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 Ph.D. Program

Curricula/Syllabi of Ph.D. Program

Program Title: Ph.D.

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 Southampton University, 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 Ph.D. degree, candidates need to complete 18 credit hours of course work along with a 6

credit hours for research work/thesis. 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 man-power 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 Ph.D. 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 programwas 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 Ph.D. degree in Biological Sciences, since almost 150 apply every year for admission against the 15 seats. The students use these degrees for subsequent careers in 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 in 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 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 Ph.D. Programs", as outlined by the HEC.

- **Years of studies completed:** 18yrs—M.S. / M.Phil. or equivalent terminal degree in any field of Biological Sciences (Biological Sciences, Botany, Zoology, Molecular Biology, Microbiology, Genetics, Biochemistry or equivalent) with 1st. Div / CGPA equal or greater than 3.0 / OPM 70% after acquisition of 18 years education (http://pu.edu.pk/dpcc/rule_eligibility.htm).
- **Study Program/Subject.** Candidates must have completed their last terminal degree in any field of Biological Science (Biological Sciences, Botany, Zoology, Molecular Biology, Microbiology, Genetics, Biochemistry or equivalent)
- **Percentage/CGPA:** Either M.S./M.Phil. CGPA 3 is required to be eligible for M.Phil. admission (http://pu.edu.pk/dpcc/rule_eligibility.htm).
- **Entry test.** The candidates must secure 70% marks each in the entry test and the interview. % as per HEC Policy approved by Advanced Studies and Research Board (ASRB), in its meeting held on 20.01.2016. 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. A candidate must obtain at least 20 marks in the academic qualification, 28/40 marks for PhD entrance test and 5/10 marks in the interview separately to be eligible for admission.

  1) Publications in HEC approved journals - (1 Mark per publication)-05 Marks

  2) Professional experience in relevant field - 05 Marks (One Mark for each year for job in the relevant field / as per departmental preference)

7. Duration of the Program

2 semesters course work / **Minimum** 2 years research, **Usual** 3 years research, **Allowed** 4 years research / 18 credit hours for course work.

Name of Program	Duration	No. of Modules	Total Credit Hrs
Ph.D. Program	3-5 Years	2 Semesters course work 2-4 years research work	18 hours + usually 3 years 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 (Optional)	8 (without Minor Elective and Optional)
2	9	2	2	1	1	3 (Optional)	11 (without Minor Elective and Optional)
3	None/Research	1					Full time
4	None/Research	1					Full time
5	None/Research	1					Full time
6	None/Research	1					Full time
7	None/Research	1					Full time
8	None/Research	1					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 1					
1.	SBS 701	**Journal Club 1**	Core	M.S. / M.Phil.in Life/Allied Sciences	2
2.	SBS 703	**Cloning and Gene Expression Modules**	Core	-do-	2
3	SBS 705	**Current Techniques in Biological Sciences**	Major Elective	-do-	2
4.	SBS 714	**Archaeal Diversity**	Minor Elective	-do-	2
5.	SBS 707	**Bioinformatics**	Major Elective	-do-	2
6.	SBS 715	**Advanced Food Biotechnology**	Optional	-do-	2+1
Total credit hours: 8 (excluding Minor Elective and Optional)					
Semester 2					
1.	SBS 702	**Cellular Pathways and Signal Transduction**	Basic	-do-	2
2.	SBS 704	**Protein Structure and Engineering Modules**	Core	-do-	2
3	SBS 706	**Journal Club 2**	Core	-do-	2
4.	SBS 708	**Immunology**	Basic	-do-	2
5.	SBS 713	**Functional Genomics**	Major Elective	-do-	2+1
6.	SBS 709	**Term Paper**	Optional	-do-	2
7.	SBS 710	**Scientific Writing**	Minor Elective	-do-	2
8.	SBS 711	**Forensic DNA Typing & Toxicology**	Optional	-do-	2
9.	SBS 712	**Forensic Microbiology & Entomology**	Optional	-do-	2
Total credit hours: 11 (excluding Minor Electives and Optional)					
Original Research Work leading to submission of a thesis for the award of Ph.D. degree					

#	Code	Course Title	Course Type	Prerequisite	Credit hours
Semester III-VIII					
1.	SBS 716	**Research Thesis**	Core/ Compulsory	-do-	Usually 3 years full time research
Minimum 2 years, Usual 3 years of research work, Allowed 4 years					

1. Type of course may be core (compulsory), basic (foundation), major elective (professional), minor elective (specialization) etc.

Research Thesis / Project /Internship

Usually comprised of 6 semesters-full time research (semester III to VIII)-3 years

10. Award of Degree

Areas of specialization in M.Phil. /M.S./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.

To qualify Ph.D. first two semesters and comprehensive examination, minimum 70% marks with 3.0 CGPA is required. (According to the rules given at http://pu.edu.pk/dpcc/rule_ examination.htm)

Thesis/Project/internship: Original research work leading to submission of thesis for the award of Ph.D. degree.

11. 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**

No.	Name	Designation	Area/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 Ratio: Ph.D. Faculty 40 : 23 or ~2 : 1

14. Course Outlines separately for each course

Attached below (Pages 10-50 Ph.D. syllabus)

School of Biological Sciences, University of the Punjab

Ph.D. Syllabus Content files

Pages 10-50

+ Annexure I

Pages 51-72

Ph.D. Semester 1 Syllabus

Course Title: Journal Club 1

Course code: SBS 701

Semester: 1st

Credit Hours: 2 (2+0)

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

  Students taking this course should have a M.S./ M.Phil. in any of the fields of Biological/Life Sciences.

- **Learning Outcomes**

This course will help students to:

1. Understand how discoveries are linked to developments and improvement in scientific techniques.
2. Acquire knowledge which will enhance their ability to apply these techniques during their research projects.

- **Contents**

Units I-II

UNIT-I Student-led Class Sessions

1.1 Presentations: Each student will be assigned to make a presentation about an advance scientific technique in the field of molecular biology.

1.2 Scientific articles: The presenter will describe in detail scientific articles about discovery and advances in that specific technique along with its purpose, procedure and applications.

1.3 Scientific technique: This scientific technique topic will be assigned at the beginning of the semester by the instructor.

UNIT-II Presentations

2.1 Presentation: Presentation by each student in front of the entire academic body of the department on critical analysis of a recently published research article in a scientific journal that focuses on these techniques.

2.2 Participation: Every student will be required to attend all the presentations and actively participate in the weekly Journal Club.

- **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**
    - **Books**

1. Junker BH, Schreiber F. 2011. Analysis of Biological Networks. John Wiley & Sons, Inc.
2. Toone EJ. 2006. Advances in Enzymology and Related Areas of Molecular Biology Volume 75. John Wiley & Sons, Inc.
3. Ulvskov P. 2010. Annual Plant Reviews: Plant Polysaccharides, Biosynthesis and Bioengineering. Volume 41, Blackwell Publishing Ltd.

    - **Journal Articles/ Reports**

Research articles from Nature, Science, PNAS, JBC among others

Course: Cloning and Gene Expression Modules

Course Code: SBS 703

Semester: 1st

Credits Hours: 2 (1 + 1)

Pre-requisite course requirement/skills

M.Phil. in Biological/Life Sciences. Students should have a basic understanding of

DNA recombinant technology like cloning, post transcriptional modifications and translational mechanism in prokaryotes and in eukaryotes.

Learning Outcomes

On completion of this course the students will:

1. Understand different techniques like site directed mutagenesis
2. Understand different strategies used in cloning along with the choice of various vectors that will help them in their future research.
3. Understand different transcriptional and translational factors present in different organisms
4. Attain knowledge of codon preference for different amino acids used by different organisms

Contents:

Units I-III

Unit-I Gene Cloning Module

1.1 Restriction endonucleases

1.2 Expression systems

1.3 Vectors and cloning techniques Selection of clones

Unit-II Gene Expression Module

2.1 Transcription in prokaryotes and Eukaryotes

2.2 Post transcriptional modifications

2.3 RNA editing and its significance

2.4 Translation in prokaryotes and eukaryotes

2.5 Post translational modifications

2.6 Regulation of gene expression

2.7 Familiarity with gene expression Terminology (with an aim to develop targeted comprehension)

Unit-III Practicals

3.1 Develop strategies to change specific amino acids, omit specific restriction sites in the given sequence and then clone it in vector provided

3.2 Students will find 5' and 3' regions of unknown sequences by appropriate technique.

3.3 Expression patterns: Students are provided individualized cDNA sequence and are required to identify, and give basis for identification

3.4 Predict structure of putative mRNA and polypeptide chain along with translational control elements and UTRs

3.5 Locate introns and exons in given genomic sequence to find, their canonical or non-canonical boundaries along with splice sites

3.6 Identify the various components of promoter element, ribosome binding site, initiator sequence, termination sequence and 3' and 5' UTRs

- **Teaching learning strategies**
  1. Lectures
  2. Tutorial
  3. Group Discussion
  4. Assignment/Seminar/ Class presentation
  5. Quiz test/ oral test
- **Assignments-Types and number with calendar**

Every student will be given two individualized problems to work for a specific time period. Students will submit solution for each problem in the form of a written document. It will be evaluated and oral presentations will be conducted These will take place before midterm as well before final assessments. For this course tutorial classes will be conducted that are compulsory for students.

Assessment and Examinations

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester as an exam
2	Formative Assessment	25%	Classroom participation, attendance, attitude and behavior, short tests, quizzes etc
3	Final Assessment	40%	Module submission and presentations along with test

- **Books Recommended/ Suggested Readings**

- **Books**

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.
2. Brown TA. 2016. Gene Cloning and DNA Analysis. 7th edition. Blackwell.
3. Dale JW, Von Schantz M. 2002. From Genes to Genome. 1st edition. John Wiley & Sons.
4. Green MR, Sambrook J. 2012. Molecular Cloning – A Laboratory Manual. 4th edition. Cold Spring Harbor Laboratory, Long Island, New York, USA.
5. Reece RJ. 2004. Analysis of Genes and Genomes. 1st edition. John Wiley& Sons.
6. 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.
7. Winnacker EL. 2003. From Genes to Clones. 1st edition Wiley-BVCH Verlag.

- **Journal Articles/ Reports**

1. Genome Medicine
2. Journal of Amino Acids
3. Journal of Biochemistry and Molecular Biology
4. Molecular Biotechnology

Course title: Current Techniques in Biological Sciences

Course code: SBS 705

Semester: 1st

Credit hours: 2 (2+0)

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

  M.Phil. in Biological Sciences and equivalent.

- **Learning Outcomes**

This course aims to deal with some of the recently developed and commonly used techniques for analysis and biological molecules and processes.

After course completion, the students shall:

1. Understand the principles of the recently developed and commonly used techniques for the study of biological molecules and processes.
2. Understand the applications of selected techniques for the study of biological molecules and processes.

- **Contents:**

  UNITS I-XI

  Unit-I Protein Fractionation

  Unit-II Mass Spectroscopy and Analysis of Proteins

  Unit-III Circular Dichroism and Secondary Structure Analysis of Proteins

  Unit-IV Plant Tissue Culture

  Unit-V Animal Cell Culture

  Unit-VI Ligase Free Cloning

  Unit-VII Restriction Mapping and Next Generation DNA Sequencing

  Unit-VIII Protein-DNA Interaction

  Unit-IX X-ray Structure Analysis of Protein Structure

  Unit-X Animal Transgenics

  Unit-XI CRISPR/Cas9 and Genome Editing

- **Teaching-learning Strategies**

  Series of multiple lectures given by faculty on the basis of their field of expertise, discussion and interactive sessions

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

Written assignments on various topics and quizzes will be conducted before midterm and final term exams.

- **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 MCQ test.

- **Books Recommended/ Suggested Readings**

1. Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA, Struhl K. 2003. Current Protocols in Molecular Biology. John Wiley & Sons, New York.
2. Green MR, Sambrook J. 2012. Molecular Cloning: A Laboratory Manual. 4th Edition. Cold Spring Harbor Laboratory, Long Island, New York.
3. Ladd M. Palmer R. 2013. Structure determination by X-ray crystallography. 5th edition. Springer.
4. Metzker M L. 2010. Sequencing Technologies: The Next Generation. Nature Reviews Genetics, 11: 31-46.
5. Venn RF. Ed. 2008. Principles and Practice of Bioanalysis. 2nd Edition. CRC Press, Taylor and Francis Group.
6. Yamamoto T. Ed. 2015. Targeted Genome Editing Using Site-Specific Nucleases ZFNs, TALENs, and the CRISPR/Cas9 System. Springer, Japan.

Course Title: Archaeal Diversity

Course Code: SBS 714

Semester: 1st

Credit hours: 2 (2+0)

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

This course is designed for Ph.D. students who are expected to know about basic cell structure, structural units, compositions, biochemical pathways, and fundamental processes of cell division, replication, transcription, and translation. Students are likely to have a basic knowledge of the diversity of life on the Earth and to know elementary principles that govern evolution.

- **Learning Outcomes**

On completion of the course, the students will:

1. Understand about the diversity of life in extreme environments, basic knowledge of extremophiles, their classification, and principles that govern protein stability in extremophiles.
2. Understand how extremophiles emerged in the tree of life.
3. Understand diversification from other domains of life.
4. Understand how microorganisms thrive under extreme conditions.

- **Contents:**

Units I-XI

Unit-I What are Archaea?

Unit-II History/Discovery of the Archaeal Domain

Unit-III Phylogenetic Tree

Unit-IV Differences in Archaea, Bacteria, and Eukarya

4.1 Structural features

4.2 Genomic differences

4.3 Functional distinctions

Unit-V Classification of Archaea

5.1 Basis of classification

5.2 Old and new members of Archaea

Unit-VI Halophiles

6.1 Features and characteristics

6.2 Cell structure and proteins conferring stability

Unit-VII Thermophiles

7.1 Features and characteristics

7.2 Cell structure and proteins conferring stability

7.3 Hyperthermophiles

Unit-VIII Methanogens

8.1 Features and characteristics

8.2 Cell structure and proteins conferring stability

Unit-IX Diversity of uncultivated Archaea

9.1 Discovery of new members

Unit-X Metabolic Pathways Distinct in Archaea

10.1 Distinct features

10.2 The difference between Archaea, Bacteria, and Eukarya

10.3 Metabolites production

Unit-XI Features of the Archaeal Genome

11.1 Genomes characteristics

11.2 The difference between Archaea, Bacteria, and Eukarya

- **Teaching learning strategies**
    1. Course Website
        a. www.thearchaea.com
        b. Lectures and reading materials are available on the above-said website.
    2. Lectures
    3. Group Discussion
    4. Class Assignment/Seminar and presentations on selected topics
    5. Guest speaker
    6. Quiz test/ oral test
    7. Latest research papers/reviews discussion
- **Assignments-Types and number with calendar**

Two Assignments, one before midterm and second afterward, will be given to students. Presentations on the selected topics (15 minutes on each topic) will continue throughout the course along with discussions and question/answer sessions.

- **Assessment and Examinations**

Sr. No.		Weightage	Details
1.	Midterm Assessment	35%	Written Exam will take place at the mid-point of the semester
2.	Formative Assessment	25%	It includes classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes
3.	Final Assessment	45%	It will be a test

- **Books Recommended/ Suggested Readings**

o **Books**

1. Barker DM. 2010. Archaea: salt-lovers, methane-makers, thermophiles, and other archaeans. Crabtree Publishing Company, USA.
2. Das S, Dash HR. 2018. Microbial diversity in the genomic era. 1st ed. Academic Press; USA.
3. Forterre P, Fagan TL. 2016. Microbes from Hell. 1st ed. University of Chicago Press; USA.
4. Garrett RA, Klenk HP. 2008. Archaea: evolution, physiology, and molecular biology. 1st ed. John Wiley & Sons, USA.
5. Kata SY. 2011.Archaea: Structure, Habitats, and Ecological Significance (Microbiology Research Advances). UK ed. Nova Biomedical, UK.
6. Watkins G. 2015. Encyclopedia of Archaea. Callisto Reference Publishers, USA.

o **Journal Articles/ Reports**

1. Britton KL, Baker PJ, Borges KM, Engel PC, Pasquo A, Rice DW, Robb FT, Scandurra R, Stillman TJ, Yip KS. 1995. Insights into thermal stability from a comparison of the glutamate dehydrogenases from Pyrococcus furiosus and Thermococcus litoralis. European Journal of Biochemistry. May;229(3):688-95.
2. dd Zillig W. 1991. Comparative biochemistry of Archaea and Bacteria. Current Opinion in Genetics & Development. Dec 1;1(4):544-51.
3. Eme L, Doolittle WF. 2015. Archaea. Current Biology. Oct 5;25(19):R851-5.

4. Li WT, Shriver JW, Reeve JN. 2000. Mutational analysis of differences in thermostability between histones from mesophilic and hyperthermophilic archaea. Journal of Bacteriology. Feb;182(3):812.
5. Macario AJ, Lange M, Ahring BK, De Macario EC. 1999. Stress genes and proteins in the archaea. Microbiology and Molecular Biology Reviews. Dec;63(4):923.

Course Title: Bioinformatics

Course Code: **SBS 707**

Semester: 1st

Credit hours: 2 (1 + 1)

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

Students should have adequate knowledge of Biological Sciences; they should possess basic computer skills and proficient with MS office and internet browsing.

- **Learning Outcomes**

This course would theoretically and practically equip the students to:

1. Develop strong bases of computational biology and fundamental computational methods
2. Understand and use current bioinformatics and computational tools in their research and data analysis.
3. Understand how to analyze, manage and display research data in a scientific manner.

- **Contents**

Units I-V

Unit-I Introduction, Background and History of Bioinformatics

1.1 Origin and advancement of bioinformatics

1.2 Bioinformatics and biological sciences

1.3 Sequence databases

1.4 Literature databases

1.5 Data and file formats

Unit-II Basic Tools of Bioinformatics

2.1 Data mining

2.2 Retrieving protein and nucleotide sequences

2.3 Pattern and motif discovery

2.4 Restriction analysis

2.5 BLAST and BLAT

2.6 Primer and probe designing

2.7 Multiple sequence alignment and phylogenetic analysis

2.8 Protein structure and function analysis

Unit-III Bioinformatics Resources for Biological Sciences

3.1 Whole genome sequence data

3.2 Genome browsers

3.3 Gene expression databases

3.4 Gene Ontology

3.5 Proteomic resources

3.6 Pathway analysis

3.7 Protein structure

Unit-IV Data Analysis and Presentation

4.1 Statistical analysis

4.2 Data presentation

4.3 Bibliography management

Unit-V Practicals

Students would practically use latest tools of bioinformatics and data analysis for solving biological problems. Students would learn using online and offline softwares

5.1 Primer3

5.2 NCBI Blast

5.3 Local blast

5.4 Protein structure prediction

5.5 BioEdit

5.6 Mega Prism GraphPad

5.7 EndNote

- **Teaching learning strategies**

1. Lectures
2. Tutorial
3. Group Discussion
4. Assignment/Seminar/ Class presentation
5. Quiz test/ oral test
6. Practical work

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

Students would be assigned problem-based questions related to the topics covered usually once a month and would be required to turn in the assignments by the next class.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written + Practical
2.	Formative Assessment	25%	Assignment
3.	Final Assessment	40%	Written + Practical

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

1. Boxvanis AD, Ouellette BF, Francis OB. 2005. Bioinformatics: A practical Guide to the Analysis of Genes and Proteins. John Wiley.

2. Mercado L. 2019. Exploring Bioinformatics: EDTECH.

3. Shaik NA, Hakeem KR, Banaganapalli B, Elango R (Eds.). 2019. Essentials of Bioinformatics, Volume I: Understanding Bioinformatics: Genes to Proteins (Vol. 1). Springer.

    - **Journal Articles/ Reports**

Latest articles from prestigious journals in the field would be recommended for class discussion

Course Title: Advanced Food Biotechnology

Course Code: SBS 715

Semester: 1st

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 the importance/role of microorganisms in food processing, preservation and waste management.
2. Understand the basic molecular biology techniques involved in food biotechnology.
3. Understand how to manipulate microbial cells for various processes involved in food biotechnology.
4. Understand international regulatory requirements with regard to genetically modified organisms and foods.

- **Contents**

Units 1-V

Unit-I Introduction, Background and History of Biotechnology

1.1 Biotechnology, food biotechnology

1.2 Recent advances and trends

1.3 Techniques and applications.

1.4 Use and issues of Genetically Modified Microorganisms in foods

Unit-II Principles of Microbiology and Fermentation Technology

2.1 Fermentation: types, equipment

2.2 Factors affecting the fermentation

2.3 Control of fermentation conditions

2.4 Fermentation kinetics

2.5 Stoichiometry

2.6 Bioreactors

2.7 Solid state bioprocessing and transformation

Unit-III Application of Biotechnology to Food Products

3.1 Yeast based products: Alcoholic beverages, industrial alcohols, baker's yeast, bread and related products

3.2 Bacteria based fermented products, dairy, meat and fish, vegetable, vinegar and organic acids, bacterial biomass

3.3 Mold based products

3.4 Other microbial based products: Enzymes, sweeteners, flavors, amino acids and vitamins

Unit-IV Food Safety and Regulatory Requirements

4.1 Food Safety: Safety evaluation of novel food products, genetically modified foods

Unit-V Practicals

5.1 Isolation, purification and maintenance of yeast and bacterial cultures

5.2 Aerobic and anaerobic fermentation and production of various fermented food products

5.3 Genomic DNA and plasmid extraction

5.4 Agarose gel electrophoresis application to food biotechnology

5.5 PCR, cloning and transformation pertinent to food biotechnology

5.6 Production of metabolites and enzymes, their purification

5.7 Testing and analysis of genetically modified foods; protein-based methods to detect the transgene product

5.8 DNA-based methods to detect the transgene or associated marker or regulatory sequences

- **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 biotechnology topic. Each group should submit a written report on the assigned topic. The last five classes will be dedicated to student presentations (20min for topic). It is expected that each student will present (10 minutes each). A class-based discussion (5 min) will follow the presentation. Details on the group presentation will be share through email.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Exam will take place at the mid-point of the semester
2.	Formative Assessment	25%	Classroom participation, attendance, assignments, presentations, attitude and behaviour, hands-on-activities, short tests, quizzes etc
3.	Final Assessment	45%	Test but can be based partly on term paper, research proposal development, field work and report writing etc

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

1. Capuccino JG and Sherman N. 1996. Microbiology and Laboratory Manual. The Benjamin Cummings Pub. Co., New York, USA.

2. Joshi VK and Singh RS. 2012. Food Biotechnology. 1st edition. IK International Publishing House, India.

3. Lee BH. 1996. Fundamentals of Food Biotechnology. VCH Publishers, Inc, New York, USA.

4. Mitttal GS. 1992. Food Biotechnology: Techniques and Applications. Technomic Pub Inc. Lancaster, USA.

5. Potter NN and Joseph HH. 1995. Food Science. 5th edition. Chapman and Hall New York, USA.

6. Shetty K. 2005. Food Biotechnology. 2nd edition. Marcel Dekker, Inc., New York, NY, USA.

7. Thomas JA and Fuchs RL. 2002. Biotechnology and Safety Assessment. Taylor & Francis, Philadelphia, USA.

  - **Journal Articles/ Reports**

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

Ph.D. Semester 2 Syllabus

Course Title: Protein Structure and Engineering Modules

Course Code: SBS 704

Semester: 2nd

Credit hours: 2 (0 + 2)

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

  M.Phil. in Biological/Life Sciences.

- **Learning Outcomes**

  At the completion of this course, the students will:

1. Understand how to use problem solving to enhance their capability for understanding protein structure in the light of given secondary protein structural elucidation problem, and factors governing the protein structure and function.
2. Understand various techniques for designing proteins for improved properties and having more than one function for applications in industry, medical and other fields.
3. Understand the different strategies of protein engineering and their production for more effective and productive applications in medicine, industry and other fields.

- **Contents**

Units I-II

Unit-I Engineering Proteins

1.1 Modification of proteins by deletion, fusion, mutation and addition for improved activity, stability and other properties.

1.2 Site-directed mutagenesis, directed evolution, error-prone PCR and genetic recombination.

1.3 Designing enzymes with multifunctional activities.

1.4 Designing fusion molecules for detection of multiple antibodies as in serodiagnosis of infectious diseases like tuberculosis and others.

1.5 For further reading students will be required to consult the recent publications regarding these topics.

Unit-II Practicals

Practical part of this course will be comprised of Problem Solving Exercises.

2.1 drawing α helical, parallel and anti-parallel sheet structure arising from a hypothetical hexapeptide

2.2 Prediction of secondary structure elements in a given protein sequence using Chou and Fassman method and its comparison with other algorithms

2.3 Comprehensive review of structure and function of membrane proteins

2.4 Locating the membrane spanning segments in the given protein sequences

2.5 For further reading students will be required to consult the recent publications regarding these topics.

- **Teaching learning strategies**
    1. Lectures
    2. Tutorial
    3. Group Discussion
    4. Assignment/ Class presentation
- **Assessment and Examinations**

The evaluation of this course is based upon the oral presentations and the written documents submitted which includes 50 % weightage each for Engineering Protein part and practical for problem solving approach learning. This will take place before final assessment

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	It takes place at the mid-point of the semester as an exam
2	Formative Assessment	25%	Classroom participation, attendance, attitude and behaviour, short tests, quizzes hands-on-activities
3	Final Assessment	40%	Practical assessments and presentations along with test

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

1. Berg JM, Tymoczko JL, Gatto Jr. GJ, Stryer L. 2015. Biochemistry. W.H. Freeman, San Francisco, USA.
2. Creighton TE, 1993. Proteins: Structure and Molecular Properties. 2nd Edition. W.H. Freeman, New York, USA.
3. Ogawa T. (Ed.) 2013. Protein Engineering – Technology and Applications. InTech Publisher, Croatia.
4. Park SJ, Cochran JR. (Eds.) 2010. Protein Engineering and Design. CRC Press, Taylor and Francis Group.

- **Journal Articles/ Reports**

  Recent developments in this area shall be obtained from the reviews and publications.

Course Title: Cellular Pathways and Signal Transduction

Course Code: SBS 702

Semester: 2nd

Credit Hours: 2 (2 + 0)

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

  M.Phil. in Biological/Life Sciences.

- **Learning Outcomes**

This course will help students to:

1. Understand the advanced concepts used in cell biology with special emphasis on signal transduction. It will be helpful for students to pursue a research career in the field of cell biology.
2. Understand research methodologies specific to signal transduction.

- **Contents**

Units I-IV

Unit-I Cell Growth, Specialization and Differentiation

1.1 Multicellular life

1.2 Stem cells

1.3 Cell turnover

1.4 Programmed cell death

Unit-II Receptors

2.1 Molecular properties of different classes of receptors

2.2 The structure-function relationships of kinases

2.3 Small and heterotrimeric G-proteins

2.4 Second messenger molecules and the enzymes that generate them

Unit-III Understanding of Major Signaling Pathways

3.1 Adrenalin, insulin, EGF

3.2 Wnt/catenin signaling pathways

3.3 Example processes like energy metabolism, cancer biology, and tissue differentiation

Unit-IV Experimental Methods Used in Cell Biology

4.1 Isolating cells and growing them in culture

4.2 Cell architecture

4.3 Cell spreading, shape and motility

4.4 Microscopy

4.5 Bioassays

4.6 In vitro and in vivo tumor models.

- **Teaching-learning Strategies**

Series of lectures, interactive sessions, hands on training

- **Assignments-Types and numbers with calendar**

A problem based assignment during the course time to be given in midterm and due in final term.

- **Assessment and Examinations:** Written exam, quizzes, assignment, presentation, written review on a specific aspect of any receptor

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 may include term paper, research proposal development, field work and report writing as well.

- **Books Recommended/ Suggested Readings**

1. Alberts B, Bray D, Hopkin K, Johnson AD, Lewis J, Raff M, Walter P. 2013. Essential cell biology. 3rd Edition. Garland Science.
2. Berg JM, Tymoczko JL, Gatto, Jr. GJ, Stryer L. 2015. Biochemistry. 8th edition. W. H. Freeman & Company, San Francisco, USA.
3. Helgason CD, Miller CL. 2005. Basic cell culture protocols. 3rd edition. Humana Press.
4. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe M, Amon A. 2021. Molecular cell biology. 9th Edition. Macmillan Learning.
5. Pecorino L, 2012. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics. 3rd edition. Oxford University Press, UK.

Course title: Journal Club 2

Course code: SBS 706

Semester: 2nd

Credit hours: 2 (2+0)

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

  M.S./M.Phil. in any field of Biological and Allied Sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

  After completion of the course, the students will:

1. Understand how to critique scientific manuscripts.
2. Understand findings of a large number of significant research studies.
3. Understand how to extract the most important pieces of information from a research article and summarize them in the form of a scientific abstract.

- **Contents:**

  Units I-III

  Unit-I Research Article

  1.1 The course includes class sessions where each student will individually analyze, evaluate and present at least a research article in the field of molecular biology. The article will be selected and assigned by the instructor. Each presentation will be followed by questions and discussion involving the whole class.

  Unit-II Critical Review

  2.1 Each student will prepare an assignment comprising of critical review of the presented topic.

  Unit-III Presentations

  3.1 There will be at least one presentation by each student in front of the entire academic body of the department on critical analysis of a recently published research article in an elite scientific journal (such as Nature, Science, Cell, PNAS, JBC etc). The research article will be assigned to each student in the beginning of the semester. Besides that every student will be required to attend all the presentations and actively participate in the weekly Journal Club.

- **Teaching-learning Strategies**

Each student will present the assigned topic/s followed by discussion in which teachers and all students will participate.

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

Each student will submit an assignment comprising of critical review of the presented topic before final term exam.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Presentation made by each student will be analyzed in reference to its scientific format and contents.
2.	Formative Assessment	25%	It is continuous assessment. It will be based on the attendance of each student in the journal club-I as well as his/her general attitude and commitment during the guidance sessions with the teachers.
3.	Final Assessment	40%	Each critical review prepared by students as well as their participation in class discussions will be assessed.

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

1. Knudsen S. 2002. A Biologist's Guide to Analysis of DNA Microarray Data. John Wiley & Sons, Inc.
2. Schumacher HS. 2015. Biomarker Validation. Wiley-VCH Verlag GmbH & Co. KGaA
3. Tsai CS. 2006. Biomacromolecules: Introduction to Structure, Function and Informatics. John Wiley & Sons, Inc.

    - **Journal Articles/ Reports**

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

Course Title: Immunology

Course Code: SBS 708

Semester: 2nd

Credit Hours: 2 (2+0)

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

M.S./M.Phil. in any field of Biological and Allied Sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

At the end of this course, students will be able to:

1. Understand how immune system is organized in the body to combat invading pathogens.
2. Understand numerous research methods published in the literature that would be helpful for them to pursue a research career in the fields of Immunology.

- **Contents**

Units I-XIII

Unit-I Immune System

1.1 Overview of the immune system, innate immunity and adaptive immunity.

Unit-II Cells and Organs of Immune System

2.1 Haematopoiesis, cells of immune system, organs of immune system.

Unit-III Antigens and Epitopes

3.1 Characteristics of antigens, classification of antigens, factors of Immunogenicity, super antigen, classification of antigenic determinants

Unit-IV Antibodies

4.1 Antibody structure, types, organization and expression of Immunoglobulin genes

Unit-V Antigen-Antibody Interactions

5.1 Ag-Ab interaction: Principles and Application

Unit-VI Generation of Immune Cells

6.1 Generation of B cells, generation of T cells

Unit-VII B and T cells

7.1 B and T cells activation, differentiation and memory generation

Unit-VIII Receptors and Signaling

8.1 B and T cell receptors

Unit-IX Cytokines and Chemokines

9.1 Types and action of cytokines and chemokines

Unit-X Immunological Disorders

10.1 Allergy, autoimmune diseases, auto inflammatory syndromes. Cancer and immune system

Unit-XI Immunotherapy

11.1 Monoclonal antibody therapy, check point inhibitors therapy, cytokine immunotherapies therapy, oncolytic virus therapy, T cell therapy, cancer vaccines

Unit-XII Immunological Techniques

12.1 Antibody generation, Antibody isolation and purification, Immunoblotting, Immunodiffusion, Immunoelectrophoresis, Immunohistochemistry, Immunoprecipitation, Immune cell isolation.

Unit-XIII Practicals

13.1 Raising antibodies against different proteins,

13.2 Analysis of antibody-antigen reactions.

- **Teaching-learning Strategies**

1. This course 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.

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

Each student will be assigned a topic related to this course. They will prepare in depth presentations on topics included in their course which will further serve to review and clarify the subject. All assignments will be handed out before end of midterm exam and will be due before the final term 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. Abbas AK, Lichtman AH, Pillai S. 2019. Basic Immunology. 6th Edition. Elsevier.
2. Coico R, Sunshine G. 2015. Immunology: A short course. 7th Edition. Wiley-Blackwell.
3. Owen JA, Punt J, Stranford SA. 2013. Kuby Immunology. 7th Edition. New York, USA.
4. Paul WE. 2012. Fundamental Immunology. 7th Edition. Lippincott Williams and Wilkins.

- **Journal Articles/ Reports**

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

Course Title: Functional Genomics

Course Code: SBS 713

Semester: 2nd

Credit hours: 3 (2 + 1)

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

Students should have adequate knowledge of Biological Sciences, Plant and Animal systems and their genomes. They should possess basic knowledge of Biochemistry and Molecular Biology.

- **Learning Outcomes**

This course would theoretically and practically enable the students to:

1. Understand plant/animal function and biotechnology.
2. Understand molecular functions and their applications in genetic engineering.
3. Understand the use the tools of functional genomics involving large scale analysis of genomics, transcriptomics and proteomics.
4. Understand to introduce desired traits in appropriate living systems to overcome the current challenges faced by animal and plant life.

- **Contents:**

  Units I-VI

Unit-I Introduction, Background and History of Genomics

1.1 Genomics and Functional Genomics

1.2 Plant and animal systems

Unit-II Tools for Genetic Engineering

2.1 Comparative transcriptomics (microarray analysis, Next generation sequencing)

2.2 Metabolomic dynamics

2.3 Protein profiling

2.4 Functional analysis of genetic factors

Unit-III Utilization of Bioinformatic Resources for Biotechnology

3.1 Genome structure and sequence analysis

3.2 Gene expression omnibus (GEO)

3.3 Gene Ontology

3.4 Proteomic resources

Unit-IV Genetic Engineering Methods

4.1 Transformation systems,

4.2 Expression Vectors.

4.3 Knockout systems and gene silencing

4.4 Heterologous expression systems.

Unit-V Validation of Genetically Modified Organisms (GMOs)

5.1 Characterization of GMOs.

5.3 Biosafety studies

5.3 Patenting

5.4 Commercialization

Unit –VI Practicals

6.1 Acquisition and analysis of high throughput data related to vital functions

6.2 Microarray data analysis,

6.3 Real time expression analysis,

6.4 Heat map analysis,

6.5 Recombinant plasmid construction

6.6 Agrobacterium mediated transformation

6.7 Validation of transgene

- **Teaching-learning Strategies**
  1. 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**

  Each student would be assigned two problem based questions in the second semester and would be required to turn in the assignment before final term exam.

- **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%	Assignments and presentations
3.	Final Assessment	45%	It will be a test

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

1. Altman A, Hasegawa PM. 2012. Plant Biotechnology and Agriculture: Prospects for the 21st Century. 1st Edition. Elsevier Inc.
2. Hammond J, McGarvey P, Yusibov V. 1999. Plant Biotechnology: New Products and Applications. Springer Link.
3. Kaufmann M, Klinger C, Savelsbergh A. 2017. Functional Genomics Methods and Protocols. 3rd Edition. Humana Press.
4. Poltronieri P, Hong Y. 2015. Applied Plant Genomics and Biotechnology. 1st Edition. Woodhead Publishing.
5. Stewart Jr. CN. 2016. Plant Biotechnology and Genetics: Principles, Techniques, and Applications. 2nd Edition. John Wiley Sons.
6. Wink M. 2011. An Introduction to Molecular Biotechnology: Fundamentals, Methods and Applications. 2nd Edition. John Wiley & Sons.

    - **Journal Articles/ Reports**

One article from a prestigious journal in the field would be assigned to each student for class discussion.

Course title: Term Paper

Course code: SBS 709

Semester: 2nd

Credit hours: 2 (2+0)

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

M.S./M.Phil. in any field of Biological and Allied Sciences (Plant Sciences, Animal Sciences, Molecular Biology, Microbiology, Biochemistry).

- **Learning Outcomes**

The participants will be able learn to:

1. Prepare a proposal for an unsolicited review.
2. Plan, structure and write a review.
3. Create a clear and compelling story supported by relevant citations.
4. Identify the features of a successful review and apply them to their writing.

- **Contents**

Units I-II

Unit-I Writing

1.1 How to write a review paper

Unit-II Presenting

2.1 The students will be required to write and present in a bound form a comprehensive review on an assigned topic. The topic of term paper will essentially be in the area of his current research interest.

- **Teaching-Learning strategies**

Introductory lectures will be organized to explain the basic elements of a good quality review. Different review articles will be selected and explained that how to plan, structure and write reviews. The participants will be asked to choose a topic of their interest, write and present in a bound form a comprehensive review.

- **Assignments-Types and numbers with calendar**

A single assignment – choosing a topic and writing a review article will be assigned after a month of semester start.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1	Midterm Assessment	35%	Assignments, quizzes
2	Formative Assessment	25%	It is continuous assessment. It will be based on the attendance of each student well as his/her general attitude and commitment during the guidance sessions with the teachers
3	Final Assessment	40%	Review article (term paper) written by the participants will be evaluated at the end of the semester

- **Books Recommended/ Suggested Readings**

1. Hofmann A. 2015. Writing in the biological sciences: A comprehensive resource for scientific communication. 2nd edition. Oxford University Press, UK.
2. Noguchi J. 2006. The science review article: An opportune genre in the construction of science. Volume 17. Peter Lang, Bern.
3. Ridley D. 2008. The literature review: a step-by-step guide for students. 1st edition. Sage Publications, London, UK.

Course title: Scientific Writing

Course code: SBS 710

Semester: 2nd

Credit hours: 2 (2+0)

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

This course is designed for students and researchers in Biological Sciences who are planning to publish their research work in peer-reviewed journals or wish to refresh their scientific writing skills.

- **Learning Outcomes**

After completion of the course the students will:

1. Understand and learn, how to manage and present the data
2. Understand and learn how to write clearly, (write a great title, abstract, and structure of paper).
3. Understand and learn what editors look for in a great paper.

- **Contents**

Units I-II

Unit-I Writing a Research Paper

1.1 Types and elements of scientific writing (research paper, review paper, grant application, report writing etc.)

1.2 How to plan, outline and then write a research paper (starting from data management, data presentation, title, abstract, introduction to conclusion)

1.3 Scientific literature vocabulary and language (precision, clarity, conciseness, scientific vocabulary and word choice)

Unit-II Publishing a Research Paper

2.1 Understanding the editorial process of peer-reviewed journals, selection of suitable journals and writing cover letters

2.2 Authorship and other ethical considerations

2.3 Final checklist and submission process

- **Teaching-Learning Strategies**

The course is planned to provide give hands-on experience in drafting, organizing and revising scientific texts related to the areas of the research of the participants. Course contents will be adapted to the proficiency levels of the participants. After the introductory lectures about each unit, different writing exercises with guidance from the instructors throughout the semester.

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

Small assignments for writing practice of the taught topics throughout semester, before midterm and final term exams.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Assignments, quizzes
2.	Formative Assessment	25%	It is continuous assessment. It will be based on his/her general attitude and commitment during the guidance sessions with the teachers
3.	Final Assessment	45%	A research article (term paper) written by the participants will be evaluated at the end of the semester.

- **Books Recommended/ Suggested Readings**

1. Alley M. 2018. The Craft of Scientific Writing. 4th edition. Springer Publications.
2. Day RA, Gastel B. 2006. How to Write and Publish a Scientific Paper. 6th edition. Greenwood Press, Westport.
3. Lebrun JL. 2007. Scientific Writing: A Reader and Writer's Guide. World Scientific Publishing, Singapore.
4. Matthews JR, Matthews RW. 2007. Successful Scientific Writing a Step-by-Step Guide for the Biological and Medical Sciences. 3rd edition. Cambridge University Press, UK.
5. Ridley D. 2008. The Literature Review: A Step-by-Step Guide for Students. 1st edition. Sage Publications, London, UK.

Course title: Forensic DNA typing & Toxicology

Course code: SBS 711

Semester: 2nd

Credit hours: 2 (2+0)

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

This course is designed for students and researchers in Biological Sciences who are planning to specialize in Forensic sciences. They must have M.S./M.Phil. education and have completed all first semester courses.

- **Learning Outcomes**

  After completion of the course, the student will:

  1. Understand advanced knowledge in the fields DNA typing.
  2. Understand advanced knowledge in toxicology.
  3. Gain pertinent skills for successful use in field.

- **Contents**

  Units I-II

  Unit-I: Forensic DNA Analysis

  1.1 Collection and storage of biological evidence, chemical and microscopic analysis of biological stains,

  1.2 Documentation of crime scene

  1.3 Gender identification

  1.4 Mitochondrial DNA, additional polymorphism markers

  1.5 Degraded DNA

  1.6 PCR inhibition

  1.7 Forensic Genetics: basic principles of inheritance, human population genetics, DNA profiling and forensic investigation

  1.8 Humoral and cellular immunology

Unit-II Toxicology

2.1 Mechanisms of toxicology

2.2 Toxicokinetic sand chemical carcinogenesis

2.3 Toxic responses of different body system

2.4 Pharmacokinetics and drug action. Toxic substances and xenobiotic transformation

- **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 numbers with calendar**

Small assignments for writing practice of the taught topics shall be given throughout semester

- **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	45%	It will be a test

- **Books Recommended/ Suggested Readings**

1. Butler J. 2004. Forensic DNA typing: Biology and Technology Behind STR Markers. 2nd edition. Elsevier Academic Press. Burlington, USA.
2. Burke T, Dolf G, Jeffreys A J, Wolff R. (eds). 1991. DNA Fingerprinting: Approaches and Applications. 1sr edition. Birkhäuser Verlag, Basel, Switzerland.
3. Klaassen CD. 2013. Casarett and Doull's Toxicology: The basic science of poison. 8th edition. McGraw-Hill Medical Publishing Division, New York, USA.
4. Robertson J, Ross A, Burgoyne L. (eds). 1990. DNA Forensic Science: Theory, Techniques and Application. 1st edition. CRC Press, New York, USA.
5. Russell L. 2011. Excitotoxins: The taste that kills. Health Press. Santa Fe, USA.

Course Title: Forensic Microbiology & Entomology

Course Code: SBS 712

Semester: 2nd

Credit hours: 2 (2+0)

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

This course is designed for students and researchers in Biological Sciences who are planning to specialize in Forensic Sciences. They must have M.S./M.Phil. education and have completed all first semester courses.

- **Learning Outcomes**

  After completion of the course, the students will:

  1. Understand and gain advanced knowledge to evaluate microbial and insect infestation after death.
  2. Understand and gain advanced skills for successful use in field.
  3. Understand in depth to evaluate forensic evidence as pertaining to microflora and insects and its application.

- **Contents**

Units 1-IV

Unit-I Basics on Determining Events after Death

1.1 What happens after death? Cellular death; brain stem death; rigor mortis

1.2 Estimating time and cause of death

1.3 Common insects on dead bodies

Unit-II Forensic Entomology

2.1 Medicolegal forensic entomology; at the crime scene; use of arthropods in contraband trafficking

2.2 Estimate age of blowfly or calliphoridae (eggs, larvae, pupae, adults)

2.3 Flesh flies or sarcophagidae. Nature of prokaryotes, eukaryotes (fungi, algae, protozoa) and viruses

Unit-III Pathogens and Poisoning

3.1 Food poisoning and intoxication

3.2 Epidemiology of infectious diseases and their control

3.3 Molecular diagnostics and PCR detection of pathogens, and variety of dipterous and coleopterous insects.

3.4 Visual observation and notations at the scene; collection of data from the scene and the body. Forensic insect identification cards.

Unit-IV Postmortem

4.1 Postmortem interval estimation with day-degrees

4.2 using single triangulation or single sine method

4.3 Some selected case histories

- **Teaching-learning Strategies**
  1. Lectures
  2. Group Discussion
  3. Class Assignment/Seminar and presentations on selected topics
  4. Quiz test/ oral test
  5. Latest research papers/reviews discussion
- **Assignments-Types and numbers with calendar**

Two Assignments, one before midterm and second afterward, will be given to students. Presentations on the selected topics (15 minutes on each topic) will continue throughout the course along with discussions and question/answer sessions.

- **Assessment and Examinations**

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written Exam will take place at the mid-point of the semester
2.	Formative Assessment	25%	It includes classroom participation, attendance, assignments, and presentations. hands-on-activities, short tests, quizzes
3.	Final Assessment	45%	It will be a test

- **Books Recommended/ Suggested Readings**

1. Baron S. (Ed). 2001. Medical Microbiology. 4th edition. University of Texas Medical Branch Publishers, Galveston, Texas, USA.
2. Bert H, Wilson E O. 2000. The Ants. Springer-Verlag, Berlin, Germany.
3. Budowle B, Schutzer S, Morse S. (Eds). 2019. Microbial Forensics. Academic Press, New York, USA.
4. Saukko P, Bernard K. 2015. Knight's Forensic Pathology. 4th edition. CRC Press. Taylor & Francis Group, Boca Raton, Fl, USA.
5. Talaro KP, Chess B. 2018. Foundations in Microbiology. 10th ed. McGraw-Hill College: Blacklick, Ohio, USA.

Annexure I for Ph.D. scheme of studies, comparison of previous and new courses
Pages 51-72

Annexure 1 for Ph.D. scheme of studies: Comparison of previous and new courses

Scheme of studies for Ph.D. degree in Biological Sciences

Previously Approved Courses	**Updated Courses**
Course SBS 701 Frontiers in Molecular Biology (Journal Club) **4 Credits** The course will comprise of at least one presentation by each student on critical analysis of a recently published research article in an elite scientific journal (such as Nature, Science, Cell, PNAS, JBC etc) dealing with frontiers of Molecular Biology. The research article will be assigned to each student in the beginning of the semester. Besides that every student will be required to attend all the presentations and actively participate in the weekly Journal Club.	**Course SBS 701 Journal Club 1** **2 Credits (2+0)** **Objectives:** To develop students' presentation and perception skills with regards to scientific techniques. **Outcomes:** This course will help students to: 1. Understand how discoveries are linked to developments and improvement in scientific techniques. 2. Acquire knowledge which will enhance their ability to apply these techniques during their research projects. **Contents:** Please see pages 10-11 of Ph.D. syllabus **Major Differences:** 1. This course has been split from previous SBS701 (credit hours 4) into two courses of 2 credit hours each SBS 701 and SBS 706. Please see SBS 706 as well. 2. This section focuses more on learning and presenting specific scientific techniques. 3. This course has more interactive approach by including 'student led' class sessions.

	4. The students will present technique based articles only. 5. Arranged according to HEC criteria.
Course SBS 502 Signal Transduction **2 Credits** In this course every student is required (i) to write a short essay on Receptor & Signaling, and (ii) to search for original experiments and evidences, which led to the discovery of the specific receptor and the signaling pathway. Every student is assigned an individualized receptor. Signaling pathways mediated by G proteins, ionic channels, steroids, neurotransmitters and tyrosine kinase are considered for this assignment. ***Books Recommended*** 1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J. and Stryer, L., 2015. *Biochemistry*. W.H. Freeman, San Francisco.	**Course SBS 702 Cellular Pathways and Signal Transduction** **2 Credits (2+0)** **Objectives:** This course introduces advanced topics on the growth, division and differentiation of eukaryotic cells. We will focus on major areas of contemporary eukaryotic cell biology-including the mechanistic of cell signal transduction involved in cell proliferation, cell differentiation, and cell migration in normal as well as special states, such as embryonic development, regenerative processes and cancer. Experimental methods used in cell biology will also be introduced to students. To enhance participants' critical thinking abilities, students will research and write a review on any subject within the topics covered by the course. **Outcomes:** This course will help students to: 1. Understand the advanced concepts used in cell biology with special emphasis on signal transduction. It will be helpful for students to pursue a research career in the field of cell biology. 2. Understand research methodologies specific to signal transduction.

	Contents: Please see pages 31-33 of Ph.D. syllabus **Major Changes:** 1. Title change 2. Addition of new topics such as cell signaling involved in stem cells, cell turnover and programmed cell death. Few key experimental methods used in cell biology 3. Addition of updated books 4.Formatted according to HEC criteria
Course SBS 704 Cloning Module (Recombinant DNA Technology) **2 Credits** This course comprises: a. Formal Lectures (8) encompassing Gene cloning concepts and basic techniques (restriction endonucleases, vectors, expression systems, selection of clones etc.). b. Problem solving Exercises Every student will be given individualized problem to work in a specified time period, at the end of which a solution in the form of a written document is submitted. The evaluation is based upon this document as well as on oral presentation, which the student is required to make at the appointed time. For this course, every student is required to meet the relevant	**Course SBS 703 Cloning and Gene Expression Modules 2 Credits (1+1)** **Objectives:** This course is designed to give deep understanding of different methods used in DNA recombinant technology like cloning. A part of this course will address transcription, post transcriptional modifications and the other translational mechanism in prokaryotes and in eukaryotes. **Outcomes:** On completion of this course the students will: 1. Understand different techniques like site directed mutagenesis 2. Understand different strategies used in cloning along with the choice of various vectors that will help them in their future research.

faculty member for at least 4 hours/week for formal discussion, besides informal meetings. In this module, students will be required to develop cloning strategy of an individualized genes with the help of a given vector. c. Familiarity with Gene Cloning Terminology (with an aim to develop targeted comprehension) ***Books Recommended:*** 1. Dale, J.W. and von Schantz, M., 2002. *From Genes to Genome.* John Wiley. 2. Brown, T.A., 2001. *Gene Cloning and DNA Analysis*. Blackwell. 3. Reece, R.J., 2004. *Analysis of Genes and Genomes*. John Wiley. 4. Winnacker, E.L., 2003. *From Genes to Clones.* Wiley-BVCH Verlag. (Important Note: Those Ph.D. students who have obtained their M.Phil. degrees from institutions other than SBS are required to take *Course 510 : Molecular Biology Lab* instead of above Course).	3. Understand different transcriptional and translational factors present in different organisms 4. Attain knowledge of codon preference for different amino acids used by different organisms **Contents:** Please see pages 12-14 of Ph.D. syllabus **Major Differences:** 1. Syllabus updated by adding more topics like RNA editing, Post translational modifications, Regulation of gene expression. 2. Practical added 3. Latest edition of reference books are incorporated 4. Course is formatted according to HEC criteria
Course SBS 705 DNA-Protein Module 2 credits	This course is discontinued and part of it is added to SBS 703. Please see above.

Every student is given individualized problem to work in a specified time period, at the end of which a solution in the form of a written document is submitted. The evaluation is based upon this document as well as on oral presentation, which the student is required to make at the appointed time. For this course, every student is required to meet the relevant faculty member for at least 4 hours/week for formal discussion, besides informal meetings. In this module every student is given an individualized DNA sequence and is required to identify, and give basis for identification, the various components of promoter element, ribosome binding site, initiator sequence, termination sequence, introns and exons. They also are required to predict structure of mRNA and polypeptide chain, and evaluate the codon preferences with evolutionary implications for various amino acids. Familiarity with Molecular Biology Terminology (with an aim to develop targeted comprehension)	
Course SBS 705 Protein Structure Module **2 Credits** This course comprises the following: a. Assignments on Specialized Topics:	**Course SBS 704 Protein Structure and Engineering Modules** **2 Credits (0+2)** **Objectives:** This course is designed to provide broad spectrum view of structural aspects of protein, techniques available to design engineered

The students will be given assignments on the various specialized areas of protein structure and function. Each student makes a comprehensive oral presentation including the latest information available. The assignment is also submitted in the written form before the end of the semester. b. Problem solving Exercises: Every student will be given individualized problem on the various topics including (1) drawing α helical, parallel and anti-parallel sheets structure arising from a hypothetical hexapeptide, (2) prediction of secondary structure elements in a given (individualized) protein sequence using Chou and Fassman method, (3) description of biological functions of membrane proteins, and (4) locating the membrane spanning segments in the given proteins (individualized) using relevant literature. The solutions shall be presented both as oral presentations, made at appointed times, and in the form of written documents.	proteins and their physicochemical structural analysis. **Outcomes:** At the completion of this course, the students will: 1. Understand how to use problem solving to enhance their capability for understanding protein structure in the light of given secondary protein structural elucidation problem, and factors governing the protein structure and function. 2. Understand various techniques for designing proteins for improved properties and having more than one function for applications in industry, medical and other fields. 3. Understand the different strategies of protein engineering and their production for more effective and productive applications in medicine, industry and other fields. **Contents:** Please see pages 28-30 of Ph.D. syllabus **Major Differences:** 1. Contents of the course have been categorized into more of practical portions i.e. Engineering proteins and practicals (also comprising of problem solving exercises) respectively. 2. More reference books have been added.

c. Familiarity with Protein-Enzyme Structure Terminology (with an aim to develop targeted comprehension). The schedule of the above-mentioned activities is appropriately spread throughout the semester. The students are required to meet the relevant faculty member for at least two hours/week for formal discussions regarding the assignments on specialized topics and the problem solving exercises, besides informal meetings. The evaluation of this course is based upon the oral presentations and the written documents submitted. ***Books Recommended:*** 1. Creighton, T. E., 1993. *Proteins: Structure and Molecular Properties*. Second Edition. W.H. Freeman, New York.	3. The outline of the course has been formatted according to HEC.
Course SBS 706 Analytical techniques 2 Credits **Objectives:** This course aims to deal with some of the recently developed and commonly used techniques for analysis and biological molecules and processes.	**Course SBS 705 Current Techniques in Biological Sciences 2 Credits (2+0)** **Objectives:** This course aims to familiarize students with the current techniques available in biological sciences for the investigation of biological macromolecules.

Contents:

Over view of protein fractionation techniques. Mass spectroscopy and analysis of proteins. Circular dichroism and secondary structure analysis of proteins. Restriction mapping and next generation DNA sequencing. Protein-DNA interaction. X-ray structure analysis of protein structure. CRISPR/Cas9 and genome editing.

Impact:

The students shall learn the principles and applications of some of the recently developed and now commonly used techniques for the study of biological molecules and processes.

Books Recommended:

1. Ausubel, F.M., Brent, R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.A. and Struhl, K., 2003. *Current Protocols in Molecular Biology.* John Wiley & Sons, New York.

Outcomes:

This course aims to deal with some of the recently developed and commonly used techniques for analysis and biological molecules and processes.

After course completion, the students shall:

1. Understand the principles of the recently developed and commonly used techniques for the study of biological molecules and processes.
2. Understand the applications of selected techniques for the study of biological molecules and processes.

Contents: Please see pages 15-16 of Ph.D. syllabus

Major Differences:

1. Topics on animal transgenics, ligase free cloning added.
2. Arranged according to HEC criteria

2. Green, M.R. and Sambrook, J., 2012. *Molecular Cloning – A Laboratory Manual.* 4th Edition. Cold Spring Harbor Laboratory, Long Island, New York. 3. Metzker, M. L., 2010. Sequencing Technologies - The Next Generation. *Nature Reviews Genetics,* 11: 31-46. 4. Venn, R. F. (Ed.) 2008. *Principles and Practice of Bioanalysis,* Second Edition. CRC Press, Taylor and Francis Group. 5. Ladd, M. and Palmer, R., 2013. *Structure determination by X-ray crystallography,* 5th edition, Springer. 6. Yamamoto, T. (Ed.) Targeted Genome Editing Using Site-Specific Nucleases ZFNs, TALENs, and the CRISPR/Cas9 System 2015, Springer, Japan. (Important Note: Those Ph.D. students who have obtained their M.Phil. degrees from institutions other than SBS are required to take *Course 509 : Protein Chemistry and Enzymology* instead of above Course 706)	
Course SBS 701 Frontiers in Molecular Biology (Journal Club) 4 Credits	**Course SBS 706 Journal Club 2** **2 Credits (2+0)** **Objectives:**

The course will comprise of at least one presentation by each student on critical analysis of a recently published research article in an elite scientific journal (such as Nature, Science, Cell, PNAS, JBC etc) dealing with frontiers of Molecular Biology. The research article will be assigned to each student in the beginning of the semester. Besides that every student will be required to attend all the presentations and actively participate in the weekly Journal Club.	Development of skills pertaining to critical analysis and presentation of scientific manuscripts. **Outcomes:** After completion of the course, the students will: 1. Understand how to critique scientific manuscripts. 2. Understand findings of a large number of significant research studies. 3. Understand how to extract the most important pieces of information from a research article and summarize them in the form of a scientific abstract. **Contents:** Please see pages 34-35 of Ph.D. syllabus **Major Differences:** 1. This course has been split from previous SBS701 (credit hours 4) into two courses of 2 credit hours each SBS 701 and SBS 706. Please see SBS 701 as well. 2. This course will have class sessions where individual analysis and presentation skills will be polished. 3. This part focuses more on assimilation and critique of published scientific data. 4. The students will present research articles only. 5. Arranged according to HEC criteria.
Course SBS 707 Bioinformatics **2 Credits**	**Course SBS 707 Bioinformatics** **2 Credits (1+1)**

1. Introduction to BI. - What is BI. - History of BI. - Uses of BI (Protein, Gene). - Comparison of BI with experimental tools. 2. The central Dogma (RNA-DNA-Protein). 3. Short introduction to protein (amino acids, sequence). 4. Analyzing Protein sequence by the use of BI tools (sequence-structure-function). - Retrieving protein sequences from database. - Alignment of protein \ nucleotide sequences. - Computing physico-chemical parameters of proteins. - Predicting elements of secondary structure of proteins. - Predicting 3D structure of protein from sequence. - PTMs. 5. Short introduction to DNA/RNA (structure, genetic code).	**Objectives:** Bioinformatics course would equip the students with the latest tools and techniques of bioinformatics and their use in biotechnology and functional genomics. **Outcomes:** This course would theoretically and practically equip the students to: 1. Develop strong bases of computational biology and fundamental computational methods 2. Understand and use current bioinformatics and computational tools in their research and data analysis. 3. Understand how to analyze, manage and display research data in a scientific manner. **Contents:** Please see pages 21-23 of Ph.D. syllabus **Major Changes:** 1. Course content updated 2. Books updated 3. Practical added 4. Formatted according to HEC criteria

6. Analyzing the DNA/RNA sequence by the use of BI tools.

- Retrieving the DNA sequence from database.
- Computing the sequence.
- Identifying restriction sites.
- Predicting elements of DNA/RNA secondary structure.
- Computing the optimal alignment between two or more DNA sequences.

7. Working with a genome.

- Finding which genomes are available.
- Analyzing sequences.
- Locating gene homologous in genome.
- Displaying genomes.

8. Interpretation of Data.

Books Recommended:

1. Mount, D.W., 2002. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory, Long Island,. New York.

2. Boxevanis, A.D., Ouellette, B.F.F. and Francis, O.B. 2005. *Bioinformatics: A practical Guide to the Analysis of Genes and Proteins.* John Wiley.

3. Campbell, A.M., and Heyer, L.J., *Genomics, Proteomics and Bioinformatics.* Benjamin Cummings	
Course SBS 708 Immunology **2 Credits** Innate immunity, adaptive immunity. Cells and organs of immune system – Haematopoiesis, cells of immune system, organs of immune system. Generation of B-cells and T-cells: antigens, antibodies immunoglobulins. Organization and expression of immunoglobulin genes. Antigen-antibody interaction. Major histocompatibility complexes. T cell receptors. T cell maturation, activation and differentiation. B cell generation, activation and differentiation. Immune effector mechanism. The Complement system: leukocyte migration and inflammation. Hypersensitive reactions. The immune system in health and diseases. **Practicals:** Raising antibodies against different proteins, Analysis of antibody-antigen reactions. ***Books Recommended:***	**Course SBS 708 Immunology** **2 Credits (2+0)** **Objectives:** The foremost objectives of this course are to introduce the basic concepts about the immune system and to develop necessary skills in the students for the critical analysis of contemporary literature related to the field of Immunology. **Outcomes:** At the end of this course, students will be able to: 1. Understand how immune system is organized in the body to combat invading pathogens. 2. Understand numerous research methods published in the literature that would be helpful for them to pursue a research career in the fields of Immunology. **Contents:** Please see pages 36-38 of Ph.D. syllabus **Major Differences:** 1. Books added and updated. 2. Formatted according to HEC approved format

1. Paul, W.E. (Ed.), 1999. *Fundamental Immunology*. Lipponcott-Raven, Philadelphia. 2. Goldsby, R.A., Kindt, T.J., Osborne, B.A., and Kuby, J., 2003. *Immunology*. W.H. Freeman, New York.	
Course SBS 709 Term paper **2 Credits** The students will be required to write and present in a bound form a comprehensive review on an assigned topic. The topic of term paper will essentially be in the area of his current research interest/programme.	**Course SBS 709 Term Paper** **2 Credits (2+0)** **Objectives:** The goal of this course is to enable students to to survey literature and prepare a comprehensive review. The students will be required to write and present in a bound form the review on an assigned topic. The topic of term paper will essentially be in the area of his current research interest/programme. **Outcomes:** The participants will be able learn to: 1. Prepare a proposal for an unsolicited review. 2. Plan, structure and write a review. 3. Create a clear and compelling story supported by relevant citations. 4. Identify the features of a successful review and apply them to their writing. **Contents:** Please see pages 42-43 of Ph.D. syllabus **Major Differences:** 1. Books added and updated.

	2. Formatted according to HEC approved format
Course SBS 710 Scientific Writing 2 Credits The aim of this course is to enhance the capability of scientific writing. Students will be given lessons on English conversation, English grammar, precise writing, scientific writing (thesis writing) etc.	**Course SBS 710 Scientific Writing 2 Credits (2+0)** **Objectives:** The aim of this course is to enhance the capability of scientific writing. Students will be given lessons on English, precise writing, scientific writing (thesis writing) etc. **Outcomes:** After completion of the course the students will: 1. Understand and learn, how to manage and present the data 2. Understand and learn how to write clearly, (write a great title, abstract, and structure of paper). 3. Understand and learn what editors look for in a great paper. **Contents:** Please see pages 44-45 of Ph.D. syllabus **Major Differences:** 1. Books added and updated 2. Formatted according to HEC approved format
Course SBS 711 Forensic DNA typing & Toxicology 2 Credits Forensic DNA analysis. Collection and storage of biological evidence, chemical and microscopic analysis of biological stains,	**Course SBS 711 Forensic DNA Typing & Toxicology 2 Credits (2+0)** **Objectives:**

documentation of crime scene. Gender identification, mitochondrial DNA, additional polymorphism markers, degraded DNA, PCR inhibition. Forensic Genetics: basic principles of inheritance, human population genetics, DNA profiling and forensic investigation. Humoral and cellular immunology. Mechanisms of toxicology. Toxicokinetics and chemical carcinogenesis. Toxic responses of different body system. Pharmacokinetics and drug action. Toxic substances and xenobiotic transformation. ***Books Recommended:*** 1. Butler, 2005. *Forensic DNA typing*. Elsevier Academic Press. 30-Corporate Drive, Burlington, USA. 2. Burke, T., Dolf, G., Jeffreys, A. J. and Wolff, R. (eds),1992. *DNA Fingerprinting: Approaches and Applications*, Birkhäuser Verlag, Basel. 3. Robertson, J., Ross, A., and Burgoyne, L. (eds), 2001. *DNA Forensic Science. Theory, Techniques and Application.* CRC Press, New York. 4. Curtis, D., 2001. *Casarett and Doull's Toxicology The basic science of poison.*	This course aims to teach students the commonly used techniques for analysis of DNA for forensic sciences. **Outcomes:** After completion of the course, the student will: 1. Understand advanced knowledge in the fields DNA typing. 2. Understand advanced knowledge in toxicology. 3. Gain pertinent skills for successful use in field. **Contents:** Please see pages 46-47 of Ph.D. syllabus **Major Differences:** 1. Books updated 2. Formatted according to HEC criteria.

McGraw-Hill Medical Publishing Division, New York. 5. Russell, L., 2000. Excitotoxins: The taste that kills. Health Press. PO Drawer 1388. Santa Fe, NM 87504.	
Course SBS 713 Forensic Microbiology & Entomology **2 Credits** Forensic entomology: what happens after death? Cellular death; brain stem death; rigor mortis. Estimating time and cause of death, common insects on dead bodies. Medicolegal forensic entomology; at the crime scene; use of arthropods in contraband trafficking. How to estimate age of blowfly or calliphoridae (eggs, larvae, pupae, adults); flesh flies or sarcophagidae. Nature of prokaryotes, eukaryotes (fungi, algae, protozoa) and virus. Food poisoning and intoxication. Epidemiology of infectious diseases and their control. Molecular diagnostics and PCR detection of pathogens, and variety of dipterous and coleopterous insects. Visual observation and notations at the scene; collection of data from the scene and the body. Forensic insect identification cards. Post mortem interval estimation with day-degrees, using single triangulation or single sine method. Some selected case histories. ***Books Recommended:***	**Course SBS 712 Forensic Microbiology & Entomology 2 Credits (2+0)** **Objectives:** To develop students' ability to evaluate microbial and insect infestation after death. **Outcomes:** After completion of the course, the students will: 1. Understand and gain advanced knowledge to evaluate microbial and insect infestation after death. 2. Understand and gain advanced skills for successful use in field. 3. Understand in depth to evaluate forensic evidence as pertaining to microflora and insects and its application. **Contents:** Please see pages 48-50 of Ph.D. syllabus **Major Differences:** 1. Books updated. 2. Formatted according to HEC criteria.

1. Bert, H. and Wilson E. O., 2000. *The Ants.* Springer-Verlag, Berlin.

2. Bernard, K., 2002. *Forensic Pathology.* Arnold Publisher. ISBN 0-340-58897-7.

3. Baron, S. (Editor), 2001. *Medical Microbiology* 4th edition. University of Texas Medical Branch Publishers, Galveston, Texas.

4. Tarano, K. P., 2002. *Foundations in Microbiology* 4th ed. McGraw-Hill College. Blacklick, Ohio, U.S.A.

5. Breeze, R., Budowle, B., Schutzer, S. (Eds), 2005. *Microbial Forensics*. Academic Press, New York, USA

Course SBS 716 Plant Functional Genomics 3 Credits

Objectives:

This course involves teaching sessions that deal with the tools of genomics and can apply these tools to increase their understanding of plant function and plant biotechnology.

Contents:

1. Identification of candidate genes for genetic engineering.

Course SBS 713 Functional Genomics 3 Credits (2+1)

Objectives:

This course involves teaching and practical sessions that deal with the tools of functional genomics involving large scale analysis of genomics, transcriptomics and proteomics to overcome the current challenges faced by animals and plants. The approaches which increase the understanding of plant function and plant biotechnology would be taught.

Comparative transcriptomics (microarray analysis, Next generation sequencing). Metabolomic Dynamics. Protein profiling. Functional analysis of candidate genes. 2. Plant transformation methods. Plant expression Vectors. Knockout systems. Heterologous expression systems. Mutant populations. 3. Validation of genetically modified organisms (GMOs). Characterization of GMOs. Biosafety issues. 4. Accessing and utilizing bioinformatics resources for plant biotechnology. Gene expression omnibus (GEO). Gene Ontology **Practical:** Isolation of desired genes from plants and their cloning in plant expression systems. **Impact:** This course would enable the students to build the strong bases of plant molecular functions and its application in genetic engineering to introduce desired traits in appropriate plant systems.	**Outcomes:** This course would theoretically and practically enable the students to: 1. Understand plant/animal function and biotechnology. 2. Understand molecular functions and their applications in genetic engineering. 3. Understand the use the tools of functional genomics involving large scale analysis of genomics, transcriptomics and proteomics. 4. Understand to introduce desired traits in appropriate living systems to overcome the current challenges faced by animal and plant life. **Contents:** Please see pages 39-41 of Ph.D. syllabus **Major Differences:** 1. Name Changed 2. Animal genomics added 3. Practical amended 4. Books updated 5. Formatted according to HEC criteria

Recommended Books: 1. Altman, A. and Hasegawa, P.M., 2012. *Plant Biotechnology and Agriculture*. Elsevier Inc. pp. 547. 2. Stewart, Jr. C.N., 2012. *Plant Biotechnology and Genetics: Principles, Techniques, and Applications.* 2nd Edition. Wiley Inc. pp 400. 3. Hammond, J., McGarvey P., and Yusibov, V., 2012. *Plant Biotechnology- New Products and Applications.* Springer Link, pp. 196. 4. Poltronieri, P. and Hong, Y., 2015. *Applied Plant Genomics and Biotechnology.* Elsevier Science. Pp 356. 5. Wink, M., 2013. *An Introduction to Molecular Biotechnology: Fundamentals, Methods and Applications.* John Wiley. Pp. 636.	
Course SBS 715 Archaea, the third domain of life 1 Credit What are Archaea? History of the archaeal domain. Root of the phylogenetic tree. Classification of Archaea. Diversity of uncultivated Archaea. Features of archaeal genome. Halophiles. Thermophiles. Methanogens.	**Course SBS 714 Archaeal Diversity** **2 Credits (2+0)** **Objectives:** In this course, the main objective is to learn how diverse the life is on the Earth and consider basic principles that govern evolution

Books Recommended: 1. Klenk, H-P and Garrett, R.A. *Archaea: Evolution, Physiology and Molecular Biology*. Blackwell Publishing. 2. Friend, T. *The third domain*. National Academies Press. 3. Forterre, P. *Microbes from Hell.* (translated by Teresa Lavender Fagan). 4. Barker, D. *Archaea: salt lovers, methane makers, thermophiles.* 5. Watkins, G., 2015. *Encyclopedia of Archaea*. Callisto Reference Publishers.	particularly highlighting the peculiar features of extremophiles Archaea. **Outcomes:** On completion of the course, the students will: 1. Understand about the diversity of life in extreme environments, basic knowledge of extremophiles, their classification, and principles that govern protein stability in extremophiles. 2. Understand how extremophiles emerged in the tree of life. 3. Understand diversification from other domains of life. 4. Understand how microorganisms thrive under extreme conditions. **Contents:** Please see pages 17-20 of Ph.D. syllabus **Major Differences:** 1. Title of the course has been updated. 2. Different metabolic pathways distinct in archaea have been included in the course. Other topics are also updated according to latest knowledge available in the relevant field. 3. Credit hour added as course content is increased 4. Formatted according to HEC criteria
Not offered	**Course SBS 715 Advanced Food Biotechnology 3 Credits (2+1)**

	Objectives: The course is offered to teach students about food processing. They will also learn industrial use of enzymes to enhance or supplement foods. **Outcomes:** On completion of this course the students will: 1. Understand the importance/role of microorganisms in food processing, preservation and waste management. 2. Understand the basic molecular biology techniques involved in food biotechnology. 3. Understand how to manipulate microbial cells for various processes involved in food biotechnology. 4. Understand international regulatory requirements with regard to genetically modified organisms and foods. **Newly offered course.** **Contents:** Please see pages 24-27 of Ph.D. syllabus
SBS 716 Research Thesis Minimum 2 years, Usual 3 years, Allowed 4 years, Research Work leading to submission of a thesis based on original research work for the award of Ph.D. degree **No Change**	