UNIVERSITY OF CALCUTTA

Notification No.CSR/19/2023

It is notified for information of all concerned that the Syndicate in its meeting dated 10.07.2023 (vide Item No.9) approved & subsequently confirmed by the Syndicate dated 13.07.2023 the matter regarding modified syllabus for P.G. course in Biochemistry, under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the session 2023 -2024.

28/7/2023

SENATE HOUSE
KOLKATA-700 073

Prof.(Dr.) Debasis Das
Registrar

UNIVERSITY OF CALCUTTA

Uniform Examination Regulations for Two-Year Post Graduate (M.A. / M.Sc. / M.Com.)Courses (Under C.B.C.S.)(With effect from the academic year 2018 – 2019)

1. The two -Year Post Graduate (M.A. / M.Sc. / M.Com.) Course (Under C.B.C.S.) shall be for a minimum duration of four (4) consecutive semesters of six (6) months each, i.e. two (2) years. The odd semester will start ordinarily in the month of July and the even semester in the month of January of every year.
A candidate pursuing a regular course of study for two-year Post Graduate (M.A. / M.Sc. / M.Com.) course (Under C.B.C.S.) **shall have to clear all the semesters in all respects within a span of four years from the year of admission to the particular course and combination, failing which enrolment of the candidate shall stand cancelled.**
2. End semester examinations are to be held ordinarily at the end of the concerned semester, i.e. Semester I and Semester III in December-January and Semester II and Semester IV in June-July.

3. A candidate shall be eligible for appearing at any of the Semesters of P.G. Examination, provided he/she prosecutes a regular course of studies in the concerned subjectoffered by the University keeping percentage of attendance as specified bellow-

a) A student attending at least 75% of the total number of classes* held shall be allowed to appear at the concerned Semester Examination subject to fulfilment of other conditions laid down in the regulations.

b) A student attending at least 60% but less than 75% of the total number of classes* held shall, however, be eligible to appear at the concerned Semester Examination upon obtaining condonation order from the Vice-Chancellor (Principal for affiliated colleges) andon payment of requisite condonation fees/ short attendance fees as may be prescribed by the University from time to time.

c) A student attending less than 60% of the total number of classes* held shall not be allowed to appear at the concerned Semester Examinations and he/she has to take re-admission to the same Semester in the very next year for attending the classes and appearing at the said Semester Examination subject to fulfilment of clause (a) or (b) above.

**Such attendance will be calculated from the date of commencement of classes or date of admission, whichever is later.*
4. Theoretical examinations would be held after the completion of curriculum at the end of each semester (clause 2).

Duration of the theoretical examinations-
Up to 25 marks: 1 hour
26 to 50 marks: 2 hours
51 to 80 marks: 3 hours
81 to 100 marks: 4 hours

5. A candidate is required to appear (in examination) in each and every paper / course / module / part / group of the respective syllabus. A candidate in order to be declared to have passed an examination, must obtain at least 40% marks (including Internal Assessment) in each paper / course. In case of a paper/coursecontaining both theoretical and practical portions, a candidate is required to secure at least 35% marks (including Internal Assessment) separately in the

theoretical and practical portions and at least 40% marks (including Internal Assessment) in aggregate in that paper.

6. A candidate who is **eligible** to appear at any of the End Semester Examinations does not enrol or does not appear at the examinations or fails to secure pass marks in any paper(s) at the concerned examinations, as stated in Clauses 5 above, will be allowed to attend the classes in the next higher semester, as applicable.

7. Internal Assessment has to be done in the semester in which a candidate becomes eligible to appear in the concerned end semester examination. The candidates remaining absent in the written examination for Internal Assessment will be awarded zero (0) marks in the written part of internal examination.

Marks obtained in Internal Assessment (i.e., marks for attendance, if any, and marks of written examination or any other component of internal assessment, taken together) shall be retained for the entire duration of his/her enrolment.

8. If a candidate secures pass marks in Practical Paper(s)/Module(s) /Project Work but fails to secure pass marks in other papers, the marks of Practical Paper(s)/Module(s) /Project Work along with Internal Assessment of the other papers shall be retained for the entire duration of his/her enrolment.

9. A candidate may continue his/her course of study for the next higher Semester and appear at any higher End Semester examination without appearing at the lower End Semester Examinations subject to Clause 3(c).

10. A candidate who fails to secure pass marks (as stated in Clause 5 above) in one or more papers of a semester may appear in those paper(s) when the concerned End Semester Examinations will beheld next.

11. If a candidate fails to secure pass marks in one or more papers in 3rd and / or 4th End-semester examinations, he/she may appear in the supplementary examinations to be held after 3 months of the publication of results of 4th semester examinations.

12. Non-appearance (absence) in any examination for any reason shall be counted as a chance. Failure to fill up the examination form shall also be considered as a missing chance.

13. A failed candidate, intending to re-appear in a subsequent semester examination has to submit examination form / application to the Controller of Examinations through the Head of the Department (Principal for affiliated colleges) as per the notice to be issued by the department of Controller of Examinations.

The candidate has to clear the entire course within 4 years from the year of first admission in that course.

14. The schedule for the End-Semester Examination shall be prepared and announced by the Controller of Examinations in consultation with the Post Graduate Board of Studies concerned.

15. Names of the paper-setters (at least one internal paper setter from the concerned academic department of this University and one external*/substantive teacher of the affiliated colleges having teaching experience of the paper concerned in PG Course), head-examiner (preferably regular faculty of the concerned academic department of the University),examiners, scrutineers,

re-examiners, third examiners (if required) of each subject / course / paper and board of moderators(regular faculty members of the concerned academic department of this University and at least one external*) shall be recommended by the Post Graduate Board of Studies and approved by the Vice- Chancellor.

**Any expert having teaching experience in Master Degree and are not engaged in teaching either in concerned academic department of this University or any affiliated college of this University (if viable otherwise).*

16. Concerned Post Graduate Board of Studies will recommend the following for approval of the higher authorities.

a. Pattern of questions with marks distribution

b. Modalities for holding internal assessment

c. Modalities for holding practical examinations, if any

d. Modalities for submission of dissertation or project (if any)

e. Modalities for holding Viva-Voce examinations, if any,etc.

17. An examination shall be held always under the current syllabus (if viable otherwise).

18. Question papers shall be set in English Version. However, for language based subjects, question papers will be set in the particular language only.

19. Medium of Answer

For examinations in subjects (other than language based ones) candidates shall have the option of writing their answers in either Bengali or English unless instructed otherwise in respective question paper(s). For examinations in Language based subjects (e.g. Bengali, Hindi, Urdu, English etc.) candidates shall have to write their answers in the respective language only.

20. The provisional result of each semester will be published showing the details of courses studied (code, title, marks secured, credits, grade point and letter grade) along with SGPA of that semester and Cumulative Grade Point Average (CGPA) of the last semester.

21. Award of Degree

a) The final result of a candidate shall be determined on the basis of CGPA in a 10 point scale.

b) Grade Card shall be made as per grading system. Course-wise marks (Internal and End Semester Examination added together) will be converted into percentage of marks. Percentage of marks will be converted into Letter Grade and Grade Point. Credit and Grade point will be converted into Credit Point. Finally, Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) will be computed.

c) The Grade Card of a Semester shall be issued only after completion of that Semester.

d) The date of publication of final result for a regular student, who shall clear all the semesters in normal course, shall be the date of publication of result of the 4th Semester.The final date of publication of result for students clearing previous semester(s) subsequent to their clearing 4th Semester examination shall**be the date of publication of the last result clearing all papers.**

e) Grading and marking system will be followed as-

% of Marks (M)*	Letter Grade	Grade Point (GP)
$M \geq 90$	O (Outstanding)	$09 \leq GP \leq 10$
$80 \leq M < 90$	A+ (Excellent)	$08 \leq GP < 09$
$70 \leq M < 80$	A (Very Good)	$07 \leq GP < 08$
$60 \leq M < 70$	B+ (Good)	$06 \leq GP < 07$
$55 \leq M < 60$	B (Above Average)	$5.5 \leq GP < 06$
$50 \leq M < 55$	C+ (Average)	$05 \leq GP < 5.5$
$40 < M < 50$	C (Below Average)	$04 < GP < 05$
$M = 40$	P (Pass)	$GP = 04$
$M < 40$	F (Fail)	00
Absent	Ab	00

In case Percentage value of Marks involves decimal figures, candidate shall be awarded the next higher integer value if the decimal value (Rounded off up to two decimal places) exceeds 0.50.

****Numerical Grade Point shall not be calculated in respect of a failed course. *Numerical Grade Point shall be Rounded off up to two decimal places.***

The multiplicative factors shall be 0.10 for all Grades for the purpose of calculating numerical Grade Point.

Formula for calculating Grade Point:

If the student secures P%, where P≥40, his / her Grade Point will be **[4.0 + {(P- 40) × 0.10}]** or equivalently **P × 0.10**

For example, If the student secures 52% in a particular course, his / her Grade Point for the course will be [4.0 + 12 × 0.10}] = 5.2or 52x0.10 = 5.2.

22. A candidate failing to obtain the pass marks in a semester examination due to shortage of one marks (in aggregate / in any course)shall be given benefit of one additional mark in the paper in which he/she secure lowest marks and the same shall be shown in the Tabulation Rolls. However, in the Mark-sheet only the total marks shall be shown after such addition.

23. The performance of a candidate in *n*-th Semester examination, who earns all the Credit of that semester, will be assessed by the "**Semester Grade Point Average**" (**SGPA**) , "*Sn*" to be computed as :

$$\text{SGPA}[S_n] = \frac{\sum_{k=1}^{D_n} C_{nk}\ GP_{nk}}{\sum_{k=1}^{D_n} C_{nk}}$$

Where,'*GPnk*'denotesthe grade point obtained in *k*-th Course of*n*-th Semester;
'*Cnk*'denotes the credit of*k*-thCourse of*n*-thSemester;
'*Dn*'denotes the number of Courses in*n*-thSemester.

Example of Computation of SGPA:

Course	Credit	Letter Grade	Grade Point	Credit Point
Course 1	3	A	8	3×8=24
Course 2	4	B+	7	4×7=28
Course 3	3	B	6	3×6=18
Course 4	4	B	6	4×6=24
Total	14			94

SGPA = 94/14 = 6.71.

24. On completion of the Post Graduate course, the overall performance of a candidate will beassessed by the '**Cumulative Grade Point Average' (CGPA)** to be computed as:

$$\text{CGPA}[C] = \frac{\sum_{n=1}^{4} Q_n\ S_n}{\sum_{n=1}^{4} Q_n}$$

Where, $Q_n = \sum_{k=1}^{D_n} C_{nk}$ = total credit in n-th Semester;

Example of Computation of CGPA:

	Semester 1	Semester 2	Semester 3	Semester 4
SGPA	6.71	6.31	6.60	6.71
Credit	14	16	15	14
SGPA × Credit	94	101	99	94

CGPA: 388 (i.e. 94+101+99+94)/59 (i.e. 14+16+15+14) = 6.576.

25. Final Grade and Class will be determined as follows-

CGPA (C)	Letter Grade	Class
9.000 ≤ C ≤ 10	O (Outstanding)	I
8.000 ≤ C < 9.000	A^+(Excellent)	I
7.000 ≤ C < 8.000	A (Very Good)	I
6.000 ≤ C < 7.000	B^+(Good)	I
5.500 ≤ C < 6.000	B (Above Average)	II
5.000 ≤ C < 5.500	C^+(Average)	II
4.000 ≤ C < 5.000	C (Below Average)	II
C < 4.000	F (Fail)	

Both SGPA and CGPA will be rounded off to the third place of the decimal and will be shown as such on the mark sheet.

26. Candidates appearing in a semester examination shall have to take admission to the next higher semester (wherever applicable) immediately after completion of the examination.

27. RULES FOR RE-EXAMINATION:

Candidates seeking review may apply to the University in a prescribed form along with requisite fees within seven (7) working days from the date of issue of Grade Card subject to the followingconditions:

a) Application for review shall be restricted to theoretical modules/courses/papers only.

b) A candidate will be eligible to re-examine his/her script if he/she appeared the said semester of examination as a whole but not appeared as supplementary candidate i.e. any candidate who appear some courses (but not all courses) of the concerned semester of examinations will not be eligible to re-examine his/her scripts.

c) Maximum two (02) theoretical modules/courses in any semester examination may be re-examined on request by the examinee subject to the condition that she / he secures a minimum of 40% marks in the rest of theoretical modules/courses in a semester.

d) In re-examination of module(s)/ course(s) / paper(s) for any semester of post graduate examinations, the marks awarded by the re-examiner in a particular module/course / paper will be taken as the marks obtained by the examinee in that module/course / paper.

e) If on re-examination in a module/course the marks get enhanced by more than 15% or get reduced by more than 5% than that awarded by the original examiner (the percentage be calculated on the basis of the full marks in that module/course), the script of the module/course be referred to a third examiner and average of two marks (excluding the lowest one) as awarded

by the three examiners shall be taken as the marks obtained by the examinee in that module/course, provided that such a final award does not result in the failure of the examinee or in lowering of the Letter Grade of SGPA/CGPA / Class or status obtained by the examinee prior to re-examination in which cases the original award be retained.

28. Cancellation of Examination:
Candidate may apply for cancellation of enrolment of any end semester examination within the ten (10) days from the completion of examination of theoretical portion. The said cancellation of examination will also be counted as a chance.
29. After Re-examination, FSI and other process of Final Semester Examination a Rank Certificate in order of Merit shall be issued to-

a) First ten candidates (in each subject who has successfully completed/clear all the semester examination at the first available chance) with first class (CGPA ≥ 6.000) marks in aggregate (second class will not be considered).

b) First three candidates (in each subject who has successfully completed/clear all the semester examination at the first available chance) in second class in aggregate, where no First class candidate is available.

30. Each candidate shall receive his/her degree in the form of a Diploma/Certificate stating the year of passing, letter grade, CGPA and class on successful completion of the course in the specific format-

(Roll No……) Diploma No……

(Registration No. ……..)

University of Calcutta

LOGO

This is to certify that ……..(Name)……obtained the degree of Master of Arts/Science/Commerce in …… (Subject)…… in this University in the semester system examination (under CBCS) in the year……, and that he/she obtained / was placed in ……(Letter) ….GradewithCGPA ……..and ……Class.

Senate House, Vice-Chancellor

(Date of publication of result)
Logo embossed

Distribution of Courses in Four Semesters for M.Sc in Biochemistry (for the academic session 2021-2022 and onwards)

	COURSES			MARKS	CREDITS
Semester-I					
T	1.	BCT101	Metabolism-I	30	3
	2.	BCT102	Microbiology	30	3
	3.	BCT103	Advanced Enzymology	30	2
	4	BCT104	Fundamentals of Biochemistry	30	3
	5.	BCT105	Cell Biology-I	25	3
P	1.	BCP101	Analytical Biochemistry I	40	3
	2.	BCP102	Microbiology	30	3
				215	**20**
Semester-II					
T	1.	BCT201	Biophysical Chemistry	30	2
	2.	BCT202	Molecular Biology-I	30	3
	3.	BCT203	Metabolism-II	30	3
	4.	BCT204	Recombinant DNA Technology	35	3
	5.	BCT205	Bioenergetics	25	2
P	1.	BCP201	Analytical Biochemistry II	25	2
	2.	BCP202	Molecular and Cell Biology I	40	3
	3.	BCP203	GRAND VIVA	30	2
				245	**20**
Semester-III					
T	1.	BCT301	Molecular Biology and Genetics	30	2
	2.	BCT302	Cell Biology-II	30	2
	3.	BCT303	Neurobiochemistry & Endocrine signaling	30	2
	4.	BCT304	Plant Biochemistry	25	2
	5.	----------	CBCC-A	50	4
	6.	----------	CBCC-B	50	4
P	1.	BCP301	Molecular and Cell Biology II	30	2
	2.	BCP302	Project Presentation	30	2
				275	**20**
Semester-IV					
T	1.	BCT401	Immunology	30	2
	2.	B CT402	Microbial Genetics and Virology	30	2
	3.	BCT403	Cell Biology III	30	2
	4.	BCT404	Biochemistry & Cell Biology of Diseases	35	3
	5.	BCT405	Ecological Principles	25	2
P	1.	BCP401	Immunotechniques	30	3
	2.	BCP402	Molecular and Cell Biology II	25	2
	3.	BCP403	Bioinformatics	30	2
	4.	BCP404	GRAND VIVA	30	2
				265	**20**
			GRAND TOTAL	**1000**	**80**

[T=Theoretical, P=Practical]

A. Theoretical Courses

(Numbers in Parentheses indicate no. of lecture hours)

Semester I

BCT101 Metabolism-I 30 Marks

Carbohydrate metabolism

- Concept metabolism, Different types of metabolisms and their characteristics, five basic biochemical reactions types in metabolism.(1)
- Basic concept of dietary simple and complex carbohydrates molecules, digestion (enzyme α- amylase, β-amylase etc.), absorption mechanisms.(1)
- Major pathways of glucose and other sugar utilization, discovery of EMP pathways, the two phases of glycolysis pathways with enzymatic reaction mechanisms. TCA cycle and its anaplerotic roles, gluconeogenesis pathways, HMP pathway and its importance. Tracing of metabolic pathways by radio isotopes.(3)
- Determination of free energy change in glycolysis, fates of glycolysis end products in different organs, Cori cycles, changes in glucose metabolism in diabetes and cancer.(1)
- Metabolic regulations of glucose, enzymatic regulation, glucose regulation by insulin and glucagon in pancreatic cells, role of AMPK kinase in controlling metabolic pathways.(1)
- Conversion of glucose to glycogen and glycogen breakdown pathway. Regulations pathways of these two pathways.(2)

Lipid Metabolism

- Lipid structure, Lipid Classification (fatty acids, triacylglycerols, glycerophospholipids, sphingolipids), Lipid digestion, absorption and transport. (2)
- Lipid Oxidation (β- oxidation: Saturated & Unsaturated, Minor pathways of fatty acid oxidation : α - oxidation, γ-oxidation). (2)
- Lipid biosynthesis (fatty acids, triacylglycerols, glycerophospholipids) (1)
- Ketone bodies (synthesis, functions) (1)
- Cholesterol (utilization ,synthesis) (2)
- Lipoproteins (structure, classification, functions) (2)
- Regulation of lipid metabolism and metabolic disorders (fatty acids, cholesterol, lipoproteins) (1)

Amino acid Metabolism

- An overview of source and utilization of amino acids in human body. (1)
- Breakdown of amino acids (Amino group: transamination, oxidative deamination; Carbon skeleton: glucogenic, ketogenic). (2)
- Urea cycle (complete reactions, regulation of the urea cycle). (2)
- Biosynthesis of the nonessential amino acids, Metabolic disorders (PKU, BCAA, Hyperhomocysteinemia). (1)

Nucleotide Metabolism

- Sources of atoms in purine and pyrimidine, experiments to find out the sources, structures, purine biosynthesis (de novo and salvage). (2)
- Purine catabolism, diseases related to purine metabolism, conversion of mono phosphate

to di and tri. (1)

- Regulation of purine biosynthesis, pyrimidine biosynthesis, conversion of UTP to CTP.(1)
- Ribonucleotide reductase, its importance and regulation, conversion of dUMP to dTMP, importance of the pathway in designing anti cancer drugs, Anaplerotic substrates in muscle AMP generation, designing inhibitors to treat various metabolic disorders.(2)

Reference books:

1. Lehninger's Principles of Biochemistry, David L. Nelson, Michael M. Cox. Publisher:W.H.Freeman.
2. Biochemistry-Jeremy M Berg, John L Tymoczko,and Lubert Stryer. Publisher:WHFreeman
3. Biochemistry, 4thEdition-DonaldVoet, Judith G.Voet.–Publisher: JohnWiley & Sons.
4. Biochemistry; Voet , D. and Voet, J.G. [Eds.] (1999) 3 Ed. Jhon Wiley and sons.
5. Biochemistry; David Rawn, J. (1989) Neil Patterson Publishers.
6. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill.

BCT102 Microbiology 30 marks

- **Growth of bacteria:** Growth of bacteria in liquid medium, methods of measurement of growth, growth kinetics, relation of growth to substrate concentration, the chemostat, synchronized growth, growth on solid medium, uses of solid media, techniques of pure cultures, differential media, selective media, synthetic media. (2).
- **Staining of bacterial cells:** Stains and Staining, dyes, chromophoric and auxo-chromic groups, classification of biological stains, basic dyes, acid dyes, principle of staining: physical and chemical, mordants, simple staining, Differential staining, Gram staining, Mechanism of Gram and acid- fast staining, Endospore staining, (2)
- **Control of microorganisms by physical agents :**The rate of death of bacteria, condition influencing antimicrobial action, high temperature, Thermal death time (TDT), decimal reduction time (D value), F value, 12-D Process, Pasteurization and Z-value; low temperature, Desiccation, Osmotic pressure, Radiation, Surface Tension, filtration. (2)
- **Control of microorganisms by chemical agents:** Characteristics of an ideal antimicrobial chemical agent and its selection for practical application. Sterilization, disinfectant, antiseptic, sanitizer, germicide, bactericide, bacteriostatic, Major groups of antimicrobial agents and their mode of action: phenol and phenolic compounds, alcohols, halogens, Heavy metals and their compounds, Dyes, synthetic detergents, quaternary ammonium compounds, aldehydes, Gaseous agents, Evaluation of antimicrobial chemical agents, tube dilutions and agar diffusion techniques, phenol coefficient methods. (3)
- **Antibiotics and other chemotherapeutic agents:** Historical highlights of chemotherapy, Classes of antibiotics and their properties; Structure and mode of action of antimicrobial agents: Aminoglycosides, Carbapenems, macrolides, β-lactam antibiotics, Quinolones and fluoroquinolones, Sulphonamides, Tetracyclines, Chloramphenicol, Chloroquine, Rifampicin, Streptolydigin, Puromycin; Inhibitors of nucleic acid and protein synthesis, Inhibitors of DNA and RNA polymerases, Antifungal agents: affecting terminal respiration of microbes, inhibitors of ergosterol synthesis (Polyenes etc.), Antiviral drug structures and their mode of action, microbiological assay of antibiotics, nonmedical uses of antibiotics. (6)

- **Resistance to antimicrobial drugs:** mechanisms; β-lactamase inhibitors, the genetics of drug resistance, biochemical mechanisms of drug resistance, practical approaches to the control of drug-resistance. (2)
- **Water microbiology;** Characteristics of pollution indicator microorganisms, Definitions for indicator and index microorganisms of public health concern, Microbiological characteristics of pollution indicator microorganism, Growth pattern of fecal and non-fecal coliforms on differential media, IMViC test. (1)
- **Microbial Life**: Origin and Discovery, How did life originate? Stanley Miller and Harold C. Urey's experiment, Microscopes reveal the microbial world. Contribution of Robert Hooke and Anton van Leeuwenhoek, Dimension of microorganisms, Contribution of Louis Pasteur, Robert Koch, Angelina and Walther Hesse in microbiology, Koch's Postulates, Microbes include Eukaryotes and Prokaryotes, Endosymbiosis, Application of microbes.(1)
- **Observing Microbial Cell:** Resolution of objects by our eyes, Microbial size and shape, Different kinds of stain, Simple staining, Gram staining, Negative staining, Acid fast staining. Emerging methods of microscopy: Atomic force microscopy, Bacterial Cell division, Role of MreB, FtsZ and Crescentin, Min D.(1)
- **Bacterial Cell Structure and function:** Three Domain Classification, Ribotyping, Carl Woese and the three domains of life, Cell Membrane, Membrane fluidity, Role of desaturase in Arctic Cyanobacteria, Hopanoids, Difference between eubacteria and archaebacteria in terms of membrane structure, The cell wall and outer layers, Glycocalyx, Slime layers, Capsules, Cysts, S layer.(1)
- Peptidoglycan structure, Difference between Gram positive and Gram negative bacteria, Action of lysozyme and penicillin, Spheroplast and Protoplast, Role of autolysin, Structure and function of Teichoic acid, Pili or Fimbriae.(1)
- The Gram negative outer membrane: LPS and Porins, Endotoxin, Periplasmic space, Ribosomes, Svedberg unit, Difference between eukaryotic and prokaryotic ribosome, polysome, ribotyping, Inclusion bodies, Bacterial flagella: Structure-Function, Chemotaxis: Mechanism. (1)
- The nucleoid and gene expression, Two component signaling system in bacteria, Plasmids, Coupled transcription and translation, DNA binding proteins, Chaperones, Secretory Proteins, Sec Chaperones, Types of secretion. (1)
- **Stringent response and quorum sensing**.(1)
- **Effect of different environmental factors on bacterial growth:** pH, Temperature, Oxygen, Salt, Pressure, Classification of bacteria based upon the environmental factors, Mechanism of alkaliphiles and acidophiles.(1)
- **Classification based upon oxygen requirement,** Microaerophiles, Facultative anaerobe, ARC and FNR system, bacterial respiratory chain components, role of cytochromes, Endospores,Bacterial Endospores: Formation, Germination of endospores, Role of sigma factors.(1)
- **Tutorial:** Bacterial nutrition, Autotroph, Heterotroph, Requirement of trace elements, Synthetic media, Isolation of nitrogen fixing bacteria, isolation of hydrocarbon degrading bacteria.

- **Tutorial:** Types of media: Complex, Selective, Differential, Synthetic, Bacterial culture and enumeration, Detection of live and dead bacteria: Trypan Blue Staining, Milk, Sterilization.

Reference Books:

Microbiology by Pelczar M.J., Ried, RD and Chan, ECS.
Microbiology by Gerard J. Tortora, Berdell Ra. Funke and Christine L. Case. Publ: Pearson Education Inc
Microbiology by Prescott LM, harley JP & Klein DA(2005). McGraw Hill International Edition, USA.
Microbiology by Davis, Bernard D, Renato Dulbecco & others.

BCT103 Advanced Enzymology 30 marks

- Classification, comparison between chemical and biological (enzyme) catalysis, coenzyme, cofactors, Concept of rate enhancement in intermolecular vs intramolecular reactions i.e. extent of randomness and reaction rate with an example, how is the enhanced rate of an enzyme catalyzed reaction explained with the help of that concept.
  Functional groups (R-groups of amino acids) involved in enzyme catalysis, classical approach to identify crucial amino acid(s) involved in enzyme catalysis (use of specific inhibitors of amino acids followed by limited proteolysis) (4)
- Mechanism of enzyme reactions: serine protease, carbonic anhydrase (metalloenzyme) and restriction endonuclease (5);
- Regulation of enzyme activity: Covalent modifications (examples) [PTMs and proteolytic activation of enzymes] Blood clotting cascade, Zymogens, isozymes and their significance (LDH) –(2) ; Allosteric enzymes, Sigmoidal kinetics; Aspartate transcarbamoyase (ATCase), T & R states (quaternary structures), positive and negative modulators; PKA and role of cAMP. (3) .
- Transition state analogue, catalytic antibodies, suicide inactivation. (1)
- Thermodynamics of enzyme-substrate interactions, Binding energy in catalysis; Fundamental principles of reaction Kinetics and equilibria. (1)
- pH and buffers:Bronsted-Lowry Concept of Acids and Bases, Buffers: HendersonHasselbalch equation, Biological buffer systems: The phosphate buffer system, The bicarbonate buffer system, The protein buffer system, The amino acid buffer. system, The hemoglobin buffer system. (3)
- Steady state enzyme kinetics; differences between a chemical equilibrium and steady state kinetics; Limitation of Michaelis-Menten equation, Briggs-Haldane kinetics ; Van Slyke-Cullen behavior, Physiological significance of kinetic parameters (3);
- Multisubstrate systems and their kinetics; Multienzyme complexes (2)
- Immobilised enzyme systems(1);
- Kinetics of Enzyme Inhibition; Irreversible inhibitors. (1)
- Enzyme reconstitution, Enzyme assays, Isolation, Purification and Criteria for Determining Purity of Enzymes.(2); Measurement and magnitude of enzyme rate constant; Transient kinetic methods Detection of intermediate in reactions-Relaxation methods. (1)

Reference Books:

1. Lehninger's Principles of Biochemistry, David L. Nelson, Michael M. Cox. Publisher:W.H.Freeman.
2. Biochemistry-Jeremy M Berg, John L Tymoczko,and Lubert Stryer. Publisher:WHFreeman
3. Biochemistry, 4thEdition-DonaldVoet, Judith G.Voet.–Publisher: JohnWiley & Sons.
4. Fundamentals of Enzymology; 3rd Edn. Nicholas C. Price and Lewis Stevens, Oxford University Press (2012).

5. Enzymes; Trevor Palmer, East – West Press Pvt. Ltd., Delhi (2004).
6. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis; Robert A. Copeland , Wiley-VCH Publishers (2000).
7. Enzyme Kinetics and Mechanism; Paul F. Cook, W. W. Cleland, Garland Science (2007).
8. Biochemical Calculations, Irwin H. Segel (1976) 2nd Ed. John Wiley and Sons.

BCT104 Fundamentals of Biochemistry 30 marks

- Carbohydrates: Importance, Nomenclature, Classification, Asymmetry, Optical Isomerism, Mutarotation, General structure of monosaccharide, disaccharide, oligosaccharides, polysaccharides (Lactose, Maltose, Cellobiose, Isomaltose, Trehalose, Starch, Glycogen, Cellulose, Pectin, Chitin, Heparin.
- Amino Acids: Importance, Structure, Distribution in Proteins, Location in proteins, Physical properties, Electrochemical properties, Classification, Amino acid titration, pI of peptides, IUPAC name of amino acids, Chemical Synthesis of Amino Acids, peptide sequencing, peptide synthesis: solution phase and solid phase synthesis, Separation of Amino acids, Nonprotein Amino Acids, Toxic analogues, misincorporation of amino acids analogues (6 lectures).
- Introduction to biomolecules, Proteins: importance, Peptide bonds, Chemical Bonds involved in Protein structure. Protein Configuration: Primary Structure, Secondary Structure, Tertiary Structure, Quaternary Structure, Physical Properties of Proteins: Shape and Size, Domain and Super secondary structures, Denaturation, Anfinsen Experiment, Hemoglobin and Myoglobin, DPG/BPG, Hemoglobinopathies, Protein folding, unfolding, misfolding and conformational diseases.
- Lipids: Importance, Definition, Alcohols and Fatty Acids, Biological roles of lipids, Classification: Simple Lipids and Compound Lipids, Properties of Fats and oils: Solubility, Melting Point, Insulation, Emulsification, Surface Tension, Chemical Properties: Reactions involving COOH group, Hydrolysis, Saponification, Rancidity, Hydrogenation, Halogenation, Oxidation, Oxidative Rancidity, Reactions involving OH . group, Dehydration.
- Nucleic acid as genetic material, Nucleosides, Nucleotides, DNA, Various bonds in DNA, Watson-Crick model and Double helical structure, Variants of Double helical DNA, DNAs with unusual bonds, DNA topology and linking numbers, Denaturation and renaturation (kinetics), Cot analysis, Prokaryotic and Eukaryotic chromosomes, Nucleosomes, Chromatin, Repetitive DNA, transposons and repro-transposons (6)
- What is RNA, difference with DNA, stability, reason for presence of uracil, forces stabilizing RNA, RNA secondary structure, role of RNA binding protein and chaperones, RNA folding problems, Watson and non-Watson base pairing, RNA world hypothesis, various types of RNA. **(6 lectures)**

Reference books:

1. Nelson DL & Cox MM (2008). Lehninger's Principles of Biochemistry 5th ed., WH Freeman & Company
2. Berg JR, Tymoczko CZ & Stryer L (2006). Biochemistry, 6th ed., WH Freeman & Company
3. Conn E.E. & Stumpf PK (1988) Outline of Biochemistry John Wiley & Sons.
4. Freifelder. Physical biochemistry, freeman company.
5. David Sheehan (2009). Physical Biochemistry: Principles and Applicatons, John Wiley & Sons Ltd, Chichester, England,
6. Skoog, Holler & Nieman. Principles of Instrumental Analysis.

7. Biochemistry; Voet, D. and Voet, J.G. [Eds.] 3rd Ed. Jhon Wiley and sons, (1999).

BCT105 Cell Biology-I 25 marks

- Visualization of cell: Evolution of techniques, stains and dyes, power of microscopy, concept of marker proteins, immuno-staining, immunofluorescence staining (direct and indirect), choice of antibodies, immuno-EM (gold labeled antibodies) ---- (6)
- Subcellular fractionation: Cell lysis methods, Differential centrifugation, enrichment of organelles i.e. organelle marker proteins, assay of marker enzyme/proteins in the subcellular fractions, Western blotting ------ (6)
- A brief history of studies on Plasma Membrane structure: Fluid Mosaic Model (1)
- The chemical composition of membranes: Membrane lipids, The asymmetry of membrane lipids, membrane carbohydrate, Liposome.(1)
- The structure and function of Membrane Proteins: Cell fusion experiment, FRAP, SPT. Two Classes. Membrane fluidity, Transition temperature, Factors influencing membrane fluidity, Role of Cholesterol in membrane fluidity, Lipid Rafts.(2)
- Movement of substances across cell membrane, ion channels, potassium ion channel, Sodium Potassium ATPase pump. (2)
- Overview of the major functions of the cytoskeleton, the study of different cytoskeleton. (1)
- Microtubules: Structure and Function, Dynamic instability of Microtubules. (1);
- Microtubule associated proteins (MAPs), Motor proteins: Kinesin, Dynein, In vitro motility assay(1);Microtubule organizing centers (MTOCs) in animal and plant cell(1)

Reference Books:

1. Molecular Cell Biology, 4th edition. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. New York: W. H Freeman

Semester -II

BCT201 Biophysical Chemistry 30 marks

- Application of Spectroscopic techniques to study biomolecular interaction: Structural elucidation of the electromagnetic spectrum - quantization of energy. Regions of the spectrum. Basic principles of electronic, vibrational and rotational transitions, UV- Vis spectroscopy,instrumentation and application in clinical analysis, Fluorescence spectroscopy, principle, instrumentation, Stern-Volmer Equations and quenching, Life time decay, Energy transfer, Fluorescence anisotropy, Application of Fluorescence principle in biomedical instruments and diagnosis. Infrared spectroscopy, Mass spectrometry and their biomolecular applications. Circular Dichroism spectroscopy, principle, instrumentation, and application in the study of proteins and nucleic acids, and analysing bio-molecular conformation, determination of structural parameters by these techniques and limitations and precautions.
- Protein Separation and Characterization, Chromatographic techniques, Detection and analysis of protein-protein interactions. Basic techniques like mass spectrometry, and protein microarrays. Proteomics. (10 Lectures)

Reference Books:

1. Freifelder. Physical biochemistry, freeman company.

2. Wilson K & Walker J(2005). Principles and Techniques of Biochemistry and Molecular Biology, 6th ed.,Cambridge University Press.
3. David Sheehan(2009). Physical Biochemistry: Principles and Applications, John Wiley & Sons Ltd, Chichester, England,
4. Upadhyay, upadhyay & Nath. Biophysical chemistry.
5. Sawhney SK & Singh R(1996). Introductory Practical Biochemistry, Narosa Publishing House Pvt Ltd, New Delhi.
6. Skoog, Holler & Nieman. Principles of Instrumental Analysis.

BCT202 Molecular Biology-I 30 marks

- **DNA replication:** Models of DNA replication - Semi-conservative, semi-discontinuous, bidirectional replication, Origin of replication, rolling circle (single stranded phage and lambda), mitochondrial D loop, Enzymology (DNA Polymerases, Helicases, SSB, Primases ligases, topoisomerases, Mechanisms (Initiation, Elongation, Termination) and control in prokaryotes and eukaryotes, fidelity of replication, Telomere and Telomerase (10).
- **DNA damage and repair mechanisms**: Introduction, DNA damage, types of DNA repair and their mechanisms – Direct repair, Base excision repair, Nucleotide excision repair, mismatch repair, recombinational repair, Photoreactivation, SOS repair; DSB, NHEJ, Post replication repair, Brief mention of DNA repair defects in Human diseases –ataxia telangiectasia, xeroderma pigmentosum, Bloom's syndrome, Fanconi anemia, Cockayne syndrome, hereditary breast cancer (4).
- **Mechanism of Transcription** (5) :RNA Polymerase; Sigma Subunits; The Structure of Promoters; Enhancers and Enhancer-Binding Proteins; DNA, Abortive Initiation; Pre-Initiation complex assembly in Eukaryotes and general transcription factors; Initiation. Elongation and termination, PolII CTD phosphorylation and PolII recycling during eukaryotic transcription; Inhibitors of transcription.
- **Discovery of the genetic code** (2)
- **Protein Synthesis** (4): Ribosome composition; tRNA; Fidelity of aminoacylation; Shine Dalgarno hypothesis and its experimental verification; Initiation; Ribosome translocation and translational elongation; EF-Tu –GTP regeneration; Termination and nonsense suppression; Messenger instability; Stringent Response, inhibitors of protein synthesis. Cap dependent initiation, IRES, uORFs and role of eIF2 kinases in translation initiation.
- **Regulation of Gene expression in Prokaryotes** (4): Overview of regulatory strategies; araBAD Operon, trp Operon: DNA looping and unlooping; Riboswitches; Heat shock response in E.coli, Flagellar variation in salmonella; Lux Operon and quorum sensing, Two component systems in nutrient sensing; Ordered gene expression,Lac operon: Model to understand the logic of experimental design for investigating various aspects of gene expression and its regulation , RNA as a regulator of gene expression

Reference books:

1. Genes VIII, Lewin, B, Publish Oxford University Press
2. Molecular Biology of the Gene by Watson JD, Losick R. Pub Pearson Education
3. Nelson DL & Cox MM (2008). Lehninger's Principles of Biochemistry 5th ed., WH Freeman & Company
4. Berg JR, Tymoczko CZ & Stryer L (2006). Biochemistry, 6th ed., WH Freeman & Company
5. Molecular Biology, Robert Weaver, McGraw-Hill Education

BCT203 Metabolism-II 30 marks

- Macronutrients: Carbohydrates, proteins, lipids, essential lipids and amino acids; Digestion and absorption; Protein nutrition, Protein digestibility, Nitrogen balance, BV, NPU, PER, Protein sparing foods, Calorific value of nutrients; Caloric metabolism, activity, BMR; Factors affecting BMR, Body mass index (BMI), Food safety and toxicity. (8)
- Metabolism of micronutrients: Vitamins- Water soluble Vitamins, Fat soluble Vitamins metabolism [Vitamins in relation to coenzyme concept, one carbon and one hydrogen metabolisms] (3)
- Elements in biochemistry- Major elements: Ca, Phosphorus; Trace elements: Fe, Cu (Uptake, transport, storage and homeostasis); Metal overload and toxicity, Remediation through chelate therapy. (3)
- Heme metabolism: Biosynthesis (focus on precursor site), catabolism (porphyrins and bilirubin metabolism); disease involved. (1)
- Xenobiotics metabolism , Lipinski "rules of five".(1)
- Detection and characterization of metabolites-Concept of metabolomics. (1)
- Redox metabolism. Glutathione S-transferases in Redox Regulation and Glutathione Dependent Catalysis; Glutaredoxin and Thioredoxin Systems; Structural Basis of Redox Active Enzymes; Redox Activities of Antioxidants in a Cellular Context; Mitochondria, Reactive Oxygen Species and Human Disease (3)

Reference books:

1. Lehninger's Principles of Biochemistry, David L. Nelson, Michael M. Cox. Publisher:W.H.Freeman.
2. Biochemistry-Jeremy M Berg, John L Tymoczko,and Lubert Stryer. Publisher:WHFreeman
3. Biochemistry, 4thEdition-DonaldVoet, Judith G.Voet.–Publisher: JohnWiley & Sons.
4. Biochemistry; Voet , D. and Voet, J.G. [Eds.] (1999) 3 Ed. John Wiley and sons.

BCT204 Recombinant DNA Technology 35 marks

Introduction

A brief historical perspective on recombinant DNA technology. Paul Berg, Boyer Stanley cohen? Why do we clone genes ? (1)

Restriction modification system: Bacterial defense mechanism, Classification and brief characteristics restriction endonucleases, star activity, modification system (methylated and hemi-methylated DNA), brief comparison of DNA methylation in eukaryotic system (2).

Ligation of two DNA fragments: the reaction involved, characteristics of T4 DNA ligase

Plasmid as vectors: Definition, natural and artificial, application, copy number control, Multicloning site (MCS) selection systems antibiotic based, alpha complementation blue white screening (1)

Cloning of DNA (8)

1. Cloning vector

Basic and essential characteristics of a cloning vector, brief characteristics of vectors for cloning of large DNA fragments viz YAC, BAC, PAC, COSMID lambda-phage vectors; vectors used for making genomic DNA and cDNA libraries.

Cloning hosts and DNA transformation techniques

Host systems: Basic features of common host bacteria, examples; competence for transformation of foreign DNA, transformation, Electroporation, gene gun

2. Gene cloning workflow

Workflow for the sub-cloning: Isolation of a DNA fragment/insert from a vector using restriction

endonuclease(s), ligation of that fragment into another vector digested with same restriction enzyme(s), directional cloning, use of alkaline phosphatase to prevent self-ligation of digested vectors, transformation of ligation mixture into an appropriate host, selection of transformants using selectable markers and blue-white screening, Trouble-shooting
Outline for construction of genomic and cDNA libraries (critical parameters to be discussed), strategies for screening of recombinants in brief.
3. Recombinational cloning: Gateway, Cre Loxing, Recombineering

Expression of heterologous proteins (4)
The need for inducible vectors. The need for tight control of gene expression. Commonly used expression vectors, pQE series, pET series, pBAD, Tet Off and Tet ON
Application of tags for recombinant proteins. Affinity tags for purification His, GST. Solubility tags like thioredoxin NusA, Export tags such as DsbA, Fluorescent tags for cell biology, FLAG tags for immunoaffinity
Host systems: Bacteria, yeast, insect cell (baculovirus), mammalian cell; transformation, transfection and transduction methods of introduction of DNA into different types of cells.
Inducible expression systems: IPTG, Tet-on/off, ecdysone

Genetic engineering of higher organisms – transgenic technologies (2)
Basic principles of generating transgenic, knock out, knock down and knock in variants; use of Agrobacterium and Ti plasmid (binary vector) for plant systems.
Application of RDT in agriculture, animal husbandry, medicine (antibody, vaccine) and industry; Gene therapy (3).

PCR and its applications: Historical perspective, Discovery of Kary Mullis, Introductory lecture on PCR, the amplification cycle and Taq DNA polymerase, Eliminating non-specific PCR, hot start, proofreading polymerases, Primer design.(2)

Semi-quantitative and quantitative PCR: The concept of Ct value. Taqman probes and their use in qPCR. How to estimate nucleic acid conc using qPCR. Applications of qPCR, detection of pathogens in clinical samples (3)

Cloning PCR products: TA vector, blunt ended ligation, directional cloning. digestion of the amplicon/insert and the vector with restriction enzymes, ligation, transformation, and selection. PCR based screening for the recombinants, whole genome amplification, PCR with allele-specific and degenerate primers (2).

Reverse transcribed PCR (RT-PCR) Preparation of cDNA using mRNA and reverse-transcriptase (2)

Studying sequence variation: RFLP, STR, VNTR, RAPD, AFLP and SSR, DNA fingerprinting its application in determining parenting and in forensic science, Application of Inverse-PCR, DOP-PCR, droplet digital PCR, **PCR and Site directed mutagenesis** (2)

DNA sequencing: Sanger sequencing of genes and short stretches of DNA, physical mapping of chromosomes (top down and bottom-up approaches), positional cloning, large scale sequencing with particular emphasis on HGP, capillary gel electrophoresis, Sequence assembly and annotation, principles of Next generation sequencing (NGS) and its applications, RNA-seq: methods and applications (3)

Gene expression:

Techniques for Studying Gene Expression: Northern blot, RNase protection assay, S1 mapping, primer extension, run-off transcription, IVT, nuclear run-on assay.

Functional analysis of regulatory and coding sequences (promoter analysis, deletion mapping), Microarray, differential display.Analyses of regulatory DNA sequences: Promoter/cis-acting response elements-reporter assays, CAT, beta-Gal, GFP/RFP, luciferase (3).

Analysis of DNA-protein interaction: Overview of EMSA, Footprinting, ChIP, Chip on ChIP, ChIP-seq analyses and outcome of each method, Genome editing, Zn Finger, TALEN, CRISPR (4)

Reference Books:

1. Old & Primrose (1994). Principles of gene manipulation. Blackwell Scientific Publications.
2. Sambrook & Russel (2001). Molecular Cloning, 3rd volume. CSH Press.
3.Genome Analysis. 4th volume. (2000). CSH Press.
4. Lewin B (2004). Genes VIII, International Edition, Pearson Education
5. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, & Walter P(2008). Molecular Biology of the Cell, 5th ed., Garland Science Publishing
6. Human Molecular Genetics by Tom Strachan and Andrew P. Reed, Garland Science

BCT205 Bioenergetics 25 marks

- Fundamentals of Thermodynamics: Concept of thermodynamics systems, properties of systems,different processes, Definition of work and heat, First law of thermodynamics, concept of internal energy, enthalpy, molar heat capacity, Laws of thermochemistry and applications, Limitations of the first law of thermodynamics, Introduction of second law of thermodynamics: carnot cycle, concept of entropy, free energy,chemical equilibrium, chemical potential, Gibbs-Helmholtz equation, Basic concept of statistical thermodynamics.
- Application of thermodynamics in biological sciences: Energetics for metabolics reactions, Energetics of different interactions (forces) and protein structure, Energetics of protein folding,Energetics of Nucleic acids structure, Thermodynamics approach of understanding mechanism of life.
- Oxidative phosphorylation: Principles of energy metabolisms. Types of chemical reactions involve bioenergetics, Ultrastructure mitochondria and other energy transducing membranes, Energy harnessing cascade from nutrients, reducing equivalents. Why is ATP the energy currency of a cell? (2)
- Electron transport mechanism and its carriers -Complex I, II, III, IV; concept of redox potential; Respirasome concept. How electron transports are coupled with proton pumping. (4)
- Mitchell's Hypothesis—experimental verification, Determination of P/O ratio, ATP synthesis by F_1-F_O ATP synthase, E. Racker's experiment. Relation of proton movement and ATP synthesis. Experimental demonstration of the movement of ATP synthase. Methods used in bioenergetics. Principle of Clark electrode for measuring respiration. (3)

Reference books:

1. Lehninger's Principles of Biochemistry, David L. Nelson, Michael M. Cox. Publisher:W.H.Freeman.
2. Biochemistry-Jeremy M Berg, John L Tymoczko,and Lubert Stryer. Publisher:WHFreeman
3. Biochemistry, 4thEdition-DonaldVoet, Judith G.Voet.–Publisher: JohnWiley & Sons.

4. Biochemistry; Voet , D. and Voet, J.G. [Eds.] 4 Ed. Jhon Wiley and sons.
5. Bioenergetics 3, Nicholls, David G., and Ferguson, Stuart J.

Semester-III

BCT301 Molecular Biology and Genetics 30 marks

- **Laws of inheritance:** Mendel's Laws, concept of dominance, segregation, independent assortment; Chromosome theory of inheritance (3)
- **Extensions of Mendelian Genetics:** Concept-Multiple alleles, lethal alleles, Epistasis, penetrance, expressivity, pleiotropy, phenocopy (3)
- **Linkage:** Concept-recombination, genetic mapping eukaryotes (Drosophila). (2)
- **Sex-linked inheritance:** Conceptual basis, sex influenced traits, mechanism of sex determination (2)
- **Cytoplasmic (extranuclear) inheritance:** Basis and mechanism (1)
- **Changes in Chromosome number and structure:** Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation (2)
- **Population genetics:**Random mating population, Hardy-Weinberg principle, Sources responsible for changes in gene frequencies: Mutation, selection, migration and random genetic drift.(4)
- **Post-transcriptional processing:** mRNA processing -5' and 3' modifications, Splicing, Editing, tRNA and rRNA processing, RNA interference (in detail), mi RNA, antisense RNA, NMD. (7)
- **Gene regulation and Epigenetics:** Proximal & Distal Promoter Elements, Enhancers and Silencers, Gene-specific Regulators, Eukaryotic transcription factors, Nucleosomes and histones, Levels of packaging of DNA to Chromosome. DNAse I sensitivity of locus, Dnase I hypersensitivity, boundary elements experimental methods, and model organisms. (2). Histone Modifications. Discussion of the histone code. DNA methylation, Nucleosome positioning, shifting and chromatin remodeling complexes Chromatin associated proteins, the formation and maintenance of heterochromatin, Model locus like PHO, Globin etc (3) Role of epigenetics in biological phenomena such as imprinting, X-inactivation, cellular reprogramming, tumorigenesis, and the onset of certain types of neurological disorders. (2)

Reference Books:

1. Maloy SR, Cronan JE &Freifelder D(2009). Microbial Genetics, Jones& Bartlett publishers.
2. Nucleosome Histone, and Chromatin; Part-A; Carl Wu and C. Allis, Academic Press (2012).
3. Lewin B (2008). gene XI, Oxford University press.
4. Freifelder D (2008). Molecular Biology Jones and Bartlett Publishers USA
5. Lodish et al (2007). Molecular Cell Biology W.H freeman.
6. Genetics, Strick Berger, M.W. (1990) 3rd edn. McMillan.
7. Introduction to Genetics: A Molecular Approach; T A Brown, Garland Science (2011)
8. iGenetics: A Molecular Approach, Peter J. Russell, Pearson India
9. Principles of Genetics, by D. Peter Snustad, Michael J. Simmons, and Robert H. Tamarin

BCT302 Cell Biology-II 30 marks

- **Cellular Communication:** Introduction to cell signalling, fundamental commonalities and evolution of signalling pathways; Role of PTMs in signalling; Subcellular localisation and signalling molecules; Second messengers, Sensors and effectors; The modular architecture and evolution of signalling proteins; Methods for studying signalling networks (5) ,Signalling enzymes and their allosteric regulation Receptor Tyrosine kinases, Receptor

Ser/Thr Kinase Receptor histidine kinases, cytokine signalling, Heterotrimeric and monomeric and G protein signalling (2) ,Lipid modifying enzymes in signalling; Light mediated signalling; Regulated protein degradation mediated signalling pathways (3),Signalling pathways that involve extra-cellular matrix,Information transfer across membrane; Information processing and networks (2)

- **Cell Cycle**: Introduction to the cell cycle, phases, why cells divide, biochemical and physiological hallmarks of each phase. (1); Introduction to Cyclins and CDKs, their discovery, Principles of regulation of CDK activity. Experimental approaches to study cell cycle (2); Molecular basis of START/Restriction point, Transcriptional regulation of cell cycle, protein degradation and irreversibility of the cell cycle (APC and SCF), spatiotemporal regulation of phase transition. Restriction of replication to once per cell cycle, Cytokinesis (2); Introduction to checkpoints- sensors and effectors, molecular mechanism of checkpoint activation, DNA damage and replication checkpoints, chromosome segregation checkpoint, spindle orientation and assembly checkpoint. Checkpoint override and outcomes. (2)

References Books:

1. The Biochemistry of Cell Signaling, Helmreich JM, Oxford Press
2. Cell signaling – John T Hancock, Oxford University press
3. Cell biology. Second edition: Edited by C A Smith and E J Wood. Chapman & Hall publ
4. Molecular Cell Biology, 4th edition. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. New York: W. H Freeman
5. Biochemistry 5th Edn. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer.
6. Harper's Illustrated Biochemistry; 27th Edn. Robert K. Murray, Daryl K. Granner, Victor W. Rodwell _ The McGraw-Hill (2006).
7. Biochemistry of Lipids, Lipoproteins and Membranes; 5th Edn. Dennis E. Vance and Jean E. Vance, Elsevier (2008).
6. Membrane Proteins; Douglas Rees, Academic Press (2003).
7. Introduction to Biological Membranes; William Stillwell, Elsevier (2013).
8. Molecular Biology of the Cell; 6th Edn. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter; Garland Science (2014)

BCT303 Neurobiochemistry & Endocrine signaling 30 marks

Neurobiochemistry

- Brain structure and functions - lobes of the brain, deep brain structures (hypothalamus, pituitary gland, pineal gland, thalamus, basal ganglia, limbic system), cranial nerves. Divisions of the nervous system - CNS, PNS, ANS. Brief introduction of model systems for studying nervous system (rat, mouse, aplysia, C.elegans, Drosophila etc) and brain imaging techniques.(2)
- Neurons and glial cells, Action potential, Propagation of Nerve Impulses, Nerve growth factors, Synapse (synaptogenesis, synaptic functions), Neurotransmitters and their receptors, Neurotransmission, Neuro-muscular transmission - motor neurons and neuromuscular junction, Neuroplasticity. (10)
- Blood brain barrier (structure & functions), Glucose uptake - utilization and Transport of amino acids in brain, Brain energy metabolism-astrocyte and neuron metabolic cooperation, Ventricles and Cerebrospinal fluid (composition and functions). (4)
- Biochemistry of normal aging, Neurodegenerative disorders (Parkinson's, Alzheimer's, Huntington's). (7)

- CNS drug development. (1)

Endocrine signaling

- Evolution of endocrine signaling system- origin of the vertebrate hypothalamic-pituitary-peripheral gland (pineal gland) (H-P-PG) endocrine system.
- Introduction to peptide hormones, steroid hormones (estrogen, progesterone, cortisol: gluco and mineralocorticoids) and adrenaline, monoamines and their examples (catecholamines); thyroxines and their functions and abnormalities
- Concept of convergence, divergence and crosstalk in endocrine signaling using regulation of glucose metabolism and RTK signaling as case studies.
- Gut-Brain Neuroendocrine Signaling Under Conditions of Stress.
- Integration of Nutrient sensing and endocrine signaling pathways. (Sense of hunger and fullness, Leptin etc)

Reference Books:

1.Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology, 8th Edition by Scott Brady, George Siegel, R. Wayne Albers, Donald Price. ISBN-13: 978-0123749475
2. Neuroscience: Exploring the Brain (4th Edition)by Mark F. Bear, Barry W. Connors, Michael A. Paradiso. ISBN-13: 978-0781778176
3. Neuroscience :by Dale Purves , George Augustine, David Fitzpatrick & 5 More
4. Molecular Cell Biology, 4th edition. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. New York: W. H Freeman
5. Harper's Illustrated Biochemistry; 27th Edn. Robert K. Murray, Daryl K. Granner, Victor W. Rodwell _ The McGraw-Hill (2006).
6. Molecular Biology of the Cell; 6th Edn. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter; Garland Science (2014)

BCT304 Plant Biochemistry 30 marks

- **Photosynthesis:** Chromophores : Open and Closed porphyrins, Chlorophylls, Carotenoids Xanthophylls. Light Harvesting complexes EMF energy and Photosynthetic electron transfer, Photosystems and other electron transport complexes. Linear and cyclic Electron transport NADPH/ATP ratio, Chemiosmosis Photophosphorylation Excess energy dissipation mechanisms, RUBISCO Calvin cycle and photosynthetic CO2 fixation. Photorespiration. C4 and CAM plants Examples of end products of carbohydrates produced by photosynthesis. Sucrose Phosphate Synthase and Cellulose Synthase, Sugar translocation
- **Nitrogen Fixation:** Nitrogen fixing plants. Diazotrophs associated with Plants. Nitrogenase The reduction of Nitrogen to Ammonia. Energy Costs utilizing Nitrogen or Nitrate as nitrogen source. Nitrogenase regulation in Diazotrophs. Basic mechanisms of symbiosis between Plants and Diazotrophs. Carbon Nitrogen exchange between host and symbiont, Examples of end-product of nitrogen assimilation (GS/GOGAT) cycle GDH GDC Glutamate as precursor for Porphyrins Shikimate Pathway.

- **Sensory photobiolgy:** different photoreceptors, phytochrome, cryptochrome, photropin, structure and function, photoreversibility, roles of phytochorome in photoperiodism, germination, signaling, blue light signaling and cryptochrome mediated flowering induction, phototropin mediated stomatal opening, chloroplast movement
- **Flowering:** Induction of flowering, different stages, circadian rhythym, photoperiodism with examples, signaling mechanism of short day and long day flowering, coincidence model, role of miRNAs in flowering induction, GA signaling pathway, Autonomous pathway, vernalization and chromatin remodeling
- **Phytohormones:** Auxin, GA, cytokinin, ethylene, ABA, salicyclic acid, jasmonic acid, brassinosteroid- biosynthesis, physiological responses and signaling

Reference Books:

1. A Textbook of Plant Physiology, Biochemistry and Biotechnology by S K Verma & Mohit Verma
2. Plant Biochemistry, by Hans-Walter Heldt, Birgit Piechulla in cooperation with Fiona Heldt. Academic Press
3. Principles of Gene Manipulation, by R.W. Old, S.B. Primrose, Wiley-Blackwell Publications
5. Photosynthesis, D.O. Hall and K. K. Rao, (1999), 6th Edn. Cambridge University Press.
5. Plant Biochemistry, P.M. Dey & J.B. Harborne (2000) Hart Court Asia Pte Ltd.
6. Introduction to plant Biochemistry. Goodwin and Mercer, CBS Publisher (2000).
7. Biochemistry and Molecular Biology of Plants. Buchanan, Greussem and Jones, AAPS (2000).
8. Plant Cell Tissue and organ Culture: Fundamental Methods, O.L. Gamborg & G.C. Phillips Narosa Publishers, New Delhi (1995)
9. Plant Biochemistry; P. M. Dey and J. B. Harborne, Academic Press (1997).
10. Plant Biochemistry and Molecular Biology; Peter J. Lea, Richard C. Leegood, 2nd Edition, Wiley (1998).
11. Plant Biochemistry; Hans-Walter Heldt and Birgit Piechulla, Academic Press (2004)

Choice Based Credit courses (CBCC)

A student will have to take two courses from Choice Based Credit Courses (CBCCs) in addition to courses offered by the department. The students will have to choose one course each from two groups: CBCC-A & CBCC-B. Each course is of 50 marks and carries 4 credits.

Detailed syllabus for Choice Based Credit Courses will follow Common CSR-CBCC, 2018 (SEE LAST PAGE)

Semester-IV

BCT401 Immunology 30 marks

- **Introduction**: overview of the Immune system. (1)
- **Innate immunity:** mechanism of immune response (anatomic, physiological, phagocytic and inflammatory barriers).
- **Adaptive immunity**: Humoral and Cell-mediated immunity, primary and secondary immune modulation, clonal selection of lymphocytes. (2)
- **Antigens**: chemical nature, antigenicity and immunogenicity, hapten, epitopes, mitogens (definition, properties, examples); Adjuvant (definition, examples, function). (2)
- **Immunoglobulins** : structure and function, Immunoglobin genes, generation of diversity, affinity maturation, Isotype switching, Allelic exclusion, Ig receptor of B-cells. (2)
- **Antigen-Antibody interactions**: Precipitation reactions, Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition, Radio immunoassay, ELISA, Immunofluorescence,FACS, Immunohistochemistry, ELISPOT. (2)
- **Major histocompatibility complex**, MHC antigens, allograft rejection, inbred and congenic mice, MHC locus in mice and human, MHC antigen structures and genes, HLA typing and disease association. Antigen processing and presentation. (2)
- **B-cell maturation, activation and differentiation**, T dependent and independent antigen, Idiotype network. Monoclonal and polyclonal antibody, antibody engineering. (4)
- **T cell activation** : MHC restriction, T cell receptor complex and genes, TCR gene rearrangement, T-cell differentiation, thymic selection, super antigens, T-cell cytotoxicity. (2)
- **Complement**: The complement components, function, complement activation- (i) Classical, (ii) Alternate and (iii) lectin pathways. Regulation of complement activation pathways. (1)
- **Hypersensitivity reactions**. (2)
- **Vaccines.** (2)
- Cells and organs of Immune system. Cell-mediated effectors function, Cytokines, Immunological tolerance. Autoimmunity, Immunodeficiency. Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections. Cancer and immune system, Cancer Immunotherapy. (10)

Reference Books:

1. Goldsby, kindt & Osborne (2006). Kuby's Immunology WH Freeman & co.
2. Delves PJ & Roitt IM (2006). Roitt's Essential Immunology, 11th ed., Wiley-Blackwell

BCT402 Microbial Genetics and Virology 30 marks

- **Bacterial Genetics: 10 lectures**

  Transformation: Discovery of Transformation, Competence, Regulation of competence *in B. subtilis*, Experimental evidence for models of natural transformation, Plasmid transformation and phage transfection of naturally competent bacteria, Role of natural

transformation, Importance of natural transformation for forward and reverse genetics, artificially induced competence. (3)

- *Conjugation:* Classification of self-transmissible plasmids, Mechanism of DNA transfer during conjugation in Gram negative bacteria, Chromosome transfer by plasmids, Formation of Hfr strains, Transfer of chromosomal DNA by integrated plasmids, Chromosome mobilization, Prime factors, mapping genes by interrupted mating, fine structure analysis of genes, Transfer system of Gram positive bacteria, Plasmid attracting pheromones.(5)
- *Specialized and generalized transduction*: Horizontal gene transfer mediated by bacteriophages. (2)
- **Bacterial viruses: 10 lectures**
  Historical concept: discovery, phage assays, phage growth cycle. (1) ,Molecular genetics of phage lambda: (4), Lytic-lysogeny decision making, repressor control, retro-regulation, temporal and topological aspects of gene regulation, recombination,*Molecular genetics of phage T4:* (3), Benzer's experiment to understand the unit of recombination and the concept of cistron,Host reappropriation strategies used by phage T4,Phage defence mechanisms against viruses. Restriction modification, altruism, CRISPR.(2)
- **Animal virus: 9 lectures**
  Historical perspectives, origin of viruses, classification of animal viruses, Basic structure of animal viruses: capsid structures, envelops etc. (1) ,RNA viruses: + Strand RNA virus : Coronavirus ,- Strand RNA virus: Influenza, Retro virus : HIV (5),
  DNA virus: Adenovirus (1), Host response to virus infection and vaccines : **(**3)
- **Plant Virus: TMV (1)**

Reference Books:

1. Maloy SR, Cronan JE &Freifelder D(2009). Microbial Genetics, Jones& Bartlett publishers.
2. Dale JW(2001). Microbial Genetics of bacteria, Jones& Bartlett publishers.
3. Snyder L & Champness W(2007). Molecular Genetics of Bacteria, 3rd ed., ASM Press
4. Gardner JE, Simmons MJ & Snustad DP(1991). Principles of Genetics. John Wiley & Sons
5. Norkin LC Virology Molecular Biology and Pathogenesis, ASM Press

BCT403 Cell Biology III 30 marks

Intracellular trafficking

- **Protein trafficking:**

- **Vesicular trafficking** Co-translational protein trafficking: Secretory pathway, concept of signal sequence, experimental demonstration for co-translational transport (protease protection assay), signal recognition particle (SRP), ER translocation of polypeptides (soluble and transmembrane), ER chaperons –(5). N-glycosylation in the ER and Golgi (quality control, UPR, ERAD and proteosomal degradation) (3) .ER to Golgi transport, anterograde and retrograde transport, coat proteins their recruitment and removal, retrieval of ER resident proteins, vesicle fusion (factors involved), lysosomal biogenesis, endocytosis, protein trafficking in a polarized cell (apical & basolateral)-(5)

- **Non-Vesicular trafficking** - Co translational vs Post Translational protein trafficking (1) Nucleocytoplasmic protein transport; NLS and NES Large Cargo through Nuclear pores Small GTPases and regulation of transport. (3) Protein transport to Chloroplast and

Mitochondria and their suborganellar compartments. Proton gradients and chaperones in regulating transport. Co translational transport in both organelles Compare and contrast with ER (3); Peroxisome biogenesis and protein transport (1) Disorders of protein transport associated with Aging diseases (1)

- **RNA trafficking:** Export of protein-coding and non-coding RNA molecules from the nucleus to the cytoplasm. Retrograde tRNA transport. Involvement of RNPs and shared principles with protein transport. (1) RNA transport to cytoplasmic granules like P bodies or polarised transport in neurons or oocytes using cytoskeleton and motor proteins. (1)
- **Lipid trafficking:** Lipid transfer proteins, Sterol carrier protein (SCP), PLTP (PCTP & PITP), homologue in yeast: sec14 (1)

BCT404 Biochemistry & Cell Biology of the Diseases 35 marks

- **Malaria:** Plasmodium Life Cycle and General Morphology, Vertebrate Phases and Invertebrate stages, Classification of Plasmodium, Disease Pathogenesis, Host-Pathogen Interaction: Immunity and Resistance, Control and treatment, Metabolism, Drug target, Action and Drug Resistance.
- **Tuberculosis:** Mycobacterium tuberculosis: Cell description, Pathogenesis: Primary tuberculosis, Tuberculin reactivity, Post-primary tuberculosis, tuberculosis in immunocompromised individuals, Diagnosis, treatment, Host-Pathogen Interaction: Immunity and Resistance, Control and treatment, Drug target, Action and Drug Resistance. Multi drug resistant tuberculosis: Drug resistance mechanism.
- **Cholera:** *Vibrio cholerae*, Cholera, pathogenesis and epidemiology of cholera, Mechanisms involved in environmental survival, virulence factors, Evolution and transmission of virulence factors, Transmission and identification of toxigenic *V. cholerae*, Molecular mechanism of acquisition of the cholera toxin genes, transcriptional regulation of virulence genes, Pathogenecity Island, Host-pathogen interaction: *V. cholerae* infections and the outcome of cholera, molecular aspects of *V. cholerae* infections, Pro-inflammatory phase of infection, changes in the *V. cholerae* c-di-GMP pool during infection, Type III secretion system; Control of cholera: conceptions of cholera vaccines, Drug resistance, treatment and prevention (10).
- **Stroke:** What is stroke, Types of stroke, Pathophysiology of stroke, *in vivo* & *in vitro* models of stroke , Bio-markers, Therapy, stroke and neuroprotection.
- **Genetics of cancer**: Cancer Genetics/Genomics: Types of cancer (1), Cancer hallmarks: traditional and emerging (3), Different models of tumour development: Stochastic/replicative/deterministic/clonal (1), Oncogenes & Tumor suppressor genes, Genomic instability (MIN and CIN) & LOH (3), Cancer genomics: driver & passenger somatic mutations and precision medicine (2).
- **Cell Biology of Cancer:** Cancer: Introduction, characteristics of cancer cells. tumor viruses, oncogenes and tumor suppressor genes, defective control of cell death and differentiation, cancer stem cell, Infection and cancer (3).
- **Apoptosis:** Introduction, caspases, Pro and anti-apoptotic genes, Fas mediated apoptosis; Mitochondria dependent pathways, inhibitory pathways of apoptosis, regulation, implication in diseases; Autophagy, senescence (4).
- **Diabetes:** Brief historical perspective of diabetes, Current scenario, WHO-delared Life-style disorder; Types of Diabetes mellitus, differences & similarities between the types; Causes of the disease: genetic (metabolic disorder) & environmental (stress, food habit etc)

[2]; Factors regulating blood glucose level, Hormonal factor: Insulin, glucagon and others, brief introduction of their sources, structures and functions-hyper & hypo activities, Insulin receptor and its role (brief structure, function & desensitization-insulin resistance), Biochemical changes in lipid metabolism in diabetes - causes and molecular mechanisms, Role of gut derived hormones and micriobiome in diabetes. [5]; Associated Pancreatic disorders, different molecular mechanisms of beta-cell loss; Brief clinical aspect of this disease (symptoms, management & precautions) [3]

Text and Reference Books:

1. Mims CA(2004). Medical Microbiology, 3rd ed, Mosby
2. Paniker CKJ(2007). Ananthanarayan and Paniker's Textbook of Microbiology, Orient Longman Pvt. Limited, India.
3. Greenwood D, Slack RCB & Peutherer JF(2006). Medical Microbiology, A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis & Control, Churchill Livingstone, Elsevier, India.
4. Brooks GF, Butel JS, Morse SA, Melnick JL, Jawetz E & Adelberg EA (2004). Jawetz M &Adelberg's Medical Microbiology, 23rd ed, Lange Publication.
5.Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology, 8th Edition by Scott Brady, George Siegel, R. Wayne Albers, Donald Price. ISBN-13: 978-0123749475
6. Neuroscience: Exploring the Brain (4th Edition)by Mark F. Bear, Barry W. Connors, Michael A. Paradiso. ISBN-13: 978-0781778176
7. Biology of Cancer by Robert Weinberg, W. W. Norton & Company

BCT405 Ecological Principles 25 marks

- The Environment: Physical environment; biotic environment; biotic and abiotic interactions.
- Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
- Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.
- Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
- Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
- Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.
- Ecosystem structure; ecosystem functions. Determination of ecological efficiency. (1)
- Primary and secondary production and decomposition. Importance of C/N ratio. (2)
- Energy flow and mineral cycling (C, N, P, S); Water cycle; Concept of green-house effect, Eutrophication. (2)
- Roles of microbes in N and S cycles. Role of assimilatory and dissimilatory processes. (2)
- Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). (1)
- Metagenomics – Introduction; Pure culture and in consortium; Cultivation independent and microbial analysis; Molecular fingerprinting techniques (RFLP, T-RFLP, ARISA, DGGE, 16S rDNA based library screening, and FISH); Stable isotope

probing (SIP); Microarrays & Metagenome sequencing; Sequence-based Metagenomics Analysis and Function based Metagenomics Analysis, Microbiota in human health and diseases, Environmental metagenomics and bioprospecting

Books:

1. Ecology: Global insights & investigations, Peter Stiling

2. Elements of ecology, eighth edition, Thomas M. Smith & Robert Leo Smith

B. Practical Courses

Semester I

BCP101 Analytical Biochemistry I 40 marks

A.Characterization of an enzyme catalysis

1. Preparation of buffers: i. Acidic range,ii. Basic range,iii. Neutral range

2. Enzyme Assay and determination of Kinetic parameters (using Alkaline phosphatase (ALP) as model)

i. Determination of Specific activity of ALP

ii. Estimation of Km and Vmax of ALP by double reciprocal plot; Comparison of the values from Lineweaver-Burk, Eadie-Hofstee and Hanes-Woolfe plots.

iii. Determination of Progress curve of ALP

iv. Determination of pH Optima of ALP.

v. Inhibition of ALP by EDTA and recovery of enzyme activity by Magnesium ion.

B.Bioseparation

1. Gel filtration of proteins by FPLC **with** standard MW markers: Preparation of buffers, washing column (Sephacryl 100 or Sephacryl 200) , injecting native protein standards and blue dextran , elution of proteins in fraction collector, Conception and measurement of void volume and elution volume, preparation of OD 280 and elution volume graph, preparation of V_e/V_0 vs. molecular weight graph. Demonstrate desalting.

2. Separation of small metabolites by reverse phase chromatography (chlorophyll & Carotene (HPLC)
   Preparation of buffers, extraction of pigments from leaves and vegetables, setting up C18 column, wash and equilibrate the column, elution and detection by absorption spectra, (concept of retention time), prepare the elution profiles graph.

3. SDS-PAGE of standard protein MW markers and Preparation of graphs of the logarithmic relationship between the molecular mass of a protein and its relative electrophoretic mobility in SDS–PAGE.

4. Separation of circular and linearized plasmids (supplied) in presence of MW markers (DNA) in agarose gel.

BCP102 Microbiology 30 marks

Experiment No. 1 Preparation of Media, Preparation of Nutrient Agar Slant, Autoclave Handling, Laminar Airflow Handling, Observation: Bacteria, Yeast, Fungus.
Experiment No. 2 Inculation of Bacteria in nutrient Agar Slants. Preparation of Media for slants and Endospore preparation. Streaking for Single colony isolation.
Experiment No. 3 Simple Staining of the bacteria and yeasts (budding and fission yeast). Preparation of Czapekdox Medium for plating and slant preparation.
Experiment No. 4 Gram Staining of Bacteria.
Experiment No. 5 Endospore Staining, Repeat Gram Staining.
Experiment No. 6 Estimation of viable cells in a bacterial suspension: Pore Plate and Spread Plate Technique. Preparation of Media for Biochemical Tests.
Experiment No. 7 Inoculation of Bacteria for biochemical tests; Indole production, Acetyl methyl carbinol formation, Methyl red test, Starch hydrolysis. Inoculation of Molds.
Experiment No. 8 Biochemical tests. Preparation for qualitative examination of Milk.
Experiment No. 9 Qualitative examination of Milk.
Experiment No. 10 Staining of Fungus.
Experiment No. 11 Microbiological assay of tetracycline: determination of unknown concentration of antibiotic by cup plate method.
Experiment No. 12 Determination of MIC & MBC of different antibiotics against Gram-positive and Gram Microbiology-A Laboratory Manual, Pearson -negative bacteria.
Experiment No. 13 Microbiological examination of water: i) Inoculation of water sample into lactose broth. Observation of gas formation at 24 and 48 h. Preparation of EMB agar and Endo agar.
Experiment No.14 ii) Inoculation of bacterial culture taking from lactose broth (48 h) into EMB and Mackonkey agar medium. Incubation for 24 h.
Experiment No. 15 iii) Observation of EMB and Endo agar plates. Inoculation of single colony into NA medium, Isolated bacteria are tested for biochemical tests (IMViC), Acid and gas production in lactose broth, Gram character, Endospore staining, Growth at elevated temperature (45^{O}C), Motility test, Catalase and oxidase tests. Results will be compared with a reference faecal coliform bacteria like *E. coli***.**
Experiment no. 16 Partial identification of some given Gram+ve and Gram-ve bacterial isolates.
Experiment no. 17 Comparative growth kinetics with respect to bacterial isolates and different media composition.
Experiment no. 18 Antibiotic susceptibility test by disc diffusion assay method.

Reference Books:

1. Atlas RM, Parks LC & Brown AL (1995). Laboratory Manual of Experimental Microbiology. Mosby-Year Book,Inc., Missouri.
2. Cappuccino JG & Sherman N (2005). Education Inc

Semester II

BCP201 Analytical Biochemistry II 25 marks

Biophysical analyses of amino acids, proteins, nucleotides and nucleic acids

1. To verify the Lambert Beer's law. To determine the Beer's limit using dyes and inorganic compounds. Measurement of molar extinction coefficient.
2. To study the characteristics of UV absorption spectra of Aromatic Amino Acids like Tryptophan.
3. To Study the characteristics of UV absorption spectra of BSA and to determine λmax
4. To study the effect of different solvents/ pH on UV absorption spectra of BSA/ Lysozyme/ Ovalbumin/ any globular protein
5. To Study of UV absorption spectra of DNA solution. To determine the Tm of DNA.
6. Denaturation & Renaturation of DNA by heat (Increasing temperature). To observe Hyperchromic and Hypochromic shift.

7. To study the interaction of Ethidium Bromide /Acridine orange with DNA. To Identify the Isosbestic wavelength and to determine the binding affinity.
8. Fluorescence spectrum of BSA or any globular protein. To study the characteristics of Excitation spectrum and emission spectrum.
9. To study the fluorescence quenching of Tryptophan in BSA using Iodine/ or, any drug like Phenothiazine/ Aceclofenac.
Stern-Volmer plot and determination of Quenching constant.
10. Study of ligand binding to protein (BSA) using the fluorescent probe 1-anilinonaphthalene-8-sulfonate (ANS).

BCP202	Molecular and Cell Biology I	40 marks

Cloning of a DNA insert into a cloning vector (pUC 18/19)

i. Preparation of buffer, media and solutions, plates.
ii. Preparation of competent cells and transformation of DH5alpha with the vectors (pUC) and a TA clone containing certain insert
iii. Plasmid prep to amplify vector.
iv. Restriction digestion of those vectors and clone with appropriate enzymes and gel electrophoresis along with uncut respective plasmids
v. Dephosphorylation of the linearized vectors with CIAP
vi. Transformation of DH5alpha with intact, single digested, double digested, double digested and CIAP treated; estimation of the cfu (to determine the background)
vii. Restriction digestion of those vectors and clone with appropriate enzymes and gel electrophoresis along with uncut respective plasmids
viii. Spectrophotometric estimation of DNA quality and purity.
ix. Purification of the insert (restriction digest) from the gel/amplification of insert using PCR
x. Sub-cloning the insert in another vector, transformation, comparison of cfu between positive control and ligated product, blue-white screening and colony PCR.

BCP203	GRAND VIVA	30 marks

Semester III

BCP301	Molecular and Cell Biology II	30 marks

A. Heterologous expression of a His-tagged protein

i. Transformation of *E. coli* BL21DE3 with the cloned expression vector
ii. Checking of expression by IPTG induction
iii. Solubility check—expression condition standardization of the expressed protein.
iv. Batch purification of the overexpressed protein using Ni^{2+} -NTA Agarose
v. Western blotting of the bacterial cell lysate with appropriate antibody
vi. Affinity purification of the expressed protein and its confirmation by WB

B. Plaque Assay

C. PCR (end point and semi-quantitative) amplification of a DNA insert from a cloned vector

D. Genomic DNA Isolation & RFLP.

BCP302	Project Presentation	30 marks

Semester IV

BCP401 Immunotechniques 30 marks

A. Immunotechniques:

Precipitation reaction by double immunodiffusion (Ouchterlony method) and radial immunodiffusion (Mancini's method).

1. Detection of antigens or antibodies by ELISA (Indirect/Sandwich ELISA).
2. Blood typing.
3. Immunoelectrophoresis
4. Latex agglutination test.
5. Dot ELISA

Reference: Immuno Assay Hand Book; David Wild, Elsevier (2013).

II. i) Western blot,
ii) Quantitative precipitation assay
iii) Immunoprecipitation
iv) Immunofluorescence microscopy

BCP402 Molecular and Cell Biology II 25 marks

1. **Subcellular fractionation of animal cells and verification by WB of marker proteins.**
   i. Homogenization of cells/tissues with isotonic buffer
   ii. Centrifugation and isolation of the nucleus, membranes, mitochondria, and cytosolic fractions.
   iii. Identifications of the sub-cellular fractions
   - Visualization of nucleus by DAPI staining
   -Spectrophotometric assay of mitochondrial markers [succinate dehydrogenase/ cytochrome c oxidase/ hemes] (Any one)
   - SDS-PAGE/Western blotting analysis using marker antibodies.
2. **Transfection of animal cells with EGFP vector and imaging by fluorescence microscopy**

BCP403 Bioinformatics 30 marks

1.Sequence search and retrieval.
2. Introduction to NCBI and Uniprot
3.Introduction to sequence alignment and BLAST.
4.Multiple sequence alignment.
5.Basic sequence analysis.
6.. Basic idea of structure (mainly protein and small molecule) representation in PDB
7. Homology modelling of a plant protein
8. Modelling of the interaction of this plant protein with its inhibitor, an invading fungal enzyme
9. Modelling of a human DNA methyl transferase with a compound which is a major component of black tea.

BCP404 GRAND VIVA 30 marks

CBCC courses offered by the Department of Biochemistry:

CBCC A3: BCMGE31 (F.M. 50)	CBCC B6: BCMGE32 (F.M. 50)
4 modules of 12.5 marks each. 1. **Mechanism of enzyme reactions, disorders arising out from structural and functional irregularities of enzymes, enzyme engineering:** Classification, comparison between chemical and biological (enzyme) catalysis, coenzyme, cofactors, concept of rate enhancement in intermolecular vs intramolecular reactions i.e. extent of randomness and reaction rate with an example, how is the enhanced rate of an enzyme catalyzed reaction explained with the help of that concept. Functional groups (R-groups of amino acids) involved in enzyme catalysis, classical approach to identify crucial amino acid(s) involved in enzyme catalysis (use of specific inhibitors of amino acids followed by limited proteolysis) Mechanism of enzyme reactions: serine protease, carbonic anhydrase (metalloenzyme) and restriction endonuclease; Regulation of enzyme activity: Covalent modifications (examples) [PTMs and proteolytic activation of enzymes] Blood clotting cascade, Zymogens, isozymes and their significance (LDH); Allosteric enzymes, Sigmoidal kinetics; Aspartate transcarbamoyase (ATCase), T & R states Directed evolution of enzymes; Industrial application of engineered enzymes Metabolic disorders due to mutation in enzymes 2. **Diagnostic measures (tests) for infectious diseases (viral, bacterial, fungal and protozoal)** Dynamics of infectious diseases within populations, The infectious agents (viral,	**4 modules of 12.5 marks each.** 1. i) Bioinformatics: Introduction to Biological Databases (Protein and Nucleotide) [Sequence, structure, pathways] Understanding BLAST and its applications, sequence alignment, understanding e-value, difference between sequence similarity and sequence identity (6 marks): ii) Inborn errors of metabolism; newborn screening technology; types of amino acid-urias and their causes; metabolic markers in urine and plasma, gout (6.5) 2. **Genome Projects. An overview of genome projects with a special emphasis on HGP. Methods used in Genome analysis. Genome analysis in understanding disease biology and translating the knowledge in healthcare:** a) An introduction to the structural properties and functional dynamics of genes and genomes of prokaryotes and eukaryotes b) Introduction to pre-genomic thinking and methods c) Physical mapping & genome projects (human genome project) d) Sequencing: PCR, Cloning, Sanger's method, Large scale sequencing (top down and bottom up) and Next Generation sequencing, Sequence alignment e) Connecting traits to genes, genes to function f) Genomics and healthcare Pharmacogenomics and Cancer genome project 3. **RNA Biology:** **RNA Processing. RNA Structure and**

bacterial, fungal and protozoal) and its reservoir, Fundamental measures of disease frequency: prevalence and incidence, basic reproductive number (R_0) and effective reproductive number (R), Herd immunity, Syndrome and symptoms of diseases, Selection of specimens, Detection methods, direct method, macroscopic antigen detection, detection of pathogenic agents by serologic methods, detecting microbial antigen or evidence of immune response to an agent, Detection of pathogenic agents by culture, Identification method, Restriction fragment analysis, as by pulse-field gel electrophoresis of restriction enzyme-digested genomic DNA etc. Detection of genetic material (such as DNA or RNA) from the microorganism/specimens, Sensitivity and specificity of the test, Susceptibility testing of microorganism.

3. **Protein purification and absorption and fluorescence spectroscopy, peptidomics, detection of post translational modification of proteins, methods for proteome and peptidome analyses and their relevance in diseases and therapeutics:**

Protein purification: Cell disruption methods and production of initial crude extract: Mammalian cells, Plant Cells, Bacteria, Fungi and Yeast. Fractionation methods: Preliminary purification steps exploiting properties of proteins: stability, solubility, charge, size, affinity, hydrophobicity. Chromatographic techniques: Ion exchange, Hydrophobic, Molecular exclusion, Affinity chromatography. Monitoring protein purification, Specific activity determination, fold purification, yields. Separation of proteins: One dimensional and two dimensional SDS-PAGE.

Ultraviolet and visible light spectroscopy for qualitative and quantitative analysis of proteins, Spectrofluorimetry: Applications: Protein structure determination, Fluorescence resonance energy transfer

Mechanism. Non-classical RNAs. RNA splicing, transport and non-sense mRNA mediated decay Examples of RNA based therapeutics or other applications:

a. What is RNA, difference with DNA, stability, reason for presence of uracil in RNA, types of RNA (mRNA, rRNA, tRNA, Sn RNA, Sno RNA, Si RNA, miRNA) and brief outline of their functions, forces stabilizing RNA.
b. RNA secondary structure, RNA folding problem, role of RNA binding protein and chaperones, their assays, Watson and non-Watson base pairing, necessity of base modification in RNA, idea about intron and exon, alternate splicing, role of deadenylase in RNA stability.
c. RNA world hypothesis, supporting documents to substantiate it, Ribozyme, Self-splicing in Tetrahymena pre-rRNA and RNase P, types of ribozymes, brief outline of their functions and comparison with protein enzymes, Reaction chemistry of nucleolytic ribozymes
d. RNA interference, historical perspective, Mello and Fire's experiments,
e. Structure of siRNA, function and mechanism, Dicer, RISC and argonaute, application, micro RNA, its transcription from non-coding DNA, transport to cytosol, mechanism of inhibition of translation, antisense RNA, RNA based therapies.

4. Epigenetics and Epigenomics

Long Noncoding RNA and epigenetic inheritance:

(FRET), Fluorescence polarization and depolarization.
Peptidomics: Origins, technological development and applications of peptidomics. MALDI-MS based and ESI –MS based peptidomics analysis. Liquid Chromatography based Mass Spectrometry analysis, Label free differential peptidomics analysis and ICAT based differential peptidomics analysis and their relevance in diseases and therapeutics, Detection of post translational modification of proteins.

4. **Bioenergetics: Chloroplast and mitochondria:**
Thermodynamic concepts and calculations of free energy; Concept of redox potential; Chemiosmosis; Proton gradients and electrochemical gradients; Why is ATP the energy currency of a cell?
Ultrastructure mitochondria and Chloroplast and other energy transducing membranes; reducing equivalents.
Electron transport mechanism and its carriers in Mitochondria and chloroplast; how electron transports are coupled with proton pumping in Mitochondria and Chloroplast; Common mechanism of ATP synthesis by F1-Fo ATP synthase.

A. Classification of long noncoding RNAs.

B. Cross talk between Long noncoding RNAs and Epigenetic Mechanisms
C. Long noncoding RNAs in chromatin state regulation
D. Long noncoding RNAs that epigenetically regulate pluripotency and development
E. Long noncoding RNA and transgenerational inheritance

Epigenetic landscape: What is epigenetics? Levels of packaging of DNA to Chromosome. Nucleosomes and histones, Epigenetics mechanisms such as Histone modification and DNA methylation. reversibility of epigenetics
Methods used in epigenome analysis: Analysis of DNA/Protein Interactions - chromatin immunoprecipitation (ChIP), DNA Methylation Analysis – bisulfite method
Clinical application of epigenomics: Epigenetics and environment, epigenetics in human diseases such as cancer, addiction.
Correlation between epigenome and transcriptome analysis: Epigenomic and transcriptomic analysis of chronic inflammatory diseases