

**Sacred Heart College (Autonomous)**

**Department of Zoology**

**MASTER OF SCIENCE [ZOOLOGY]**

**Course plan**

**Academic Year: 2018 - 19**

**Semester II**

**COURSE 05: 16P2ZOOT05: ECOLOGY - PRINCIPLES AND PRACTICES**

<b>PROGRAMME</b>	<b>Master of Science [Zoology]</b>	<b>SEMESTER</b>	<b>2</b>
<b>COURSE CODE AND TITLE</b>	<b>16P2ZOOT05: ECOLOGY, PRINCIPLES AND PRACTICES</b>	<b>CREDIT</b>	<b>3</b>
<b>HOURS/WEEK</b>	<b>3</b>	<b>HOURS/SEM</b>	<b>54</b>
<b>FACULTY NAME</b>	<b>RAJU M.K, MATHEW M.J. &amp; RAAGAM P.M.</b>		

**Programme Outcome**

	<b>Programme Outcome</b>
<b>PO 1</b>	<b>Exercise their critical thinking in creating new knowledge leading to innovation, entrepreneurship and employability.</b>
<b>PO 2</b>	<b>Effectively communicate the knowledge of their study and research in their respective disciplines to their stakeholders and to the society at large.</b>
<b>PO 3</b>	<b>Make choices based on the values upheld by the institution, and have the readiness and know-how to preserve the environment and work towards sustainable growth and development.</b>
<b>PO 4</b>	<b>Develop an ethical view of life and have a broader (global) perspective transcending the provincial outlook.</b>
<b>PO 5</b>	<b>Explore new knowledge independently for the development of the nation and the world and are able to engage in a lifelong learning process</b>

**MASTER OF SCIENCE [ ZOOLOGY ]**

<b>PROGRAM SPECIFIC OUTCOMES</b>	
<b>PSO 1</b>	<b>Demonstrate the advanced concepts of life at different levels of biological organization, from gene to genome, cell, tissue, organ, organ-systems and whole organisms; and drawing upon this knowledge, relate physiological adaptations, development, reproduction, behaviour and evolution of different forms of life.</b>
<b>PSO 2</b>	<b>Interpret the ecological interconnectedness of life on earth; to relate the physical features of the environment to the structure of populations, communities and ecosystems; and analyse the various environmental issues for providing scientifically sound and socially acceptable solutions.</b>
<b>PSO 3</b>	<b>Experiment with techniques and methods of analysis appropriate for different branches of biology with scientific temperament and problem-solving attitude.</b>
<b>PSO 4</b>	<b>Acquire techniques and skills in the design and execution of research in different branches of Zoology and in careers related to teaching in Zoology; as well as in having innovative ideas and necessary training to initiate unique start-ups and entrepreneurship in the realm of life sciences</b>

### COURSE OUTCOMES

CO	CO Statement	POs/PSOs	CL
CO1	Perceive the fundamentals of ecology and environment – Physical environment, concept of homeostasis	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	U
CO2	Relate the cybernetic nature of ecosystem - feedback control & redundancy of components; resistance and resilience stability, Gaia hypothesis.	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	U
CO3	Discuss the structure and function of Ecosystem – Ecological energetics, Animals and nutrient acquisition Biomass and productivity measurement, Biogeochemical cycles	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	U
CO4	Explain the concepts of population ecology – Population group properties, growth forms, life history strategies, population structure,	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	U
CO5	Examine the concepts of population interactions and the concept of metapopulation	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	U
CO6	Explain the concepts of community - community structure and attributes, ecotone and edge effect. Development and evolution of the ecosystem, guild	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	U
CO7	Differentiate the different kinds of natural resources: Soil, mineral resources, forest resources, aquatic resources, depletion of resources and impacts on quality of life.	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	A
CO8	Differentiate different types energy resources- Energy use pattern, recent issues and concepts in energy production and utilization.	PO1, PO2, PO3, PO4 PSO1, PSO2, PSO3, PSO4	A

CL\* Cognitive Level

R-Remember

U- Understand

- A- Apply
- An- Analyze
- E- Evaluate
- Cr- Create

**CO -PO/PSO Mapping**

	PO 1	PO 2	PO 3	PO 4	PO 5	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	1	3	3	0	3	3	1	1
CO 2	3	1	3	3	0	3	3	1	1
CO 3	3	1	3	3	0	3	3	1	1
CO 4	3	1	3	3	0	3	3	1	1
CO 5	3	1	3	3	0	3	3	1	1
CO 6	3	1	3	3	0	3	3	1	1
CO 7	3	1	3	3	0	3	3	1	1
CO 8	3	1	3	3	0	3	3	1	1

**Mapping Strength**

- 0- No Mapping strength
- 1- Low
- 2- Medium
- 3- High

SESSION	TOPIC	LEARNING RESOURCES	VALUE ADDITIONS	COURSE OUTCOME
<b>MODULE I: Ecology and Environment</b>				
1	Physical Environment- biotic and abiotic interactions.	Lecture	e-resource	CO 1
2	Concept of Homeostasis	Lecture with interaction		CO 1
3	Concepts of habitats- host as habitat,	Lecture		CO 1
4	Niche, niche width and overlap	Lecture and interaction	e-resource	CO 1
5	Fundamental and realized niche	Lecture	Video	CO 1
6	Resource partitioning,	Lecture	e-resource	CO 1
7	character displacement	Lecture		CO 1
8	Cybernetic nature of ecosystem	Lecture	e-resource	CO 1
9	Cybernetic nature of ecosystem contd...	Lecture		CO 1
10	stability through feedback control and through redundancy of components;	ICT Enabled	e-resource	CO 1

		(ppt & images, video clippings); discussion		
11	Resistance and resilience stability	ICT Enabled (ppt & images, video clippings); discussion		CO 1
12	Gaia hypothesis	ICT Enabled (ppt & images, video clippings); discussion	Video	CO 1
13	Revision			CO 1
14	CIA I			
<b>Module II: Ecosystem - Structure and Function</b>				
15	Pathways in ecosystem	ICT Enabled (ppt&images, charts, video clippings)	e-resource	CO 2
16	Energy in the environment-Laws of thermodynamics,	ICT Enabled (ppt&images, video clippings)		CO 2
17	Laws of thermodynamics contd...	ICT Enabled (ppt&images, video clippings)	e-resource	CO 2
18	Energy flow in the ecosystem	ICT Enabled (ppt&images, video clippings)	Video	CO 2
19	Primary productivity	ICT		CO 2

		Enabled (ppt&images, charts, video clippings)		
20	Primary productivity contd..	ICT Enabled (ppt&images, video clippings)	e-resource	CO 2
21	Biomass and productivity measurement. Contd...	ICT Enabled (ppt&images, video clippings)		CO 2
22	Biomass and productivity measurement. Contd...	ICT Enabled (ppt, images, animations & video clippings)	Video	CO 2
23	Pathways in ecosystem	ICT Enabled (ppt&images, charts, video clippings)		CO 2
24	Biogeochemical cycles- patterns and types (CNP).	ICT Enabled (ppt&images, charts, video clippings)		CO 2
25	Biogeochemical cycles- patterns and types (CNP). Contd.. Tropical versus Temperate Ecology	ICT Enabled (ppt&images, video clippings)	Video	CO 2
26	Revision	ICT Enabled (ppt&images, video clippings)		CO 2

<b>Module III: Population Ecology</b>				
<b>27</b>	<b>Population group properties, density and indices of relative abundance</b>	<b>ICT Enabled (ppt&amp;images, video clippings)</b>	<b>e-resource</b>	<b>CO 3</b>
<b>28</b>	<b>Concept of rate. Natality and mortality</b>	<b>ICT Enabled (ppt&amp;images, video clippings)</b>		<b>CO 3</b>
<b>29</b>	<b>Population age structure, Growth forms and concept of carrying capacity</b>	<b>ICT Enabled ppt, images, video clippings</b>	<b>Video</b>	<b>CO 3</b>
<b>30</b>	<b>Population fluctuations, density dependent and density independent controls</b>	<b>ICT Enabled ppt, images, video clippings</b>		<b>CO 3</b>
<b>31</b>	<b>Life history strategies, r &amp; k selection</b>	<b>ICT Enabled ppt, images, video clippings</b>		<b>CO 3</b>
<b>32</b>	<b>CIA- II</b>			
<b>33</b>	<b>Population structure</b>	<b>ICT Enabled (ppt&amp;images, video clippings)</b>		<b>CO 3</b>
<b>34</b>	<b>Aggregation, Allee's principle, isolation, dispersal and territoriality.</b>	<b>ICT Enabled (ppt&amp;images, video clippings)</b>	<b>Video</b>	<b>CO 3</b>
<b>35</b>	<b>Population interactions- types, positive and negative</b>	<b>ICT Enabled (ppt&amp;images, video</b>		<b>CO 3</b>

		clippings)		
36	Population interactions- interspecific and intraspecific interactions	ICT Enabled (ppt&images, video clippings)		CO 3
37	Ecological and evolutionary effects of competition	ICT Enabled (ppt&images, video clippings)		CO 3
38	Concept of metapopulation. Levin's model of metapopulation	ICT Enabled (ppt&images, charts, video clippings)	e-resource	CO 3
39	Comparison of Metapopulation and Logistic population model	ICT Enabled (ppt&images, video clippings)		CO 3
40	Metapopulation structure.	Lecture	Video	CO 3
<b>Module IV: Community Ecology</b>				
41	Concept of community - community structure and attributes, ecotone and edge effect	ICT Enabled (ppt&images, video clippings)		CO 4
42	Development and evolution of the ecosystem, concept of climax	ICT Enabled (ppt&images, charts, video clippings)		CO 4
43	Guild and its functioning in the community.	ICT Enabled (ppt&images, video clippings)		CO 4
<b>Module V: Resource Ecology</b>				
44	Natural Resources; Physical and chemical properties of soil.	Lecture and interaction		CO 5



45	Significance of soil fertility.	Lecture and interaction		CO 5
46	Mineral resources with reference to India; Impact of mining on environment;	Lecture and interaction	e-resource	CO 5
47	Forest resources- deforestation, forest scenario of India.	Lecture and interaction	e-resource	CO 5
48	Aquatic resources - Freshwater and water scarcity, water conservation measures - case studies from India	Lecture and interaction		CO 5
49	Wetlands and its importance, international initiatives for wetland conservation - Ramsar sites.	Lecture		CO 5
50	Sand mining and its impacts. Wetland reclamation- causes and consequences.	Lecture and interaction	e-resource	CO 5
51	Depletion of resources and impacts on quality of life.	Lecture and interaction		CO 5
52	Energy Resources- solar, fossil fuels, hydro, tidal, wind, geothermal and nuclear. Energy use pattern in different parts of the world	Lecture and interaction		CO 5
53	Recent issues in energy production and utilization; Energy audit, Green technology and sustainable development.	Lecture and interaction	e-resource	CO 5
54	Revision			CO 5

#### INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)	Course Outcome
1	5/1/2019	Primary productivity in pond ecosystem	CO 2
2	12/1/2019	Wetland degradation	CO 5

#### GROUP ASSIGNMENTS/ACTIVITIES – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)	Course Outcome
1	11/12/2018	Study of a pond ecosystem	CO 2

#### References

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**COURSE 06: 16P2ZOOT06: GENETICS AND BIOINFORMATICS**

<b>PROGRAMME</b>	<b>MASTER OF SCIENCE [ZOOLOGY]</b>	<b>SEMESTER</b>	<b>2</b>
<b>COURSE CODE AND TITLE</b>	<b>16P2ZOOT06: GENETICS AND BIOINFORMATICS</b>	<b>CREDIT</b>	<b>4</b>
<b>HOURS/WEEK</b>	<b>4</b>	<b>HOURS/SEM</b>	<b>72</b>
<b>FACULTY NAME</b>	<b>RAAGAM PM, JOBIN C THARIAN, MONCEY VINCENT</b>		

**Programme Outcome**

	Programme Outcome
<b>PO 1</b>	Exercise their critical thinking in creating new knowledge leading to innovation, entrepreneurship and employability.
<b>PO 2</b>	Effectively communicate the knowledge of their study and research in their respective disciplines to their stakeholders and to the society at large.
<b>PO 3</b>	Make choices based on the values upheld by the institution, and have the readiness and know-how to preserve the environment and work towards sustainable growth and development.
<b>PO 4</b>	Develop an ethical view of life and have a broader (global) perspective transcending the provincial outlook.
<b>PO 5</b>	Explore new knowledge independently for the development of the nation and the world and are able to engage in a lifelong learning process.

**MASTER OF SCIENCE [ZOOLOGY]**

**PROGRAM SPECIFIC OUTCOMES**

<b>PSO 1</b>	Demonstrate the advanced concepts of life at different levels of biological organization, from gene to genome, cell, tissue, organ, organ-systems and whole organisms; and drawing upon this knowledge, relate physiological adaptations, development, reproduction, behaviour and evolution of different forms of life.
<b>PSO 2</b>	Interpret the ecological interconnectedness of life on earth; to relate the physical features of the environment to the structure of populations, communities and ecosystems; and analyse the various environmental issues for providing scientifically sound and socially acceptable solutions.
<b>PSO 3</b>	Experiment with techniques and methods of analysis appropriate for different branches of biology with scientific temperament and problem-solving attitude.
<b>PSO 4</b>	Acquire techniques and skills in the design and execution of research in different branches of Zoology and in careers related to teaching in Zoology; as well as in having innovative ideas and necessary training to initiate unique start-ups and entrepreneurship in the realm of life sciences.

### COURSE OUTCOMES

CO	CO Statement	POs/PSOs	CL
CO1	Understand the principles of Genetic Transmission	PO1, PO2 PSO1 PSO3	U
CO2	Understand the Molecular Organization of Chromosomes and Fine structure of Genes	PO1, PO2 PSO1 PSO3	U
CO3	Understand Genetic Linkage, Recombination and Chromosome mapping	PO1, PO2 PSO1 PSO3	U
CO4	Understand DNA replication and Gene Mutation	PO1, PO2 PSO1 PSO3	U
CO5	Understand the concepts of Human Genetics, Extra-chromosomal Inheritance, Epigenetics, Quantitative and Population Genetics	PO1, PO2 PSO1 PSO3	U
CO6	Understand various Bioinformatics databases and their functional areas	PO1, PO2 PSO1 PSO3	U
CO7	Understand the idea of sequence similarity search and sequence analysis methodology	PO1, PO2 PSO1 PSO3	U
CO8	Understand the basic idea of Genomics, Proteomics, systems biology and metabolomics	PO1, PO2 PSO1 PSO3	U

CL\* Cognitive Level

R-Remember

U- Understand

B- Apply

An- Analyze

E- Evaluate

Cr- Create

### CO -PO/PSO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	3	0	0	0	3	0	1	0
CO 2	3	3	0	0	0	3	0	1	0
CO 3	3	3	0	0	0	3	0	1	0
CO 4	3	3	0	0	0	3	0	1	0
CO 5	3	3	0	0	0	3	0	1	0
CO 6	3	3	0	0	0	3	0	1	0
CO 7	1	3	0	0	0	3	0	1	0
CO 8	1	3	0	0	0	3	0	1	0

### Mapping Strength

0- No Mapping strength

1- Low

2- Medium

3- High

Session	Topic	Methods of Teaching	Value Addition	CO
<b>Module I. Principles of Genetic Transmission</b>				
1	Extension of Mendel's principles	Lecture and animation videos		CO1
2	Allelic variation and gene function- incomplete dominance and codominance	Lecture and animation videos		CO1
3	Gene action-from genotype to phenotype	Lecture and animation videos		CO1
4	Penetrance and expressivity, gene interaction epistasis	Lecture and animation videos		CO1
5	Pleiotropy, genomic imprinting, phenocopy	Lecture and animation videos		CO1
<b>Module II. Molecular Organization of Chromosomes</b>				
6	Genome size and C-value Paradox	Lecture and animation videos		CO2
7	Structure of eukaryotic chromosome, nucleosome model	Lecture and animation videos		CO2
8	Chromosome Condensation - euchromatin and heterochromatin	Lecture and animation videos		CO2
9	Repetitive nucleotide sequences in eukaryotic genomes	Lecture and animation videos		CO2
10	Kinetics of renaturation: Cot and Cot curve	Lecture and animation videos		CO2
11	Unique and repetitive sequences. Mini and micro Satellites.	Lecture and animation videos		CO3
12	Molecular structure of centromere and telomere. Polytene chromosomes and Lampbrush chromosomes. Chromosome banding techniques.	Lecture and animation videos		CO3
<b>Module III. Gene Fine Structure</b>				
13	Evolution of the concept of gene function and	Lecture and		CO3

	structure. The definition of gene	animation videos		
14	The standard genetic code, Redundancy and Wobble	Lecture and animation videos		CO3
15	DNA Structure- alternate forms of the Double Helix	Lecture and animation videos		CO3
16	Gene synthesis (in vitro Synthesis) – works of Khorana and Kornberg. Modern findings on the nature of gene	Lecture and animation videos		CO3
17	Interrupted genes In eukaryotes, exons and introns-R loops, significance of introns. Genes-within-genes (overlapping genes)	Lecture and animation videos		CO3
18	Bacteriophage Ö X174. Transposable elements in Bacteria –IS elements, composite transposons, Tn3 elements, medical significance	Lecture and animation videos		CO3
19	Transposable elements in Eukaryotes-P elements	Lecture and animation videos		CO3
20	Retrotransposons, significance of transposons	Lecture and animation videos		CO3
<b>Module IV. Genetic Linkage, Recombination &amp; Chromosome Mapping</b>				
21	Chromosome theory of heredity, Linkage and recombination of genes in a chromosome	Lecture and animation videos		CO3
22	Crossing over as the physical basis of recombination, Stern's Experiment	Lecture and animation videos		CO3
23	Molecular mechanisms of recombination (Holliday model), Gene conversion	Lecture and animation videos		CO3
24	Recombination mapping with two-point and three –point test cross in Drosophila	Lecture and animation videos		CO3
25	Coincidence and Interference	Lecture and animation videos		CO4
26	Genetic mapping by tetrad analysis in Neurospora	Lecture and animation videos		CO4
27	Mitotic recombination. Genetic recombination in Phage, rII locus	Lecture and animation videos		CO4
28	Complementation test, deletion mapping, conjugation mapping	Lecture and animation videos		CO4
29	Mapping by interrupted mating	Lecture and animation videos		CO4
30	Mapping with molecular markers and mapping using somatic cell	Lecture and animation videos		CO4
<b>Module V. Gene Mutation</b>				
31	Molecular basis of gene mutation	Lecture and animation videos		CO4
32	Mutant types- lethal, conditional	Lecture and animation videos		CO4
33	Loss of function, gain of	Lecture and		CO4

	function, germinal verses somatic mutants	animation videos		
34	Induced mutation, The Ames test for mutagen/carcinogen detection.	Lecture and animation videos		CO4
35	DNA damage and repair mechanisms	Lecture and animation videos		CO4
<b>Module VI. DNA Replication</b>				
36	The Meselson-Stahl experiment	Lecture and animation videos		CO4
37	Semi conservative replication of DNA in chromosomes	Lecture and animation videos		CO4
38	Theta replication	Lecture and animation videos		CO4
39	Rolling-circle replication	Lecture and animation videos		CO4
40	Molecular mechanisms of eukaryotic replication	Lecture and animation videos		CO4
<b>Module VII. Human Genetics</b>				
41	Karyotype, pedigree analysis	ICT (ppt & images, video clippings) and discussion		CO5
42	Lod score for linkage testing	ICT (ppt & images, video clippings) and discussion		CO5
43	Genetic analysis of complex traits - complex pattern of inheritance,	ICT (ppt & images, video clippings) and discussion		CO5
44	Threshold traits; human genome and mapping.	ICT (ppt & images, video clippings) and discussion		CO5
	<b>Module VIII. Extra Chromosomal Inheritance</b>			CO5
<b>Module VIII. Extra Chromosomal Inheritance</b>				
45	Inheritance of mitochondrial and chloroplast genes	ICT (ppt & images, video clippings) and discussion		CO5
46	Maternal inheritance	ICT (ppt & images, video clippings) and discussion		CO5
<b>Module IX. Epigenetics</b>				
47	Epigenetics - from phenomenon to field, a brief history of epigenetics - overview and concepts	ICT (ppt & images, video clippings) and discussion		CO5
48	Chromatin modifications and their mechanism of action	ICT (ppt & images, video clippings) and discussion		CO5
49	Concept of 'histone-code' hypothesis	ICT (ppt & images,		CO5

		video clippings) and discussion		
50	Epigenetics in <i>Saccharomyces cerevisiae</i>	ICT (ppt & images, video clippings) and discussion		CO5
51	Position effect variegation, heterochromatin formation and gene silencing in <i>Drosophila</i>	ICT (ppt & images, video clippings) and discussion		CO5
<b>Module X. Quantitative and Population Genetics</b>				
52	Polygenic inheritance, analysis of quantitative traits	ICT (ppt & images, video clippings) and discussion		CO5
53	Quantitative traits and natural selection	ICT (ppt & images, video clippings) and discussion		CO5
54	Estimation of heritability, QTL mapping	ICT (ppt & images, video clippings) and discussion		CO5
55	Genotype-environment interactions	ICT (ppt & images, video clippings) and discussion		CO5
56	Molecular analysis of quantitative traits	ICT (ppt & images, video clippings) and discussion		CO5
57	Phenotypic plasticity	ICT (ppt & images, video clippings) and discussion		CO5
<b>BIOINFORMATICS: Module I. Biological Databases</b>				
58	Introduction- Biological databases	Lecture with PowerPoint		CO6
59	Primary databases - Nucleotide sequence databases: GenBank, EMBL, DDBJ	Lecture with PowerPoint		CO6
60	Protein sequence databases: SWISSPROT, PIR	Lecture with PowerPoint		CO6
61	Structure databases: PDB, NDB	Lecture with PowerPoint		CO6
62	Secondary databases: PROSITE, Pfam, CATH	Lecture with PowerPoint		CO6
63	Composite databases: OWL Literature database: PubMed; Database searching – Entrez	Lecture with PowerPoint		CO6
64	Database sequence submission – BankIt.	Lecture with PowerPoint		CO7
<b>Module II. Sequence Analysis</b>				
65	Types of sequence alignment and Methods of sequence alignment	Lecture with PowerPoint		CO7
66	Scoring schemes, gaps and gap penalties	Lecture with PowerPoint		CO7
67	Construction of phylogenetic trees using BIOEDIT and Construction of phylogenetic trees using	Lecture with PowerPoint		CO7



	PHYLIP; Evaluation of phylogenetic trees			
<b>Module IV. Genomics and Proteomics</b>				
68	Structural genomics and Functional genomics	Lecture PowerPoint	with	CO7
69	Comparative genomics-Data mining in proteomics	Lecture PowerPoint	with	CO7
70	Microarrays	Lecture PowerPoint	with	CO8
71	Introduction- metabolomics	Lecture PowerPoint	with	CO8
72	Gene network, Synthetic biology.	Lecture PowerPoint	with	CO8

#### INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

S. No	Date of completion	Topic of Assignment & Nature of assignment (Individual – Written/Presentation – Graded or Non-graded etc)	Course Outcome
		Assignment Topics	
1	30-01-2019	Transposons	CO4
2	02-02-2019	Extra chromosomal inheritance	CO3
3	10-02-2019	Metabolomics	CO7

#### REFERENCES

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**COURSE 07: 16P2ZOOT07 DEVELOPMENTAL BIOLOGY**

<b>PROGRAMME</b>	<b>MASTER OF SCIENCE [ZOOLOGY]</b>	<b>SEMESTER</b>	<b>2</b>
<b>COURSE CODE AND TITLE</b>	<b>16P2ZOOT07 DEVELOPMENTAL BIOLOGY</b>	<b>CREDIT</b>	<b>4</b>
<b>HOURS/WEEK</b>	<b>4</b>	<b>HOURS/SEM</b>	<b>72</b>
<b>FACULTY NAME</b>	<b>SMITHA S &amp; JOBI MJ</b>		

**Programme Outcome**

<b>Programme Outcome</b>	
<b>PO 1</b>	Exercise their critical thinking in creating new knowledge leading to innovation, entrepreneurship and employability.
<b>PO 2</b>	Effectively communicate the knowledge of their study and research in their respective disciplines to their stakeholders and to the society at large.
<b>PO 3</b>	Make choices based on the values upheld by the institution, and have the readiness and know-how to preserve the environment and work towards sustainable growth and development.
<b>PO 4</b>	Develop an ethical view of life and have a broader (global) perspective transcending the provincial outlook.
<b>PO5</b>	Explore new knowledge independently for the development of the nation and the world and are able to engage in a lifelong learning process.

**MASTER OF SCIENCE [ZOOLOGY]**

<b>PROGRAM SPECIFIC OUTCOMES</b>	
<b>PSO 1</b>	Demonstrate the advanced concepts of life at different levels of biological organization, from gene to genome, cell, tissue, organ, organ-systems and whole organisms; and drawing upon this knowledge, relate physiological adaptations, development, reproduction, behaviour and evolution of different forms of life.
<b>PSO 2</b>	Interpret the ecological interconnectedness of life on earth; to relate the physical features of the environment to the structure of populations, communities and ecosystems; and analyse the various environmental issues for providing scientifically sound and socially acceptable solutions.
<b>PSO 3</b>	Experiment with techniques and methods of analysis appropriate for different branches of biology with scientific temperament and problem-solving attitude.
<b>PSO 4</b>	Acquire techniques and skills in the design and execution of research in different branches of Zoology and in careers related to teaching in Zoology; as well as in having innovative ideas and necessary training to initiate unique start-ups and entrepreneurship in the realm of life sciences

### COURSE OUTCOMES

	COURSE OUTCOMES	PO/ PSO	CL
CO1	Define gametogenesis and the process of formation of embryos, and molecular mechanisms that regulate embryo formation	PO1, PO5 PSO1, PSO4	U
CO2	Assess the process of fertilization and molecular mechanisms working for keeping the identity of species	PO1, PO5 PSO1, PSO4	U
CO3	Recall the critical nature of axis and structure formation during early embryonic life	PO1, PO5 PSO1, PSO4	U
CO4	Illustrate the factors and molecules that have critical roles in normal formation of embryos	PO1, PO5 PSO1, PSO4	U
CO5	Discuss the process of post embryonic development and regeneration	PO1, PO5 PSO1, PSO4	U
CO6	Identify the different perturbations during embryo formation	PO4, PO5 PSO1, PSO4	U
CO7	Discover the applied aspects of embryogenesis for treatment of infertility in human beings	PO4, PO5 PSO1, PSO4	U
CO8	Examine the potential of stem cells and scope of therapeutic cloning	PO4, PO5 PSO1, PSO4	U

CL\* Cognitive Level

R-Remember

U- Understand

C- Apply

An- Analyze

E- Evaluate

Cr- Create

### CO -PO/PSO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	0	0	0	3	0	3	0	0	3
CO 2	3	0	0	0	3	0	3	0	0	3
CO 3	3	0	0	0	2	0	3	0	0	3
CO 4	3	0	0	0	3	0	3	0	0	2
CO 5	3	0	0	0	3	0	3	0	0	3
CO 6	3	0	0	2	3	0	3	0	0	3
CO 7	3	0	0	2	2	0	3	0	0	3
CO 8	3	0	0	2	3	0	3	0	0	3

### Mapping Strength

0- No Mapping strength

1- Low

2- Medium

3- High

SESSION	TOPIC	LEARNING RESOURCES	VALUE ADDITIONS	COURSE OUTCOME
<b>Module 1 Early development at molecular level</b>				
1.	Introduction	Discussion to test the pre-requisite		CO1
2.	Molecular biology of gametogenesis	Lecture and PPT		CO1
3.	Germ plasm and determination of primordial germ cells	ICT Enabled (PPT)		CO1
4.	Germ cell determination – in nematodes, insects, mammals	ICT Enabled (PPT)		CO1
5.	Germ cell migration in insects, mammals	Discussions from Text – Gilbert	Video	CO1
6.	Primordial germ cells into functional gametes	PPT		CO1
7.	Biochemicals involved in maintaining species – specificity	Lecture and PPT		CO2
8.	Electrical and biochemical mechanisms to ensure monospermy	Lecture and PPT	Video	CO2
9.	Biochemistry of egg activation	Lecture and PPT		CO2
10.	Control mechanism in cleavage	Lecture and ppt		CO2
11.	Blastulation - significance of mid-blastula transition	Lecture and PPT		CO2
12.	Molecular basis of gastrulation	Discussion and teaching		CO2
13.	Discussion			CO2
<b>Module II. Axis and Pattern Formation – vertebrate model</b>				
14.	Anterior posterior axis	Lecture and PPT		CO3
15.	Dorsal ventral axis	Lecture and PPT		CO3
16.	Left right axis	Lecture and PPT		CO3

17.	Spemann's constriction experiments	Lecture and PPT		CO3
18.	Transplantation experiments	Lecture and PPT		CO3
19.	Embryonic induction, competence – Spemann organizer	Lecture and PPT		CO3
20.	Nieuwkoop centre and mesodermal signaling	Lecture and PPT		CO3
21.	Inducer molecules associated with organizer such as paracrine factors (FGF factors, Hedgehog proteins)	Lecture		CO3
22.	Wnt proteins, TGF – $\beta$ factors, BMP proteins	Lecture		CO3
23.	Justacrine factors, transcription factors	Lecture		CO3
24.	Role of these molecules in development. Left-right axis formation	Lecture and PPT	Video	CO3
25.	Significance of axis formation in embryonic patterning	Lecture and PPT		CO3
26.	CIA- I	1Hr.		
<b>Module III. Axis and Pattern Formation – invertebrate models</b>				
27.	Early development and axis specification in <i>caenorhabditis elegans</i> .	Lecture and PPT		CO3
28.	Early development of <i>drosophila</i> .	Lecture and PPT		CO4
29.	Molecular mechanism of anterior-posterior patterning in <i>drosophila</i> - introduction	Lecture and PPT		CO4
30.	Maternal effect genes	Lecture and PPT		CO4
31.	Zygotic genes,	Lecture and PPT		CO4
32.	Gap genes	Lecture and PPT		CO4
33.	Pair rule genes, segment polarity genes	Lecture and PPT		CO4
34.	Homeotic selector genes, realisor genes	Lecture and PPT		CO4
35.	Dorsal-ventral patterning in <i>drosophila</i>	Lecture and PPT		CO4
36.	Left right patterning in <i>drosophila</i>	Lecture and PPT		CO4
37.	Revision			CO4
<b>Module IV. Postembryonic Development</b>				
38.	Metamorphosis- Introduction	Lecture and PPT		CO5

39.	Morphological changes associated with Amphibian metamorphosis	Lecture and PPT		CO5
40.	growth of new structures, cell death and remodelling during metamorphosis.	Lecture and PPT		CO5
41.	Hormonal regulation of amphibian metamorphosis.	Lecture and PPT		CO4
42.	Insect metamorphosis – role of imaginal discs	Lecture and PPT		CO4
43.	Hormonal control of insect metamorphosis.	Lecture and PPT	Video	CO4
44.	Regeneration -Introduction	Lecture		CO5
45.	stem cell mediated, epimorphosis,	Lecture and PPT		CO5
46.	morpholaxis, and compensatory.	Lecture and PPT		CO5
47.	Mechanism of epimorphic regeneration in Salamander leg	Lecture and PPT		CO5
48.	Morpholactic regeneration in Hydra,	Lecture and PPT		CO5
49.	Compensatory regeneration in mammalian liver	Lecture and PPT		CO5
50.	Lens regeneration in amphibia	Lecture and PPT		CO5
51.	Revision			CO5
<b>Module 5 Teratogenesis</b>				
52.	Malformations and disruptions	Seminar		CO6
53.	Gene – phenotype relationship	Seminar		CO6
54.	Alcohol, retinoic acid as teratogens	Seminar		CO6
55.	CIA- II	2 hrs		CO6
56.	Drugs and chemicals, heavy metals as teratogens	Seminar		CO6
57.	Pathogens and environmental oestrogens as teratogens	Seminar		CO6
58.	Revision			CO6
<b>Module VI. Applied aspects of Developmental Biology</b>				
59.	Human Infertility – types and causes	Lecture and PPT		CO7
60.	<i>In vitro</i> fertilization	Lecture and PPT		CO7
61.	Other assisted reproductive technologies (ART).	Lecture and PPT		CO7
62.	Cloning experiments- (Amphibians, Mammals and Human)	Lecture and PPT		CO7
63.	Ethical issues.	Lecture and		CO7

		PPT		
64.	Revision			CO7
<b>Module VII. Stem cells</b>				
65.	Definition, Pluripotent, multipotent stem cells,	Lecture and PPT		CO8
66.	embryonic stem cells & adult stem cells	Lecture and PPT		CO8
67.	Types of embryonic stem cells	Lecture and PPT		CO8
68.	Stem cells and therapeutic cloning	Lecture and PPT		CO8
69.	Stem cells and regenerative medicine,	Lecture and PPT		CO8
70.	Transgenic stem cells	Lecture and PPT		CO8
71.	Stem cell banks	Lecture and PPT		CO8
72.	Ethical issues associated with stem cell experiment	Lecture and PPT		CO8

#### INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual – Written/Presentation – Graded or Non-graded etc)	Course Outcome
1	2/2/2019	Stem cells	CO8
2	4/2/2019	Regeneration	CO6

#### GROUP ASSIGNMENTS/ACTIVITES – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)	Course Outcome
1	15/2/2019	Development in chick	CO3

#### References

- Balinsky, B.I.2004. An Introduction to Embryology. .B.SaundersCo.,Philadelphia.
- Berril, N.J. 1979. Developmental Biology.Tata McGraw-Hill Pub.Co.Ltd.,New Delhi.
- Gilbert, S.F. 2006. Developmental Biology (9thedn).Sinauer Associates Inc., Publishers, Massachusetts, USA
- Hopper, A.F. and Hart ,N.H.1985. Foundations of Animal Development.Oxford University Press, Oxford.

**COURSE 08: 16P2ZOOT08 BIOCHEMISTRY**

<b>PROGRAMME</b>	<b>MASTER OF SCIENCE [ZOOLOGY]</b>	<b>SEMESTER</b>	<b>2</b>
<b>COURSE CODE AND TITLE</b>	<b>16P2ZOOT08 BIOCHEMISTRY</b>	<b>CREDIT</b>	<b>4</b>
<b>HOURS/WEEK</b>	<b>4</b>	<b>HOURS/SEM</b>	<b>72</b>
<b>FACULTY NAME</b>	<b>GISHA SIVAN &amp; JOBI M J</b>		

**Programme Outcomes**

<b>Programme Outcomes</b>	
<b>PO 1</b>	Exercise their critical thinking in creating new knowledge leading to innovation, entrepreneurship and employability.
<b>PO 2</b>	Effectively communicate the knowledge of their study and research in their respective disciplines to their stakeholders and to the society at large.
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<b>PO 4</b>	Develop an ethical view of life and have a broader (global) perspective transcending the provincial outlook.
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<b>PROGRAM SPECIFIC OUTCOMES</b>	
<b>PSO 1</b>	Understand the advanced concepts of life at different levels of biological organization, from gene to genome, cell, tissue, organ, organ-systems and whole organisms; and drawing upon this knowledge, understand physiological adaptations, development, reproduction, behaviour and evolution of different forms of life.
<b>PSO 2</b>	Understand the ecological interconnectedness of life on earth; to relate the physical features of the environment to the structure of populations, communities and ecosystems; and analyse the various environmental issues for providing scientifically sound and socially acceptable solutions.
<b>PSO 3</b>	Demonstrate proficiency in experimental techniques and methods of analysis appropriate for different branches of biology with scientific temperament and problem-solving attitude.
<b>PSO 4</b>	Develop aptitude and skills in research in different branches of Zoology and in careers related to teaching in Zoology; as well as in having innovative ideas and necessary training to initiate unique start-ups and entrepreneurship in the realm of life sciences



### COURSE OUTCOMES

	COURSE OUTCOMES	PO/ PSO	CL
CO1	Understand structure and classification of different biomolecules – protein, lipid, carbohydrate and nucleic acid.	PO1, PO2 PSO1, PSO2	U
CO2	Examine the metabolic pathways of different biomolecules	PO1, PO2, PSO1, PSO3	U
CO3	Discuss the disorders of the biomolecules	PO1,PO2 PSO1, PSO2	A
CO4	Evaluate the different enzymes and its kinetics	PO1, PO2, PO3 PSO1, PSO3	E
CO5	Analyze the biological roles of biomolecules	PO1, PO3 PSO1, PSO3	A
CO6	Discuss the synthesis and derivatives of biomolecules	PO1, PO4 PSO4	A

CL\* Cognitive Level

R-Remember

U- Understand

A- Apply

An- Analyze

E- Evaluate

Cr- Create

### CO -PO/PSO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	1	0	0	0	1	3	0	0
CO 2	3	1	0	0	0	1	0	1	0
CO 3	3	1	0	0	0	1	3	0	0
CO 4	3	1	2	0	0	1	0	1	0
CO 5	1	0	0	0	0	1	0	1	0
CO 6	1	0	0	2	0	0	0	0	1

### Mapping Strength

0- No Mapping strength

1- Low

2- Medium

3- High

SESSION	TOPIC	LEARNING RESOURCES	VALUE ADDITIONS	COURSE OUTCOME
<b>Module I. Carbohydrates</b>				
1	Reactions of monosaccharides: Oxidation, reduction, ester formation, osazone formation. Glycosidic bond.	ICT Enabled (ppt&images, video clippings)	e-resource	CO 1
2	Disaccharides: Sucrose, Lactose, Maltose, Isomaltose, Cellobiose and Trehalose.	ICT Enabled (ppt&images, charts, video clippings)		CO 1
3	Polysaccharides: Homopolysaccharides- Starch, Glycogen, Cellulose, Chitin, Dextran, Inulin, Pectin.	ICT Enabled (ppt&images, video clippings)		CO 1
4	Heteropolysaccharides- Hyaluronic acid, Heparin, Chondroitin sulphate, Keratansulphate, Dermatan sulphate and Agar-agar.	ICT Enabled (ppt&animations, images, video clippings)	e-resource	CO 1
5	Glycoproteins and Mucoproteins.	ICT Enabled (ppt&animations, images, video clippings)	Video	CO 1
<b>Module II. Proteins</b>				
6	Structure, classification and properties of amino acids.	ICT Enabled (ppt&images, video clippings)	e-resource	CO 2
7	Amphoteric properties of amino acids, pK value and iso-electric point of amino acids. Peptide bond formation and peptides.	ICT Enabled (ppt&images, video clippings)		CO 2
8	Reactions (due to carboxyl group, amino group and side chains).	ICT Enabled (ppt&images, video clippings)	e-resource	CO 2
9	Colour reactions of amino acids and proteins.	ICT Enabled (ppt&images, video clippings)		CO 3

10	Primary structure of protein (e.g. insulin). Classification and properties of proteins. Conformation of proteins- chemical bonds involved,	ICT Enabled (ppt&image s, video clippings)	e-resource	CO 3
11	Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map.	ICT Enabled (ppt&image s, video clippings)		CO 3
12	Fibrous proteins- examples (Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons.	ICT Enabled (ppt&image s, video clippings)	Video	CO 3
13	Tertiary structure- e.g. Myoglobin. Quaternary structure - e.g. Haemoglobin	ICT Enabled (ppt&image s, video clippings)		CO 3
14	CIA I	1 hr; descriptive answers only		
<b>Module III. Lipids</b>				
15	Classification of lipids: simple, compound and derived lipids. Biological importance of lipids.	ICT Enabled (ppt&image s, charts, video clippings)	e-resource	CO 4
16	Fatty acids: classification, nomenclature. Simple fats: Triacylglycerol (Triglycerides) - Physical properties.	ICT Enabled (ppt&image s, video clippings)		CO 4
17	Reactions-Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number, Polenske number and Reichert-Meissl number of lipids. Waxes.	ICT Enabled (ppt&image s, video clippings)	e-resource	CO 4
18	Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, Plasmalogens.	ICT Enabled (ppt&image s, video clippings)	Video	CO 4
19	Glycolipids, Sphingolipids. Derived Lipids	ICT Enabled (ppt&image s, charts, video clippings)		CO 4
20	Steroids: Biologically important steroids-	ICT Enabled	e-resource	CO 4

	cholesterol, Vitamin D, Bile acids,	(ppt&image s, video clippings)		
21	Ergosterol, Terpenes, Lipoproteins.	ICT Enabled (ppt&image s, video clippings)		CO 4
22	Prostaglandins- structure, types, synthesis and functions	ICT Enabled (ppt, images, animations & video clippings)	Video	CO 4
23	Toxicants of biological origin - Aflatoxin, Botulinum toxin	ICT Enabled (ppt&image s, charts, video clippings)		CO 4
<b>Module IV. Nucleic Acids</b>				
24	Structural organization of DNA (Watson - Crick Model)	ICT Enabled (ppt&image s, charts, video clippings)		CO 4
25	Characteristic features of A, B, C and Z DNA.	ICT Enabled (ppt&image s, video clippings)	Video	CO 4
26	Structural organization of tRNA;	ICT Enabled (ppt&image s, video clippings)		CO 4
27	Protein-nucleic acid interaction. DNA regulatory proteins,	ICT Enabled (ppt&image s, video clippings)	e-resource	CO 4
28	folding motifs, conformation flexibilities,	ICT Enabled (ppt&image s, video clippings)		CO 4
29	denaturation, renaturation,	ICT Enabled (ppt&image s, video clippings)	Video	CO 4

30	DNA polymerases,	ICT Enabled (ppt&image s, video clippings)		CO 4
31	Restriction endonucleases.	ICT Enabled (ppt&image s, video clippings)		CO 4
32	CIA- II			
33	Biological roles of nucleotides and nucleic acids.	ICT Enabled (ppt&image s, video clippings)		CO 4
34	Biological roles of nucleic acids.	ICT Enabled (ppt&image s, video clippings)	Video	CO 4
35	Revision			
36	Revision			
<b>Module V. Enzymes</b>				
37	Co-enzymes,Iso-enzymes,Ribozymes. Enzyme specificity	ICT Enabled (ppt&image s, video clippings)		CO 4
38	Mode of action of enzymes.Formation of enzyme substrate complex. Lowering of activation energy, various theories, active site.	ICT Enabled (ppt&image s, charts, video clippings)	e-resource	CO 4
39	Enzyme kinetics: Michaelis-Menten equation. Km value and its significance	ICT Enabled (ppt&image s, video clippings)		CO 4
40	Enzyme velocity and factors influencing enzyme velocity.	Lecutre	Video	CO 4
41	Kinetics of enzyme inhibition, suicide inhibition and feedback inhibition	ICT Enabled (ppt&image s, video clippings)		CO 4
42	Enzyme regulation: Allosteric regulations – Key enzymes, Covalent modifications. Enzyme engineering.	ICT Enabled (ppt&image s, video clippings)	e-resource	
<b>Module VI. Carbohydrate Metabolism</b>				

43	Glycogen metabolism- Glycogenesis, Glycogenolysis.	ICT Enabled (ppt&images, charts, video clippings)		CO 5
44	Adenylate cascade system	ICT Enabled (ppt&images, video clippings)		CO 5
45	Ca <sup>2+</sup> Calmodulin –sensitive phosphorylase kinase. Regulation of glycogen synthesis.	ICT Enabled (ppt, images, animations & video clippings)		CO 5
46	Minor metabolic pathways of carbohydrates: Pentose Phosphate pathway, Glucuronic acid metabolism.	ICT Enabled (ppt, images, animations & video clippings)	e-resource	CO 5
47	Galactose metabolism	ICT Enabled (ppt&images, charts, video clippings)	e-resource	CO 5
48	Inborn errors associated with carbohydrate metabolism.	ICT Enabled (ppt&images, video clippings)		CO 5
49	Glycogen storage diseases	Lecture		CO 5
50	Lactose intolerance, Galactosuria	ICT Enabled (ppt&images, charts, video clippings)	e-resource	CO 5
<b>Module VII. Metabolism of Proteins</b>				
51	Fate of carbon skeletons of amino acids: glucogenic	ICT Enabled (ppt, images, animations & video clippings)		CO 5

52	Ketogenic	ICT Enabled (ppt, images, animations & video clippings)		CO 5
53	Partly glucogenic and examples	ICT Enabled (ppt, images, animations & video clippings)	e-resource	CO 5
54	Partly ketogenic with examples	ICT Enabled (ppt, images, animations & video clippings)		CO 5
56	Synthesis of biologically significant compounds from different aminoacids with special reference to glycine,	ICT Enabled (ppt&image s, video clippings)	e-resource	CO 5
57	glutamic acid and phenylalanine,	ICT Enabled (ppt&image s, charts, video clippings)		CO 5
58	tyrosine and tryptophan.	ICT Enabled (ppt&image s, video clippings)	e-resource	CO 5
<b>Module VIII. Metabolism of Lipids</b>				
59	Alpha oxidation and omega oxidation of fatty acids.	ICT Enabled (ppt&image s, video clippings)		CO 6
60	De novo synthesis of fatty acids.	ICT Enabled (ppt&image s, video clippings)	e-resource	CO 6
61	Metabolism of cholesterol, synthesis and its regulation.	ICT Enabled (ppt&image s, video clippings)		CO 6

62	Biosynthesis of triglycerides.	ICT Enabled (ppt&images, charts, video clippings)	e-resource	CO 6
63	Metabolism of ketone bodies - Ketogenesis, Ketolysis, Ketosis.	ICT Enabled (ppt&images, video clippings)		CO 6
<b>Module IX. Nucleic Acid and Mineral Metabolism</b>				
64	Catabolism of purines and pyrimidines.	ICT Enabled (ppt, images, animations & video clippings)	e-resource	CO 6
65	Major and minor nutrients. Role of Calcium, Phosphorus,	ICT Enabled (ppt, images, animations & video clippings)		CO 6
66	Magnesium, Sodium	ICT Enabled (ppt&images, charts, video clippings)		CO 6
67	Potassium, Chloride,	ICT Enabled (ppt&images, video clippings)	e-resource	CO 6
68	Sulphur and Iron.	ICT Enabled (ppt&images, video clippings)		CO 6
69	Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species.	ICT Enabled (ppt&images, video clippings)	e-resource	CO 6
70	CIA II			
71	Free radical scavenger systems. Lipid peroxidation.	ICT Enabled (ppt, images, animations)	Video	CO 6



		& video clippings)		
72	Preventive antioxidants.	ICT Enabled (ppt, images, animations & video clippings)		CO 6

#### INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)	Course Outcome
1	4/1/2019	Enzyme kinetics: Michaelis-Menten equation. Km value and its significance	CO 4
2	21/1/2019	De novo synthesis of fatty acids.	CO 6

#### GROUP ASSIGNMENTS/ACTIVITES – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)	Course Outcome
1	2/2/2019	Structure, classification and properties of amino acids)	CO 2
2	9/2/2019	Preventive antioxidants.	CO 6

#### References

- Lenhninger, A.L. 2008. Principles of Biochemistry. (5th edn). CBS Publishers and Distributors, New Delhi.
- Stayer, L. 2011. Biochemistry. (7th edn). W.H. Freeman & Co. NY.
- Voet, D. and J.G. Voet.2004. Biochemistry. John Wiley & Sons.,NY.

#### Web resource references:

- <https://www.youtube.com/watch?v=8PWF5OeB7Ec>
- <https://udmp.lf1.cuni.cz/file/5778/purinepyrimidineporphyrie-en2015.pdf>