninger's Principles of Biochemistry. 6th ed. San Francisco: W.H. Freeman, USA.
3. Voet D, Voet JG, Pratt CW. 2017. Fundamentals of Biochemistry: Life at the Molecular Level. 5th ed. New Jersey: John Wiley& Sons, USA.

  - **Journal Articles / Reports**

1. Analytical Chemistry
2. Biochemistry
3. Journal of Biological Chemistry
4. Series of Methods in Enzymology

Course Title: Frontiers in Molecular Biology I

Course code: SBS 503

Semester: 1st

Credits Hours: 1 (1 + 0)

- **Pre-requisite course requirement/skills**

M. Sc./B.S. in all fields of biological and allied sciences (plant sciences, animal sciences, molecular biology, microbiology, biochemistry, pharmacy)

- **Learning Outcomes**

  After studying this course, the students will:

1. Learn and understand how advanced scientific techniques are developed in light of various discoveries.
2. Develop an understanding to carry out the research projects in a better way.

- **Contents**

  Units I-II

  Unit-I Journal Club Basics

  1.1 Students will attend Journal club-I and take notes of presentations made by PhD scholars

  1.2 These presentations will be based on recently published articles about advance scientific techniques in the field of molecular biology

  1.3 Each student will be expected to take part in discussion following the presentations.

  Unit-II Presentations

  2.1 The student participation via asking relevant questions and discussing issues raised by others will contribute towards class understanding

  2.2 Each student will choose any ten presentations and analyse and evaluate them independently and prepare a critique summary of each

- **Teaching learning strategies**

Each student will have two weeks after journal club to prepare the summary of the respective presentation, during which time he/she will meet and receive guidance from one of the teachers associated with the journal club. Regular classes will also be held.

- **Assignments-Types and number with calendar**

Each student will prepare ten assignments in the form of scientific abstract based on presentations made in journal club-I. These will be considered in both midterm and final term.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Each summary prepared by students will be checked in reference to its scientific format, contents and conclusion. The first half of these summaries would be considered a part of the midterm
2.	Formative Assessment	25%	This will be based on the attendance of each student in class as well in the journal club-I as well as their general attitude and commitment during the guidance sessions with the teachers.
3.	Final Assessment	40%	Second set of summaries prepared by students will be checked in reference to its scientific format, contents and conclusion. These would be considered a part of the final term assessment.

- **Books Recommended/ Suggested Readings**
  - **Books**

1. Meena SN, Naik MM. 2019. Advances in Biological Science Research: A Practical Approach. 1st edition. Academic Press, USA.
2. Najman S. 2014. Current Frontiers and Perspectives In: Cell Biology. Intech, Croatia
3. Wilson K, Walker J. 2010. Principles and techniques of practical biochemistry and molecular biology. 7th edition. Cambridge University Press UK.

  - **Journal Articles/ Reports**

Latest journal articles and reports published in reputed scientific journals such as Nature, Science, PNAS, JBC *etc*. relating to the topic of assignments are recommended.

Course Title: Molecular Biology Lab

Course Code: SBS 505

Semester: 1st

Credit hours: 2 (0 + 2)

- **Pre-requisite course requirement/skills**

M. Sc./B.S. in all fields of biological and allied sciences.

- **Learning Outcomes**

This course will help the students from different backgrounds to:

1. Attain a firm grasp on practical aspects of Molecular Biology.
2. Attain a firm grasp on practical aspects of Cell Biology.

- **Contents**

Units I-II

UNIT-I Different Techniques

1.1 Extraction, isolation, purification and estimations of biomolecules

1.2 DNA Restriction analysis, fractionation on agarose gel, PCR. Each student will be required to work individually to learn

UNIT-II Practicals

2.1 Calibration of pipettes

2.2 Preparation and sterilization of LB medium

2.3 Preparation of solutions

2.4 Pouring and streaking of plates

2.5 Inoculum and glycerol stocks preparation

2.6 Isolation of genomic DNA

2.7 UV and gel quantification of DNA, Amplification of a desired fragment of DNA through PCR

2.8 Cloning of amplified DNA fragment (gene clean, ligation, preparation of competent cells, transformation)

2.9 Small scale preparation of plasmid

2.10 Restriction analysis (single and double restriction)

2.11 Vectors to be used: pTZ57R, pTG19, pET21a, pET22

2.12 Strains to be used: DH5α, BL21, BL21C^{+}

- **Teaching-learning Strategies**

1. Lectures
2. Tutorial
3. Group Discussion
4. Assignment/ Class presentation
5. Workshop
6. Quiz test/ oral test
7. Lab./practical work

- **Assignments-Types and number with calendar**

Students will perform each practical individually and will have record on their data books that will be checked on regular basis. Each student should submit his/her data book for evaluation. In the final part of semester, the last five classes will be dedicated to student practical exam (20 min). It is expected that each student will observe their results (05 minutes each). A class-based discussion (10 min) will follow to analyse results.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It will be comprised of short test/written quiz which encompasses theoretical and numerical-based studies involved in this course.
2.	Formative Assessment	25%	Classroom participation, attendance, attitude and behaviour, hands-on-activities, assignments
3.	Final Assessment	40%	Practical test and data book evaluation

- **Books Recommended/ Suggested Readings**

1. Green MR, Sambrook J. 2012. Molecular Cloning – A Laboratory Manual. 4th edition. Cold Spring Harbor Laboratory, Long Island, New York, USA.

Course title: General & Medical Genetics

Semester: 1st

Course code: SBS 510

Credit hours: 3 (2 + 1)

- **Pre-requisites course requirements/ skills**

B.S. (Hons)/M.Sc. in Biological/Life Sciences

- **Learning Outcomes**

After completion of the course, the students will:

1. Understand the mechanism of gene expression
2. Understand the processes involved in the formation of specific structural and or enzymatic proteins
3. Understand the development and inheritance of genetic disease due to non-expression or improper expression of the defective genes.

- **Contents**

Units I-III

Unit-I General Genetics

1.1 Genetic foundations

1.2 Mendelian and non-mendelian inheritance

1.3 Transformation, transduction, conjugation, recombination and complementation

1.4 Mutational analysis

1.5 Genetic mapping and linkage analysis.

1.6 Chromatin and chromosomes karyotypes

Unit-II Clinical Cytogenetics

2.1 Translocations, inversions, deletions, and duplications

2.2 Aneuploidy and polyploidy structure

Unit-III Human Genome

3.1 Pattern of single gene inheritance

3.2 Genetic variation in human population

3.3 Gene mapping

3.4 Principles of molecular diseases

3.5 Genetics of disorder with complex inheritance

3.6 Cancer genetics

3.7 Diagnosis, prevention and treatment of genetic disorders

3.8 Genetic counseling and risk assessment

Unit-IV Practical

4.1 Genetics of common human traits

4.2 Pedigrees based on human genetic diseases

4.3 Site directed mutagenesis

- **Teaching-learning Strategies**

Series of lectures, interactive sessions

- **Assignments-Types and number with calendar**

  A problem based assignment given during the middle of the semester

- **Assessment and Examinations** Written exam, quizzes, assignment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It takes place at the mid-point of the semester as a written exam
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but can also include term paper and field work

- **Books Recommended/ Suggested Readings**

1. Brooker RJ. 2018. Genetics: Analysis and Principles. 6th Edition. McGraw Hill.
2. Griffiths AF, Wessler SR, Carroll SB, Doebley J. 2015. An Introduction to Genetic Analysis. 11th Edition. W.H. Freeman, New York.
3. Klug WS, Cummings M. 2008. The Essentials of Genetics. 6th Edition. Prentice Hall.
4. Lewis R. 2018. Human Genetics. 12th Edition. McGraw Hill.
5. Nussbaum R, McInnes R, Thompson HW. 2007. Genetics in Medicine. 7th Edition. Saunders Elsevier.
6. Pritchard DJ, Korf BR. 2013. Medical Genetics at a Glance. 3rd Edition. Wiley Blackwell.
7. Strachan T, Read A. 2011. Human Molecular Genetics. 4th Edition. Garland Science.

- **Course Title: Research Ethics**

Course Code: SBS 513

Semester: 1st

Credit Hours: 2 (2 + 0)

- **Pre-requisites course requirements/ skills**

  M.Sc./B.S. in Biological/Life and Allied sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

After completion of the course, the students will:

1. Understand about the ethics of responsibly conducting research, authorship and ownership of data issues and use of humans and animals in biomedical experimentation.
2. Understand the responsibilities, rights and limits of a researcher while conducting research in a group without compromising scientific integrity and mutual benefit.

- **Contents**

  Units I-IV

  Unit-I Research Ethics

  1.1 Responsible conduct of research

  1.2 Scientific misconduct

  1.3 Characteristics of the mentor - trainee relationship

  1.4 Conflict of Interest

  Unit-II Authorship

  2.1 Scientific publications and authorship

  2.2 Guidelines for authorship

  2.3 Emerging trends and policies

  Unit-III Scientific Record Keeping

  3.1 Why do we keep record?

  3.2 Data ownership

  3.3 Data storage and retention

  Unit-IV Use of Humans and Animals in Biomedical Experimentation

  4.1 Ethical challenges to the use of animals in research

  4.2 Constraints on the behavior of scientists

4.3 The issues of informed consent in research involving humans

- **Teaching-learning Strategies**

1. Lectures would be delivered on the topics of this course. Interactive session will be conducted to encourage students in class participation.
2. Case study: The cases related to the above topics would be presented to the students and each case would be discussed in detail to build the sense of responsible scientific behavior.

- **Assignments- Types and number with calendar**

Detailed assignment on aforementioned topics would be given to the students, which they would be supposed to submit before the final term examination.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Mid-term examination will be held according to the schedule of the semester as a test.
2.	Formative Assessment	25%	It is comprised of written assignments and their presentation, and class tests
3.	Final Assessment	40%	It will be a test according to the schedule of the semester.

- **Books Recommended/ Suggested Readings**

1. Macrina FL. 2014. Scientific Integrity: Text and Cases in Responsible Conduct of Research. 4th edition. ASM Press, USA.
2. Sandøe P, Jensen KK, Whiteley L. 2017. RCR – A textbook for courses in Responsible Conduct of Research. 2nd edition. Frederiksberg: Department of Food and Resource Economics, University of Copenhagen, Denmark.
3. Shamoo AE, Resnik DB. 2015. Responsible Conduct of Research. 3rd edition. Oxford University Press, UK.

Course Title: Molecular Biology

Course Code: SBS 504

Semester: 2nd

Credit Hours: 2 (2+0)

- **Pre-requisites course requirements**

The students must have studied basics of molecular biology during bachelor's degree and know about structure of DNA and RNA.

- **Learning Outcomes**

After completion of the course, the students will:

1. Learn the nature of the genetic structure and some specialized features of the genomes.
2. Understand structures of DNA and RNA
3. Grasp the processes of DNA replication, transcription and translation, as well as regulation of these processes.
4. Understand better the advanced and specialized areas of study and to benefit substantially even if coming from different relevant degree programs.

- **Contents**

Units I-V

Unit-I DNA Replication

1.1 Structure of DNA

1.2 Enzymology and process of DNA replication in prokaryotes and eukaryotes

Unit-II Gene Expression

2.1 The genetic code

2.2 Transcription

2.3 Enzymology and process of transcription in prokaryotes and eukaryotes

2.4 RNA processing

2.5 Translation

2.6 Enzymology and process of Protein synthesis and processing in prokaryotes and eukaryotes

2.7 Regulation of translation

2.8 Posttranslational modifications

Unit-III Gene Regulation in Prokaryotes

3.1 Positive and negative control of operons

3.2 Promoter recognition by RNA polymerases, attenuation and antitermination.

Unit-IV Gene Regulation in Eukaryotes

4.1 *cis*-acting regulatory factors

4.2 Gene rearrangements and amplifications

Unit-V Practicals

5.1 Expression of cloned gene in *E. coli* and yeast cells

5.2 Detection and analysis of proteins expressed from cloned genes

- **Teaching-learning Strategies**

This course will include class lectures. Teacher may use multimedia where required.

1. Class room lectures
2. Tutorial
3. Group discussion
4. Assignment/Seminar/ Class presentation
5. Quiz test/ oral test
6. Lab./practical work

- **Assignments- Types and number with calendar**

Students will work in groups on a randomly assigned molecular biology topic. Each group should submit an assignment on the assigned topic. The last five classes will be dedicated to students' presentations. A class-based discussion will follow each presentation. This will be at the end of the semester.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Exam at the mid-point of the semester.
2.	Formative Assessment	25%	Classroom participation, attendance, assignments and presentations, attitude and behavior, quizzes etc.
3.	Final Assessment	40%	Exam at the end of the semester.

- **Books Recommended/ Suggested Readings**

1. Berg JM, Tymoczko JL, Gatto Jr, GJ, Stryer L. 2015. Biochemistry. WH Freeman, San Francisco, USA.
2. Brown TA. 2018. Genomes IV. Garland Science, New York, USA.
3. Campbell M, Heyer L. 2006. Discovering Genomics, Proteomics and Bioinformatics. 2nd edition. Benjamin-Cummings Publishing Company, San Francisco, USA.
4. Krebs JE, Goldstein ES, Kilpatrick ST. 2014. Lewin's Gene XI. Jones and Bartlett Learning, Benjamin Cummings.
5. Malacinski GM. 2005. Essentials of Molecular Biology. 3rd edition. Jones and Bartlett Publishers.
6. Watson JD, Gilman M. 2006. Recombinant DNA: Genes and Genomes – a short course. 3rd edition. WH Freeman, New York, USA.
7. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. 2014. Molecular Biology of the Gene. 7th edition. Garland Publishing Inc., New York, USA.
8. Weaver RF. 2012. Molecular Biology. 5th edition. McGraw Hill.

M.Phil. Semester 2 Syllabus

Course Title: Cell Biology

Course Code: SBS 506

Semester: 2nd

Credit Hours: 3 (2+ 1)

- **Pre-requisites course requirements/ skills**

  B.S. (Hons)/M.Sc. in Biological/Life Sciences

- **Learning Outcomes**

  The course will enable the students to:

  1. Relate various structures of the cell to variety of functions the cells.
  2. Understand about intercommunication of cells, their contractility, and regulatory mechanism of cell division.
  3. Understand the various physiological and genetic aspects of organisms.

- **Contents**

  Units I-II

  Unit-I Theory

  1.1 Cellular compartments of prokaryotes and eukaryotes

  1.2 Dynamics, and functions cellular membrane systems (structure, chemical composition and functions of Endoplasmic reticulum, Golgi complex, Lysosomes, Glyoxysomes, Peroxisomes, Microsomes)

  1.3 Nucleus (Chromatin, Chromosomes, Nucleolus, Nuclear envelope)

  1.4 Ribosomes, mitochondria and chloroplasts (including biogenesis and evolution

  1.5 Intracellular trafficking

  1.6 Cell surface and communication

  1.7 Extracellular matrix (including cell walls)

  1.8 Cell adhesion and junctions

  1.9 Signal transduction, receptor function, excitable membrane systems

  1.10 Cytoskeleton, motility, and shape

  1.11 Actin-based systems (including muscle contraction)

  1.12 Microtubule-based systems

  1.13 Intermediate filaments prokaryotic system

  1.14 Cell division

  1.15 Mitosis, meiosis and gametogenesis

  1.16 Eukaryotic cell cycles and cytokinesis

Unit-II Practicals

2.1 Basic understanding of animal cell culture techniques

2.2 Cell culturing methods/Aseptic techniques

2.3 Handling and characterization of cell lines

2.4 Cell counts using hemocytometer

2.5 Monitoring morphology of animal cells in culture

2.6 Contamination and biosafety

2.7 Cryopreservation

- **Teaching-learning Strategies**

  Series of lectures, interactive sessions, Hands on training

- **Assignments-Types and number with calendar**

  A one-time problem based assignment during the course after midterm exam.

- **Assessment and Examinations:** Written exam, quizzes, assignment, practical performance, viva voce

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It takes place at the mid-point of the semester as a written exam
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test covering both theoretical and practical aspects. It can also include term paper and field work

- **Books Recommended/ Suggested Readings**

1. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P. 2015. Molecular Biology of the Cell. 6th edition. Garland Publishers, NY, USA.
2. Freshney RI. 2010. Culture of Animal Cells: A Manual of Basic Technique, 6th edition, Willey-Blackwell.

3. Jennie PM, Penelope ER. 2007. Introduction to Cell and Tissue Culture: Theory and Techniques. Springer.
4. Karp G. 2007. Cell and Molecular Biology. Concepts and Experiments. 5th edition. John Wiley & Sons.
5. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A, Scott MP. 2012. Molecular Cell Biology .7th international edition. WH Freeman & Company.
6. Pollard TD, Earnshaw WC. 2002. Cell Biology. Saunders, Philadelphia, USA.

Course Title: Metabolic Pathways and their Integration

Course Code: SBS 507

Semester: 2nd

Credit Hours: 2 (2 + 0)

- **Pre-requisites course requirements/ skills**

M.Sc./B.S. in Biological/Life and Allied sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

The course will enable the students to:

1. Understand the major processes involved in energy transfer in the living systems.
2. Grasp regulation and integration of major metabolic pathways.
3. Understand the processes of energy utilization and its production in the living systems, through the various biochemical pathways.

- **Contents**

Units I-III

Unit-I Major Metabolic Pathways

1.1 Anaerobic glycolysis, glycogenesis, gluconeogenesis, tricarboxylic acid cycle

1.2 Fatty acid degradation and biosynthesis

1.3 Amino acid metabolism.

Unit-II Bioenergetics

2.1 Respiration and photosynthesis

2.2 energy transformations at the substrate level, electron transport, proton and chemical gradients, energy coupling (phosphorylation and transport).

Unit-III Integration of Metabolism

3.1 Regulation and integration of metabolism

3.2 Covalent modification of enzymes, allosteric regulation

3.3 Compartmentalization and hormonal control

- **Teaching-learning Strategies**

Lectures would be delivered on the topics of this course. Interactive session will be conducted to encourage students in class participation. Students will be encouraged to read articles related to latest research on various metabolic pathways, their integration and regulation.

- **Assignments- Types and Number with calendar**

At the end of mid-term, when students have been familiarized with the course, they will be given assignments related to the contents of the course. They would be supposed to submit those assignments and present on those topics before final term examination.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Mid-term examination will be written test held according to the schedule of the semester.
2.	Formative Assessment	25%	It is comprised of written assignments and their presentation, and class tests.
3.	Final Assessment	40%	It will be a written test according to the schedule of the semester.

Books Recommended/ Suggested Readings

1. Berg JM, Tymoczko JL, Gatto Jr GJ, Stryer L. 2015. Biochemistry. 8th ed. San Francisco: W.H. Freeman.
2. Ferrier DR. 2017. Lippincott's Illustrated Reviews: Biochemistry. 7th ed. Philadelphia: Wolters Kluwer.
3. Nelson DL, Cox MM. 2013. Lehninger’s Principles of Biochemistry. 6th ed. San Francisco: W.H. Freeman.
4. Voet D, Voet JG, Pratt CW. 2017. Fundamentals of Biochemistry: Life at the Molecular Level. 5th ed. New Jersey: John Wiley & Sons.

Course Title: Analytical & Mechanistic Enzymology

Course Code: SBS 508

Semester: 2nd

Credit Hours: 1 (1 + 0)

- **Pre-requisites course requirements/ skills**

M.Sc./B.S. in Biological/Life and Allied sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

  The course will enable the students to:

  1. Acquire comprehensive knowledge of analytical and mechanistic enzymology.
  2. Understand analytical protein chemistry, and mechanisms involved in structural-function relationship of enzymes.

- **Contents**

  Units I-II

  Unit-I Numerical and Theoretical-based Problems

  1.1 Numerical- and theoretical-based problems regarding rate of enzyme reaction under different concentrations of substrate and enzyme,

  1.2 Effect of pH and temperature, determination of Km values

  1.3 mechanism of action of some enzymes

  Unit-II Mechanisms

  2.1 Selective metabolically important enzymes; triosephosphate isomerase, fructose-1,6-diphosphate aldolase and glyceraldehyde-3-phosphate dehydrogenase

  2.2 Clinically important enzymes e.g. Glutamate oxaloacetate transaminase (GOT), alanine aminotransaminase (ALT), creatinine kinase, lactate dehydrogenase, acid phosphatase etc.

- **Teaching-learning Strategies**

  Lectures would be delivered on the topics of this course. Interactive session will be conducted to encourage students in class participation. Students will be encouraged to read articles related to latest research on enzyme mechanistic.

- **Assignments- Types and number with calendar**

Detailed assignment on analytical and mechanistic enzymology course would be given to the students, which they would be supposed to submit before final term examination.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Mid-term written examination will be held according to the schedule of the semester.
2.	Formative Assessment	25%	It is comprised of written assignments and their presentation, and class tests
3.	Final Assessment	40%	It will be a written test according to the schedule of the semester.

- **Books Recommended/ Suggested Readings**
  - **Books**

1. Berg JM, Tymoczko JL, Gatto Jr GJ, Stryer L. 2015. Biochemistry. 8th ed. San Francisco: WH Freeman.
2. Nelson DL, Cox MM. 2013. Lehninger's Principles of Biochemistry. 6th ed. San Francisco: WH Freeman.
3. Voet D, Voet JG, Pratt CW. 2017. Fundamentals of Biochemistry: Life at the Molecular Level. 5th ed. New Jersey: John Wiley.

  - **Journal Articles/ Reports**

Series of Methods in Enzymology

Course Title: Frontiers in Molecular Biology II

Course Code: Course SBS 509

Semester: 2nd

Credit Hours: 1 (1+0)

- **Pre-requisite course requirement/skills**

M.Sc./B.S. in Biological/Life and Allied sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

Learning Outcomes

The course will enable the students to:

1. Figure out the most significant facts and findings from a research article
2. Comprehend and summarize research findings in the form of a scientific abstract/summary.

- **Contents**

Units I-III

Unit-I Attend and Understand Journal Club-II Presentations made by Ph.D. Scholars

1.1. These presentations will be based on recently published research articles in the field of molecular biology

Unit-II Presentation Discussions

2.1 The participation via asking relevant questions and discussing issues raised by others will contribute towards class understanding

Unit-III Ten Presentations Assignment

3.1 Analysis and evaluation of any ten Journal Club-II presentations

3.2 Preparation of a critique summary of each of the ten presentations

- **Teaching learning strategies**

Each student will have two weeks after journal club to prepare the summary of the respective presentation, during which time he/she will meet and receive guidance from one of the teachers associated with the journal club. In addition, regular class sessions will also be involved.

- **Assignments-Types and number with calendar**

Each student will prepare ten assignments in the form of scientific abstract based on presentations made in journal club-II, during the course of the semester.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Each summary prepared by students will be checked in reference to its scientific format, contents and conclusion. The first half of these summaries would be considered a part of the midterm
2.	Formative Assessment	25%	This will be based on the attendance of each student in class, and the journal club-II as well as their general attitude and commitment during the guidance sessions with the teachers.
3.	Final Assessment	40%	Second set of summaries prepared by students will be checked in reference to its scientific format, contents and conclusion. These would be considered a part of the final term assessment.

- **Books Recommended/ Suggested Readings**

- **Books**

1. Katoch R. 2011. Analytical Techniques in Biochemistry and Molecular Biology. Springer New York.
2. Meena SN, Naik MM. 2019. Advances in Biological Science Research: A Practical Approach. 1st edition. Academic Press.

- **Journal Articles/ Reports**

Latest journal articles and reports published in reputed scientific journals such as Nature, Science, PNAS, JBC *etc*. relating to the topic of assignments are recommended.

Course Title: Fundamentals of Virology

Course Code: SBS 511

Semester: 2nd

Credit Hours: 2 (2 + 0)

- **Pre-requisites course requirements/ Skills**

  M.Sc./B.S. in biological and allied sciences (plant sciences, animal sciences, molecular biology, microbiology, biochemistry)

- **Learning Outcomes**

  The course will enable the students to:

  1. Understand the fundamentals of molecular virology and host pathogen interactions.
  2. Develop an interest regarding research in virology related disciplines.

- **Contents**

  Units I-IX

Unit-I Virus Structure

1.1 Size of viruses, Virus components, Shape of the viruses, Virus like agents

Unit-II Viral Classification

2.1 Viral taxonomy, nomenclature and orthography

Unit-III Viral Genome

3.1 Genome organization of DNA and RNA viruses, salient features of viral genome

Unit-IV Virus Replication Cycle

4.1 Overview of viral replication, various steps (entry, genome replication, assembly and release) involved in virus replication

4.2 Replication strategies of ssDNA, dsDNA, dsDNA-RT, +ssRNA, -ssRNA and dsRNA viruses

Unit-V Viral Pathogenesis

5.1 Overview of mechanism of virus mediated diseases.

5.2 Discussion on virus mediated diseases

Unit-VI DNA and RNA Transforming Viruses

6.1 Viral mediated oncogenesis with some example of RNA and DNA transforming viruses

Unit-VII Virus-Host Interactions

7.1 Host defense against viruses

7.2 Viral strategies to overcome host defense

Unit-VIII Antiviral Drugs and Vaccines

8.1 Rationales of antiviral drugs

8.2 Type of antiviral vaccines

Unit-IX Research Methodologies in Virus Research

9.1 Culturing of viruses

9.2 overview of techniques involved in virus research

- **Teaching-learning Strategies**

  This course will be taught as a series of lectures. Students will be encouraged to ask questions and participate in discussions. The students will also prepare in depth presentations on topics included in their course which will further serve to review and clarify the subject.

- **Assignments- Types and number with calendar**

  Each student will be asked to prepare two assignments, one before the midterm assessment and other before the final assessment

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	This will be based on results of one short assignment and a MCQ based test
2.	Formative Assessment	25%	It will involve attendance and short class quizzes and a presentation
3.	Final Assessment	40%	It will be a test

- **Books Recommended/ Suggested Readings**
  - **Books**

1. Aceson NH. 2011. Fundamentals of Molecular Virology. 2nd Edition. Wiley Press.
2. Cann AJ. 2015. Principles of Molecular Virology. 6th Edition. Elsevier: Academic Press.
3. Carter J, Saunders V. 2013. Virology: Principles and Applications, 2nd Edition. Wiley Press.
4. Wagner EK, Hewlett MJ, Bloom DC, Camerini D. 2008. Basic Virology. 3rd Edition. Wiley-Blackwell Publishing.

  - **Journal Articles/ Reports**

    Two review articles will be assigned to the class for discussion with all students

Course: Cancer Biology

Code: SBS 512

Semester: 2nd

Credit Hours: 2 (2+0)

- **Pre-requisites course requirements/ skills**

M.Sc./B.S. in Biological/Life and Allied sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

The course will enable the students to:

1. Understand the cellular, genetic and molecular basis of cancer.
2. Learn the research methodologies used in cancer research.
3. Attain knowledge to pursue a research career in the field of Oncology.

- **Contents**

Units 1-XII

Unit-I Basics of Carcinogenesis

1.1 Molecular and cellular hallmarks of cancer

Unit-II Tumor Development

2.1 Overview of the cancer development: initiation, progression, invasion and metastasis

Unit-III Tumor Microenvironment

3.1 Tumor surrounding blood vessels, immune cells, fibroblasts, signaling molecules and the extracellular matrix (ECM)

Unit-IV Causes and Risk Factors of Cancer

4.1 Genetic and epigenetics changes, risk factors involving environmental agents, age, family history, tobacco, obesity, alcohol, viral infections, radiations and chemical

Unit-V Cancer Causing Viruses

5.1 RNA and DNA viruses oncogenic viruses and mechanism of cell transformation

Unit-VI Cancer Related Genes

6.1 Tumor suppressor genes and oncogenes (P53, PRb, MyC, RAS etc)

Unit-VII Role of P53

7.1 Apoptosis, DNA damage and repair

Unit-VIII Oncogenic Signaling Pathways

8.1 RTK/ RAS/MAP-Kinase, PI3K/Akt signaling, Wnt/ β-catenin, Notch signaling, cell cycle

Unit-IX Cancer Epigenetics

9.1 DNA methylation and histone modification

Unit-X Diagnosis of Cancer

10.1 Histological, molecular and genetic diagnosis of cancer

Unit-XI Cancer Therapeutics

11.1 Chemotherapy, radiotherapy and Immunotherapy gene therapy, stem cells therapy

Unit-XII Molecular Oncology Research Skills

12.1 Experimental techniques routinely performed in oncology research

- **Teaching-learning Strategies**

  This course will be taught as a series of lectures. Students will be encouraged to ask questions and participate in discussions. Latest manuscripts will be assigned to the students so that the students attain a firm grasp of the subject content.

- **Assignments- Types and Number with calendar**

  Each student will be asked to prepare two assignments, one before the midterm assessment and other before the final assessment

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	This will be based on results of one short assignment and a MCQ based test
2.	Formative Assessment	25%	It will involve attendance and short class quizzes and a presentation
3.	Final Assessment	40%	It will be a test

- **Books Recommended/ Suggested Readings**

  - **Books**

1. Kerr DJ, Haller DJ, van de Velde CJH, Baumann M. 2016. Oxford Textbook of Oncology. 3rd Edition. Oxford University Press, UK.

2. Pecorino L. 2012. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics. 3rd Edition. Oxford University Press, UK.

3. Weinberg RA. 2014. The Biology of Cancer. 2nd Edition. New York: W. W. Norton & Company, USA.

  - **Journal Articles/ Reports**

    Two review articles will be assigned to the class for discussion with all students

Course Title: Genomics

Course Code: SBS 514

Semester: 2nd

Credit Hours: 2 (2+0)

- **Pre-requisites course requirements/ skills.**

M.Sc./B.S. in Biological/Life and Allied sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

  After completion of the course the students will:

  1. Acquire knowledge to appreciate genome as a whole.
  2. Understand techniques involved in elucidating structure and function of genomes

- **Contents**

  Units 1-XI

Unit-I Genome Structure

1.1 Basics, Plastid Genomes, Prokaryotic genome, Eukaryotic Genomes,

1.2 DNA structure, chromosomal architecture, Hi-C

Unit-II Physical Mapping

2.1 Radiation hybrids, RFLP, STS maps, STR maps, YAC, BAC, PAC, FISH, Clones,

2.2 Screening for clone overlap and order, Contigs,

2.3 Hierarchical Shotgun sequencing, Whole genome shotgun sequencing

Unit-III Repeated DNA and Gene Families

3.1 Tandem repeats (Satellite DNA, VNTR, microsatellites or STR), Interspersed repetitive DNA (SINE, LINE)

3.2 Gene examples

3.3 Evolution of gene families, paralogues, pseudogenes, location of genes in gene families

Unit-IV Gene Identification

4.1 Gene identification in prokaryotes

4.2 Gene identification in eukaryotes

4.3 Recognition of Open reading frame (ORF), identification of small ORF genes,

4.4 Online tools for identification of ORF, translation frames

4.5 Experimental techniques for gene identification

Unit-V Variations

5.1 Mutations types, CNV, SNP, MNP

Unit-VI Transposable Elements

6.1 Types of transposons and composition

6.2 Examples of transposons SINE, LINE, LTR, IS, Tn, P elements, sleeping beauty

6.3 Enzymes involved in transposition

6.4 Movement of transposons

6.5 Disorders due to transposons

6.6 Transposon use as a tool for transgenesis

Unit-VII DNA Damage and Repair

7.1 Sources of damage and chemistry involved in damage

7.2 Reversal of DNA damage

7.3 Mismatch repair enzymes and pathways

7.4 Types of repair,

7.5 Consequences of DNA damage and loss in repair and repair disorders

Unit-VIII DNA Modification

8.1 Methylation, consequences

8.2 X-inactivation and Imprinting

8.3 Histone acetylation and methylation

8.4 Phosphothiorylation, Role of modifications

Unit-IX DNA Recombination and Gene Conversion

9.1 Homologous and nonhomologous DNA recombination

9.2 Crossing over and Models

9.3 Importance in Evolution

9.4 Factors involved and Enzymes,

9.5 Gene conversion and examples in Yeast and Neurospora

Unit-X Special Topics

10.1 Microarrays

10.2 Restriction Maps

10.3 PCR

10.4 Nucleic Acid Blotting and Hybridization

10.5 Sanger Sequencing

10.6 Massively Parallel Sequencing/ Next Generation Sequencing

Unit-XI Practical Computational Analyses

11.1 Computational Gene Prediction

11.2 Sanger Sequencing Analysis

11.3 Analyses of Massively Parallel Sequencing Data

- **Teaching-learning Strategies**
  1. This class will be taught as a series of lectures.
  2. Students will be encouraged to ask questions and participate in discussions.
  3. Latest manuscripts will be assigned to the students so that the students attain a firm grasp of the subject content.
  4. The students will also prepare in depth presentations on topics included in their course which will further serve to review and clarify the subject.
- **Assignments- Types and number with calendar**

  Each student will prepare one problem based assignment before the midterm assessment. Each student will present the topic assigned to him/her before the final assessment
- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	This will be based on results of one short assignment and a MCQ based test
2.	Formative Assessment	25%	It will involve attendance and short class quizzes and a presentation
3.	Final Assessment	40%	It will be a test

- **Books Recommended/ Suggested Readings**
  - **Books**
    1. Alberts B, JohnsonA, Lewis J, Morgan D, Raff M, Roberts K, Walter P. 2015. Molecular Biology of the Cell. 6th Edition. Garland Publishers, New York, USA.
    2. Brown TA. 2018. Genomes IV. Garland Science, New York. USA.
    3. Campbell M, Heyer L. 2006. Discovering Genomics, Proteomics and Bioinformatics 2nd Edition. Benjamin-Cummings Publishing Company, San Francisco, USA.
  - **Journal Articles/ Reports**

    Two journal articles will be assigned to the class for discussion with all students

Course Title: Advanced Food Microbiology

Course Code: SBS 515

Semester: 2nd

Credit hours: 3 (2+1)

- **Pre-requisite course requirement/skills**

Students should have a good knowledge of Biological Sciences, Food Science or Food Technology and a basic knowledge of Biochemistry and Microbiology.

- **Learning Outcomes**

On completion of this course the students will:

1. Understand about foodborne microorganisms.
2. Gain thorough knowledge of the importance/role of microorganisms in food processing, preservation and waste management.
3. Understand basic molecular biology and other cutting-edge techniques to detect and identify microorganisms associated with foods.
4. Understand techniques to manipulate microbial cells for various processes involved in food biotechnology.
5. Understand to read and communicate current literature of food borne microorganisms.

- **Contents**

Units 1-IX

Unit-I Introduction, History and Trends

1.1 Food microbiology: Advances and trends

1.2 Importance and future prospects

Unit-II General Concepts of Microbiology

2.1 Physiology and biochemistry of food borne micro-organisms

2.2 Microbial metabolism and genetics.

2.3 Culture types: collection and maintenance.

Unit-III Detection of Microorganisms in Foods

3.1 Principles and techniques,

3.2 Rapid methods vs. Conventional methods,

3.3 Estimation of microbial toxins, metabolites, inhibitory substances and pathogens.

Unit-IV Differentiation of Bacterial Strains by Electrophoretic Protein Profiles

4.1 Concept and methodology

Unit-V Bacterial Properties

5.1 Probiotic and proteolytic properties of different bacteria

Unit-VI Phages

6.1 Isolation and titration of bacteriophages

Unit-VII Food Safety

7.1 Traditional and current approaches to microbial food safety and quality

Unit-VIII Genetically Modified Microorganisms and their Application in Foods

8.1 What are GMO?

8.2 Pros and cons

8.3 Regulatory requirements

Unit-IX Practical

9.1 Microbial preservation techniques: slants, deep freezing, lyophilization

9.2 Detection of microorganism in food samples

9.3 Automated rapid and conventional detection methods for microbial toxins, metabolites

9.4 Inhibitory substances, pathogens and bacteriophages through HPLC, GC, ELISA, PCR and cell culturing

9.5 Electrophoretic protein profiles of bacteria

- **Teaching learning strategies**

1. Lectures
2. Tutorial
3. Group Discussion
4. Assignment/Seminar/ Class presentation
5. Workshop
6. Guest speaker
7. Quiz test/ oral test
8. Lab./practical work
9. Industrial Visits

- **Assignments-Types and number with calendar**

Students will work in groups of two on a randomly assigned food microbiology topic. Each group will submit a written report on the assigned topic. The last five classes will be dedicated to student presentations (20 minutes for each topic). It is expected that each student will present (10 minutes each). A class-based discussion (5 minutes) will follow the presentation. Details on the group presentation will be shared through email.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	This will be based on a test
2.	Formative Assessment	25%	Classroom participation, attendance, assignments, presentations, attitude and behaviour, hands-on-activities, short tests, quizzes etc
3.	Final Assessment	40%	Written Test but can also include a term paper, research proposal development, field work and report writing etc

- **Books Recommended/ Suggested Readings**
  - **Books**

1. Adams MR and Moss MO. 2000. Food Microbiology. Royal Society of Chemistry, London, UK.

2. David AA, Janet EL, Corry BS and Rosamund MB. 2005. Essentials of the Microbiology of Foods: A Textbook of Advanced Studies. John Wiley and Sons, New York.

3. Doyle MP, Beuchat LR and Montvile T. 2001. Food Microbiology: Fundamentals and Frontiers. Centre for Food Safety, University of Georgia, Georgia, USA.

4. Jay MJ. 1996. Modern Food Microbiology. CBS Publishers, New Delhi, India.

5. Montville TJ, Matthews KR and Kniel KE. 2012. Food Microbiology: An Introduction. ASM Press, USA.

6. Ray B. and Bhunia A. 2013. Fundamental Food Microbiology. 5th edition. CRC Press, USA.

7. Spencer JFT and De Spancer ALR. 2001. Methods in Biotechnology: Food Microbiology Protocols. Human Press, New Jersey, USA.

8. Thomas A.M. 2003. Detecting Pathogens in Food. CRC press, USA.

9. Willey JM. 2014. Prescott's Microbiology. Paperback, McGraw Hill Higher Education, USA.

  - **Journal Articles/ Reports**

1. Applied and Environmental Microbiology
2. Journal of Agricultural and Food Chemistry
3. Journal of Biotechnology
4. Trends in Food Science & Technology

Annexure I for M.Phil. scheme of studies, comparison of previous and new courses
Pages 44-69

Annexure I for M.Phil. scheme of studies: Comparison of previous and new courses

Scheme of studies for M.S./M.Phil. degree in Biological Sciences

Previously Approved Courses	**Updated Courses**
Course SBS 501 Biochemistry I **2 Credits** **Objectives:** This course aims an overall review of some of the chemical and physical principles involved in the living systems, as well as the nature, properties and functions of the biomolecules. This course shall lay foundations for all the students, who come from different relevant degree programs, to understand the structure and processes in the living systems at molecular level. **Contents:** This course comprises: a. Chemical and physical foundations thermodynamics and kinetics redox states, water, pH, acid-base reactions, and buffers, solutions and equilibria, solute-solvent interactions, chemical interactions and bonding, chemical reaction mechanisms. b. Biomolecules: Structure, assembly, organization, and dynamics small molecules, macromolecules (for example,	**Course SBS 501 Structures and Physico-Chemical Properties of Biomolecules** **2 Credits (2+0)** **Objectives:** This course aims an overall review of the basic knowledge that life exists as an array of biomolecules, the structural, physical and chemical properties of which are responsible for all life. **Outcomes:** After studying this course, the students will: 1. Understand the chemical and physical principles involved in the living systems 2. Understand the nature, properties and functions of the biomolecules. 3. Understand the structure and processes in the living systems at molecular level in order to make their foundation strong. **Contents:** Please see pages 10-11 of M.Phil. syllabus **Major Differences:** 1. Name changed.

nucleic acids, polysaccharides, proteins, and complex lipids) supramolecular complexes (for example, membranes, ribosomes, and multienzyme, and multienzyme complexes). c. Catalysis and binding enzyme reaction mechanisms and kinetics, ligand-protein interaction (for example, hormone receptors, substrates and effectors, transport proteins, and antigen-antibody interactions). **Impact:** This course shall lay a foundation for all the students coming from different relevant institutions, for better understanding of the other courses and studies in the School. ***Books Recommended:*** 1. Nelson, D. L. and Cox, M.M., 2013. *Lehninger's Principles of Biochemistry*. 6th Edition. W.H. Freeman, USA. 2. Voet, D. and Voet, J.G. and Pratt, C.W., 2017. *Fundamentals of Biochemistry.* 5th Edition. John Wiley.	2. Topics have been made more comprehensive. 3. Books have been updated. 4. Formatted according to HEC criteria.

3. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J. and Stryer, L., 2015. *Biochemistry*. W.H. Freeman, San Francisco.	
Course SBS 509 Protein Chemistry & Enzymology 2 Credits This is a practical course involving large scale production of some enzymes for commercial purpose. The students will be required to follow a protocol for isolation and purification of transaminases (GOT, GPT), trypsin, chymotrypsin, etc. from animal tissues. Each student shall study kinetics experimentally of at least one enzyme. Every student will prepare his/her own enzyme. ***Books Recommended:*** Hand-outs/Lab Instructions provided by the Instructor.	**Course SBS 502 Physicochemical Principles of Proteins and Enzymes 2 Credits (0+2)** **Objectives:** The objective of this course is to provide students a practical know-how of physicochemical principles and properties of proteins, enzymes, kinetics and large scale production of some enzymes of commercial importance. **Outcomes:** This course will provide students, intensive hands-on training on how to: 1. Study and interpret the physical and chemical properties of proteins. 2. Isolate enzymes from biological sources and determine their biochemical parameters. **Contents:** Please see pages 12-13 of M.Phil. syllabus **Major changes** 1. Name changed. 2. Course contents of practicals are revised. 3. Formatted according to HEC criteria
Not offered	**Course SBS 503 Frontiers in Molecular Biology I 1 Credits (1+0)**

	Objectives: The objective of this course is to provide students a thorough understanding of critical review of manuscripts • **Outcomes:** After studying this course, the students will: 1. Learn and understand how advanced scientific techniques are developed in light of various discoveries. 2. Develop an understanding to carry out the research projects in a better way. **Newly offered course** **Contents:** Please see pages14-15 of MPhil syllabus
Course SBS 504 Molecular Biology **3 Credits** **Objectives:** The objective of this course is to review the structure and some specialized features of the genomes. It shall cover the structures of DNA and RNA and the processes of DNA replication, transcription and translation, as well as regulation of these processes. This course shall help the students coming from different relevant degree programs to understand better the advanced and specialized areas of study. **Contents:**	**Course SBS 504 Molecular Biology** **2 Credits (2+0)** **Objectives:** The objective of this course is to review the structure and some specialized features of the related to DNA and RNA. **Outcomes:** After completion of the course, the students will: 1. Learn the nature of the genetic structure and some specialized features of the genomes. 2. Understand structures of DNA and RNA

This Course comprises: a. Genomics, genome structure, physical mapping, repeated DNA and gene families, gene identification, transposable elements. b. Genome maintenance DNA replication, DNA damage and repair, DNA modification, DNA recombination and gene conversion. c. Gene expression, the genetic code, transcription, RNA processing, translation. d. Gene regulation in prokaryotes positive and negative control of the operon, promoter recognition by RNA polymerases, attenuation and antitermination. e. Gene regulation in eukaryotes *cis*-acting regulatory factors, gene rearrangements and amplifications. **Practicals:** Expression of cloned gene in *E.coli* and yeast cells. Detection and analysis of proteins expressed from cloned genes. **Impact:** The students shall learn the nature of the genetic structure and translation of the genes into proteins, which are vital for the various functions in the living cells.	3. Grasp the processes of DNA replication, transcription and translation, as well as regulation of these processes. 4. Understand better the advanced and specialized areas of study and to benefit substantially even if coming from different relevant degree programs. **Contents:** Please see pages 22-24 of M.Phil. syllabus **Major Differences:** 1. Topics on Protein synthesis, Regulation of translation, posttranslational modification added. 2. Portion related to genomics removed and is being offered as an independent course SBS 514. Therefore, credit hours are reduced from 3 to 2. 3. This course formatted according to HEC criteria. 4. Books have been updated.

Books Recommended: 1.Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R., 2014. *Molecular Biology of the Gene*. 7th Edition. Garland Publishing Inc., New York. 2.Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T., 2014. Lewin's *Gene XI*. Jones and Bartlett Learning, Benjamin Cummings. 3.Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J. and Stryer, L., 2015. *Biochemistry*. W.H. Freeman, San Francisco. 4.Malacinski, G.M., 2005. *Essentials of Molecular Biology*. Third Edition. Jones and Bartlett Publishers. 5.Weaver, R.F., 2012. *Molecular Biology*. Fifth Edition. McGraw Hill. 6.Watson, J.D. and Gilman, M., 2006. *Recombinant DNA*: Genes and Genomes – a short course. Third Edition. W.H. Freeman, New York. 7.Brown, T.A., 2002. *Genomes II.* John Wiley & Sons.	
Course SBS 510 Molecular Biology Lab	**Course SBS 505 Molecular Biology Lab**

0+3 Credits	2 Credits (0+2)
This is a practical course involving different DNA & RNA techniques such as extraction, isolation, purification and estimations, restriction analysis, fractionation on agarose gel, PCR analysis etc. Every student will be required to work individually on DNA and RNA isolated and purified from prokaryotic and Eukaryotic cells. Calibration of pipettes, Preparation of Ninhydrin and Glycine solutions, Preparation and sterilization of LB medium, Pouring and streaking of plates, Inoculum and glycerol stocks preparation, Small scale preparation of plasmids, Large scale preparation of plasmids, UV and gel quantification, Restriction analysis (single and double restriction digestion), Preparation of competent cells, Transformation, Cloning (Gene clean, ligation, transformation), PCR. (pT7.7, pbecks, pTrc HisA, pTrc HisB, pTrc HisC, pET 21a, pET22b, pET11a, Blue Script) Strains: BL21 (simple), $BL21C^{+}$ ***Books Recommended:*** 1. Green, M.R. and Sambrook, J., 2012. *Molecular Cloning – A Laboratory Manual*. 4^{th} Edition. Cold Spring Harbor Laboratory, Long Island, New York.	**Objectives:** The objective of this course is to provide practical knowledge about Molecular and Cell Biology. **Outcomes:** This course will help the students from different backgrounds to: 1. Attain a firm grasp on practical aspects of Molecular Biology. 2. Attain a firm grasp on practical aspects of Cell Biology. **Contents:** Please see pages 16-17 of M.Phil. syllabus **Major Differences:** 1. Course updated 2. Formatted according to HEC criteria

Course SBS 503 Cell Biology I 3 credits	**Course SBS 506 Cell Biology 3 Credits (2+ 1)**
Objectives: This course aims at understanding the structural and functional aspects of various cellular organelles. The evolution and differentiation of membrane system will be highlighted. The integration of genetic material and various metabolic processes in the cytoplasm will be elucidated. **Contents:** This Course comprises: a. Cellular compartments of prokaryotes and eukaryotes: organization, dynamics, and functions cellular membrane systems (structure and transport), nucleus (envelope and matrix), mitochondria and chloroplasts (including biogenesis and evolution). b. Replication, Transcription, Protein synthesis and processing, regulation of translation, posttranslational modification, intracellular trafficking, secretion and endocytosis. **Practicals:**	**Objectives:** This course aims at understanding the structural and functional aspects of various cellular and subcellular structures in the cytosol, which are the basis of various important cellular activities/functions, such as mobility, locomotion, contraction, adhesion, communication and cell division. The evolution and differentiation of membrane system will be highlighted. The integration of genetic material and various metabolic processes in the cytoplasm will be elucidated. **Outcomes:** The course will enable the students to: 1. Relate various structures of the cell to variety of functions the cells. 2. Understand about intercommunication of cells, their contractility, and regulatory mechanism of cell division. 3. Understand the various physiological and genetic aspects of organisms. **Contents:** Please see pages 25-27 of M.Phil. syllabus **Major Differences:**

Study of various cellular components of dividing cells and those in the interphase period. Cell fractionation, *in vitro* protein synthesis. **Impact:** The course will enable the students to relate various structures of the cell to variety of functions the cells are capable of performing. This will also lay the foundation for understanding various physiological and genetic aspects of organisms. ***Books Recommended:*** 1. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P., 2013. *Essential Cell Biology*. 4th Edition. Garland Science, Taylor and Francis Group. 2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter P., 2015. *Molecular Biology of the Cell.* 6th Edition. Garland Publishers. 3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Scott, M. P., 2012. *Molecular Cell Biology* .7th International Edition. W. H. Freeman & Company.	1. Cell Biology I and II courses merged. 2. Topics on Replication, Transcription, Protein synthesis and processing, regulation of translation, posttranslational modification moved to Molecular Biology course 3. Practical added 4. Books have been updated. 5. Formatted according to HEC criteria.

Course SBS 504 Cell Biology II 1 credit **Objectives:** This course will focus on the subcellular structures in the cytosol, which are the basis of various important cellular activities/functions, such as mobility, locomotion, contraction, adhesion, communication and cell division. **Contents:** This Course comprises: a. Cell surface and communication extracellular matrix (including cell walls), cell adhesion and junctions signal transduction, receptor function, and excitable membrane systems. b. Cytoskeleton, motility, and shape actin-based systems (including muscle contraction), microtubule-based systems intermediate filaments prokaryotic system. c. Cell division, differentiation, and development, bacterial division, meiosis and gametogenesis, eukaryotic cell cycles, mitosis, and cytokinesis, fertilization and early	The course is discontinued. The course content has been included in the new course SBS 506. Please see above.

embryonic development (including positional information, homeotic genes, tissue-specific expression, nuclear and cytoplasmic interactions, growth factors and induction, environment, and polarity). **Impact:** The course shall provide an understanding about intercommunication of cells, their contractility, and regulatory mechanism of cell division. ***Books Recommended:*** 1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter P., 2015. *Molecular Biology of the Cell*. 6th Edition. Garland Publishers. 2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Scott, M. P., 2012. Molecular Cell Biology 7th International Edition. W. H. Freeman & Company. 3. Karp, G., 2007. *Cell and Molecular Biology. Concepts and Experiments*. Fifth Edition. John Wiley. 4. Pollard, T.D. and Earnshaw, W.C., 2002. *Cell Biology*. Saunders, Philadelphia.	

Course SBS 502 Biochemistry II **3 Credits** **Objectives:** This course aims to cover the major processes involved in energy transfer in the living systems. It shall include regulation and integration of major metabolic pathways for synthesis and degradation of macromolecules, as well as the energy transformation processes. **Contents:** This Course comprises: a. Major metabolic pathways, carbon, nitrogen, and sulfur assimilation, anabolism, catabolism, synthesis and degradation of macromolecules. b. Bioenergetics (including respiration and photosynthesis), energy transformations at the substrate level, electron transport, proton and chemical gradients, energy coupling (phosphorylation and transport). c. Regulation and integration of metabolism, covalent modification of enzymes, allosteric regulation, compartmentation, hormones.	**Course SBS 507 Metabolic Pathways and Their Integration** **2 Credits (2+0)** **Objectives:** This course aims to cover the major processes involved in energy transfer in the living systems. It shall include regulation and integration of major metabolic pathways. **Outcomes:** The course will enable the students to: 1. Understand the major processes involved in energy transfer in the living systems. 2. Grasp regulation and integration of major metabolic pathways. 3. Understand the processes of energy utilization and its production in the living systems, through the various biochemical pathways. **Contents:** Please see pages 25-27 of M.Phil. syllabus **Major Differences:** 1. Name changed. 2. Credit hours reduced. 3. Books have been updated. 4. Formatted according to HEC criteria.

Practicals:

Estimations of various biochemical components and metabolites of cell.

Impact:

This course shall provide an understanding of the processes of energy utilization and its production in the living systems, through the various biochemical pathways.

Books Recommended:

1. Nelson, D. L. and Cox, M.M., 2013. *Lehninger's Principles of Biochemistry*. 6th Edition. W.H. Freeman, USA.

2. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J. and Stryer, L., 2015. *Biochemistry*. W.H. Freeman, San Francisco.

3. Horton, H.R., Moran, L.A., Ochs, R.S., Rawn, J.D., and Scrimgeour, K.G., 2005. *Principles of Biochemistry*. Fourth Edition. Prentice Hall.

4. Voet, D. and Voet, J.G. and Pratt, C.W., 2017. *Fundamentals of*

Biochemistry. 5th Edition. John Wiley.	
Course SBS 508 Analytical & Mechanistic Enzymology 2 credits The students will be required to solve some theoretical problems regarding rate of enzyme reaction under different concentrations of substrate and enzyme, effect of pH and temperature, determination of Km values, mechanism of action of some enzymes, etc. ***Books Recommended:*** 1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J. and Stryer, L., 2015. *Biochemistry*. W.H. Freeman, San Francisco. 2. Nelson, D. L. and Cox, M.M., 2013. *Lehninger's Principles of Biochemistry*. 6th Edition. W.H. Freeman, USA. 3. Voet, D. and Voet, J.G. and Pratt, C.W., 2017. *Fundamentals of Biochemistry.* 5th edition. John Wiley	**Course SBS 508 Analytical & Mechanistic Enzymology 1 Credit (1+0)** **Objectives:** The objective of this course is to provide students all-inclusive knowledge of analytical enzymology with problem solving approach and mechanistic enzymology of important metabolic enzymes. **Outcomes:** The course will enable the students to: 1. Acquire comprehensive knowledge of analytical and mechanistic enzymology. 2. Understand analytical protein chemistry, and mechanisms involved in structural-function relationship of enzymes. **Contents:** Please see pages 30-31 of M.Phil. syllabus **Major changes** 1. Credit hours reduced. 2. Formatted according to HEC criteria
Not offered	**Course SBS 509 Frontiers in Molecular Biology II 1 Credits (1+0)** **Outcomes:** The course will enable the students to:

	1. Figure out the most significant facts and findings from a research article 2. Comprehend and summarize research findings in the form of a scientific abstract/summary. **Newly offered course.** **Contents:** Please see pages 32-33 of M.Phil. syllabus
Course SBS 506 General & Medical Genetics 3 Credits **Objectives:** This purpose of this course to expose the students to different Mendelian Laws of Inheritance, variety of mutations in the genome leading to different genetic diseases and make them understand the significance of inbreeding in a population with chromosomal aberrations and or point mutations. The object is also to relate the genetic mutations with tumor and cancer development. This course should make the students wiser in terms of consequences of cousin marriages if a recessive mutation exists in the family. **Contents:** This Course comprises**:** a. Genetic foundations, mendelian and non-mendelian inheritance, transformation, transduction, and conjugation, recombination and complementation, mutational analysis, genetic mapping and linkage analysis.	**Course SBS 510 General & Medical Genetics 3 Credits (2+1)** **Objectives:** The purpose of this course is to expose the students to different Mendelian Laws of Inheritance, variety of mutations in the genome leading to different genetic diseases and make them understand the significance of inbreeding in a population with chromosomal aberrations and or point mutations. The object is also to relate the genetic mutations with tumor and cancer development. This course should make the students wiser in terms of consequences of cousin marriages if a recessive mutation exists in the family. **Outcomes:** After completion of the course, the students will: 1. Understand the mechanism of gene expression

b. Chromatin and chromosomes karyotypes, translocations, inversions, deletions, and duplications, aneuploidy and polyploidy structure. c. Human genome, Pattern of single gene inheritance. Genetic variation in human population. Gene mapping. Clinical cytogenetics. Principles of molecular diseases. d. Genetics of disorder with complex inheritance. Cancer genetics. diagnosis, prevention and treatment of genetic disorders. Genetic counseling and risk assessment. **Practicals:** Genetics of common human traits, Pedigrees based on human genetic diseases, site directed mutagenesis **Impact:** The students will learn the mechanism of gene expression and about the processes involved in the formation of specific structural and or enzymatic proteins. They will also understand the development and inheritance of genetic disease due to non-expression or improper expression of the defective genes. ***Books Recommended:***	2. Understand the processes involved in the formation of specific structural and or enzymatic proteins 3. Understand the development and inheritance of genetic disease due to non-expression or improper expression of the defective genes. **Contents:** Please see pages 18-19 of M.Phil. syllabus **Major Differences:** 1. Book list updated. 2. Formatted according to HEC criteria.

1. Nussbaum, R., McInnes, R., Thompson, H.W. 2004. *Genetics in Medicine.* Saunders.

2. Klug, W.S., Cummings, M, 2008. *The Essentials of Genetics.* Sixth Edition. Prentice Hall.

3. Lewis, R., 2005. *Human Genetics.* McGraw Hill.
4. Jorde, L., Bamshad, M., White, R., 2003.*Medical Genetics.* Mosby.
5. Pritchard, D., Korf, B., 2003. *Medical Genetics at a Glance.* Blackwell.
6. Tamarin, R.H., 2001. *Principles of Genetic.* McGraw Hill.
7. Brooker, R.J., Leland, H., Leroy, H., Michael, G.L., Silver, L., Lee, M., Veres, R.C. and Ann, R., 2008. *Genetics: Analysis and Principles.* McGraw Hill.
8. Jack, J.P. *An Introduction to Human Medical Genetics*. John Wiley, N.J.
9. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., and Doebley, J., 2015. *An Introduction to Genetic Analysis.* 11th Edition. W.H. Freeman, New York.
10. Strachan, T. and Read, A., 2011. *Human Molecular Genetics.* 4th Edition. Garland Science.

Course SBS 507 Virology **1 Credit**

Course SBS 511 Fundamentals of Virology **2 Credits (2+0)**

Objectives: The objective of this course is to provide broad and general knowledge of modern Virology. Briefly, this course will elaborate the structures and replication strategies of different RNA and DNA viruses. On the other hand, the detailed discussion on host factors required for a virus survival, viral mechanism of host defense maneuvering and outcomes of viral infection will be the part of this course. Finally, fundamental strategies to hamper viral infections will also be discussed during this course. **Contents:** Viral classification and structure**.** Bacteriophages and animal and plant viruses, genome replication and regulation, virus assembly, virus-host interactions. viral pathogenesis, RNA transforming viruses, DNA transforming viruses. Host defense mechanisms. Vaccines. Ativirus drugs. Research methodologies in Virus research. **Impact:** This course will help the students from different background to understand the fundamentals of molecular virology and host pathogen interactions. It will spark the student's interest about the research in the virology related disciplines.	**Objectives:** The objective of this course is to provide the broad knowledge about modern Virology. Briefly, this course will elaborate the structures and replication strategies of different RNA and DNA viruses. On the other hand, the detailed discussion on host factors required for a virus survival, viral mechanism of host defense maneuvering and outcomes of viral infection will be the part of this course. Finally, fundamental strategies to study viruses will also be discussed during this course. **Outcomes:** The course will enable the students to: 1. Understand the fundamentals of molecular virology and host pathogen interactions. 2. Develop an interest regarding research in virology related disciplines. **Contents:** Please see pages 34-35 of M.Phil. syllabus **Major changes** 1. Name changed. 2. The course will be taught in more detail. Therefore, credit hours have been increased. 3. Books updated. 4. Formatted according to HEC criteria

Books Recommended:

1. Flint, S.J., Enquist, L.W., Krug, R.M., Racaniello, V.R., and Skalka, A.M., 2003. *Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses. Second Edition.* ASM Press.

2. Knipe, D.M. and Howley, P.M., 2001. *Fundamental Virology.* Lipponcott Williams and Wilkins.

3. Wagner, E.K. and Hewlett, M.J. 2004. *Basic Virology*. Blackwell.

Course SBS 510 Cancer Biology

2 Credits

The major purpose of this module is to provide the students a broad introduction to the cellular, genetic and molecular basis of cancer. Familiarizing the students with experimental techniques routinely performed in oncology research labs is also included in the objectives of this course.

Contents:

The basic components of carcinogenesis: inflammation, tumour suppressor genes and oncogenes, environmental agents and cancer causing viruses. Mechanism of cell transformation. Overview of the cancer development: initiation, progression,

Course SBS 512 Cancer Biology

2 Credits (2+0)

Objectives:

The major purpose of this course is to provide the students a broad introduction to the cellular, genetic and molecular basis of cancer. Familiarizing the students with experimental techniques routinely performed in oncology research labs is also included in the objectives of this course.

Outcomes:

The course will enable the students to:

1. Understand the cellular, genetic and molecular basis of cancer.

invasion and metastasis. Tumour microenvironment. Cancer pathways. Molecular and cellular hallmarks of cancer. Cancer epigenetics. Cancer therapeutics. Molecular oncology research skills. **Impact:** This course will help the student in understanding the basis of tumourigenesis and research methodologies used in cancer research. It will be helpful for students to pursue a research career in the field of Oncology. **Books Recommended:** 1. Winber, R.A., *The Biology of Cancer*, by 2nd Edition, ISBN-13: 978-0815342205. 2. Pecorino,L., *Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics*, 3rd edition, ISBN: 9780199577170	2. Learn the research methodologies used in cancer research. 3. Attain knowledge to pursue a research career in the field of Oncology. **Contents:** Please see pages 36-37 of M.Phil. syllabus **Major Differences:** 1. Books have been updated. 2. Formatted according to HEC criteria.
Course SBS 512 Research Ethics 2 Credits This course involves teaching sessions and case studies that would educate the students about the ethics of responsibly conducting research, authorship and ownership of data issues and use of humans and animals in biomedical experimentation.	**Course SBS 513 Research Ethics 2 Credits (2+0)** **Objectives:** This course involves scientific research ethics regarding conducting experiments, writing papers and collaboration. **Outcomes:**

Topics include:
• Research ethics
  ○ Responsible conduct of research
  ○ Scientific misconduct
  ○ Characteristics of the mentor - trainee relationship
  ○ Conflict of Interest
• Authorship
  ○ Scientific publications and authorship
  ○ Guidelines for authorship
  ○ Emerging trends and policies
• Scientific record keeping
  ○ Why do we keep record?
  ○ Data ownership
  ○ Data storage and retention
• Use of Humans and animals in biomedical experimentation
  ○ Ethical challenges to the use of animals in research
  ○ Constraints on the behavior of scientists
  ○ The issues of informed consent in research involving humans
Case Study: The cases related to the above topics would be presented to the students and each case would be discussed in detail to build the sense of responsible scientific behavior.
 	
Imapact:
	After completion of the course, the students will:
	1. Understand about the ethics of responsibly conducting research, authorship and ownership of data issues and use of humans and animals in biomedical experimentation.
	2. Understand the responsibilities, rights and limits of a researcher while conducting research in a group without compromising scientific integrity and mutual benefit.
	
	Contents: Please see pages 20-21 of M.Phil. syllabus
	
	Major Differences:
	Formatted according to HEC criteria.

The students would be equipped with the knowledge of responsibilities, rights and limits of a researcher while conducting research in a group without compromising scientific integrity and mutual benefit. ***Books Recommended:*** 1. Macrina. F.L., 2010. *Scientific Integrity*. ASM press. pp 402. 2. Shamoo, A.E. and Resnik, D.B., 2003. *Responsible conduct of research*. Oxford University Press. pp 339. 3. Sandøe,P., Jensen, K.K. and Whiteley, L., 2017. *RCR – A textbook for courses in Responsible Conduct of Research*. Department of Food and Resource Economics, University of Copenhagen pp110.	
Course SBS 505 Molecular Biology **3 Credits** **Objectives:** The objective of this course is to review the structure and some specialized features of the genomes. It shall cover the structures of DNA and RNA and the processes of DNA replication, transcription and translation, as well as regulation of these processes. This course shall help the students coming from	**Course SBS 514 Genomics** **2 Credits** **(2+0)** **Objectives:** The objective of this course is to review the structure and some specialized features of the genomes. **Outcomes:**

different relevant degree programs to understand better the advanced and specialized areas of study. **Contents:** This Course comprises: a. Genomics, genome structure, physical mapping, repeated DNA and gene families, gene identification, transposable elements. b. Genome maintenance DNA replication, DNA damage and repair, DNA modification, DNA recombination and gene conversion. c. Gene expression, the genetic code, transcription, RNA processing, translation. d. Gene regulation in prokaryotes positive and negative control of the operon, promoter recognition by RNA polymerases, attenuation and antitermination. e. Gene regulation in eukaryotes *cis*-acting regulatory factors, gene rearrangements and amplifications. **Practicals:**	After completion of the course the students will: 1. Acquire knowledge to appreciate genome as a whole. 2. Understand techniques involved in elucidating structure and function of genomes **Contents:** Please see pages 38-40 of M.Phil. syllabus **Major Differences:** 1. The course Genomics was part of SBS 505 Molecular Biology. Extensive details have been added to all individual topics related to genomics and study of genomes. Information about variations, shotgun sequencing and massively parallel sequencing has been introduced. Data analyses related to genomes will be practically taught as well. 2. Formatted according to HEC criteria.

Expression of cloned gene in *E.coli* and yeast cells. Detection and analysis of proteins expressed from cloned genes.

Impact:

The students shall learn the nature of the genetic structure and translation of the genes into proteins, which are vital for the various functions in the living cells.

Books Recommended:

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R., 2014. *Molecular Biology of the Gene*. 7th Edition. Garland Publishing Inc., New York.

2. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T., 2014. Lewin's *Gene XI*. Jones and Bartlett Learning, Benjamin Cummings.

3. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J. and Stryer, L., 2015. *Biochemistry*. W.H. Freeman, San Francisco.

4. Malacinski, G.M., 2005. *Essentials of Molecular Biology*. Third Edition. Jones and Bartlett Publishers.

5. Weaver, R.F., 2012. *Molecular Biology*. Fifth Edition. McGraw Hill. 6. Watson, J.D. and Gilman, M., 2006. *Recombinant DNA*: Genes and Genomes – a short course. Third Edition. W.H. Freeman, New York. 7. Brown, T.A., 2002. *Genomes II.* John Wiley & Sons.	
Not offered	**Course SBS 515 Advanced Food Microbiology 3 Credits (2+1)** **Objectives:** The students will attain a firm grasp on microbial biology as it pertains to food. **Outcomes:** On completion of this course the students will: 1. Understand about foodborne microorganisms. 2. Gain thorough knowledge of the importance/role of microorganisms in food processing, preservation and waste management. 3. Understand basic molecular biology and other cutting-edge techniques to detect and identify microorganisms associated with foods. 4. Understand techniques to manipulate microbial cells for various processes involved in food biotechnology.

	5. Understand to read and communicate current literature of food borne microorganisms. **Newly offered course.** **Contents:** Please see pages 41-43 of M.Phil. syllabus
Course SBS 513 Research project 6 (0+6) Credits A student will submit a dissertation, prepared according to the prescribed format approved by the University of the Punjab for M.Phil. degree, after completion of the experimental work undertaken for the research project under the supervision of an SBS faculty member. The student will defend the thesis before the External and Internal Examiners appointed by the University for this purpose.	**Course SBS 516 Research Thesis** **6 (0+6) Credits** A student will submit a dissertation, prepared according to the prescribed format approved by the University of the Punjab for M.S./M.Phil. degree, after completion of the experimental work undertaken for the research project under the supervision of an SBS faculty member. The student will defend the thesis before the External and Internal Examiners appointed by the University for this purpose. **Major Differences:** Name has been changed