Minutes of the Meeting of the Department of Biotechnology
Date & Time: December 17, 2020, 12:00 noon thro' Google Meet
https://meet.google.com/asq-inow-kyj?hs=224

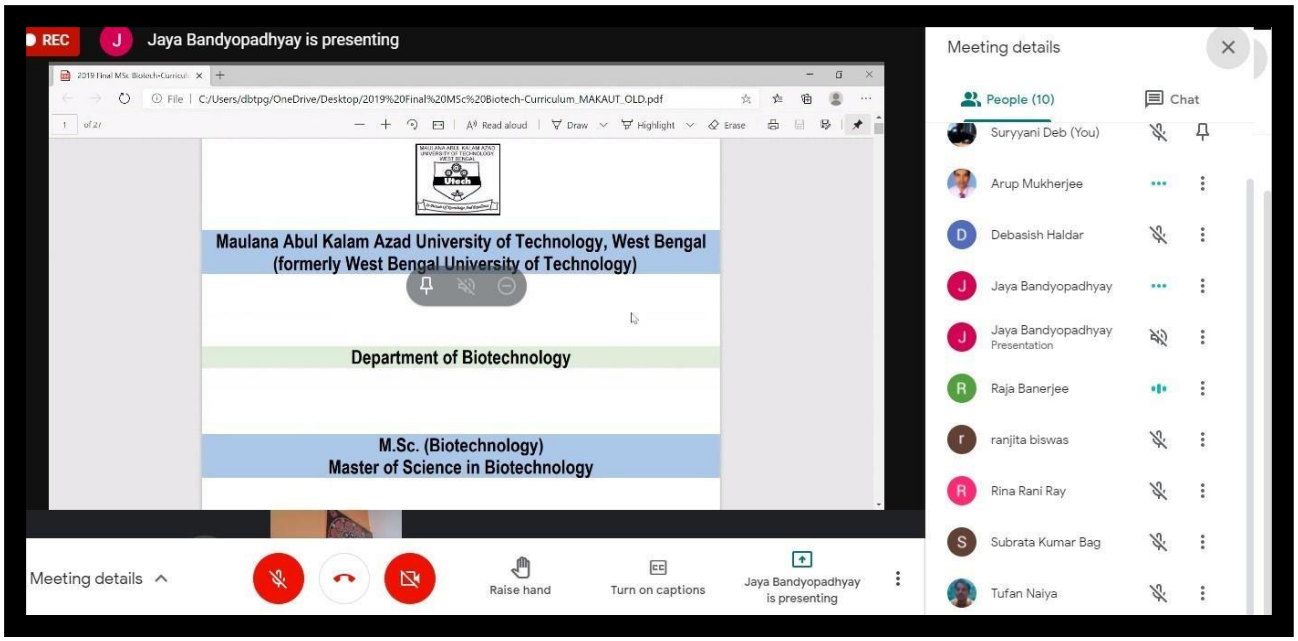
Members present:

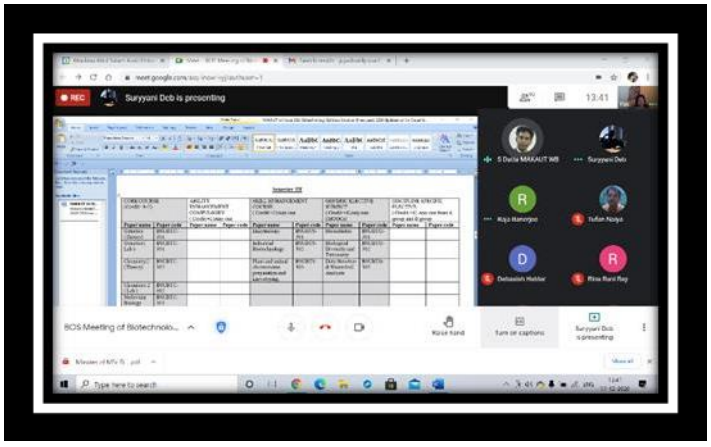
1) **Professor Debasish Haldar, IISERK (External Expert)**
2) **Professor Subrata Bag, WBUAFS, Kalyani (External Expert)**
3) **Dr. Subhashis Datta, COE & Coordinator, BOS**
4) **Dr. Jaya Bandyopadhyay, Head, Dept. of Biotechnology & Convenor**
5) **Prof. Raja Banerjee**
6) **Prof. Arup Mukherjee (Course Coordinator of MTech Biotechnology)**
7) **Dr. Rina Rani Ray**
8) **Dr. Tufan Naiya**
9) **Dr. Debdut Naskar**
10) **Dr. Ranjita Biswas (Course Coordinator of MSc Biotechnology)**
11) **Suryyani Deb (Course Coordinator of BSc Biotechnology)**
12) **Ms. Sayantani Majumder**

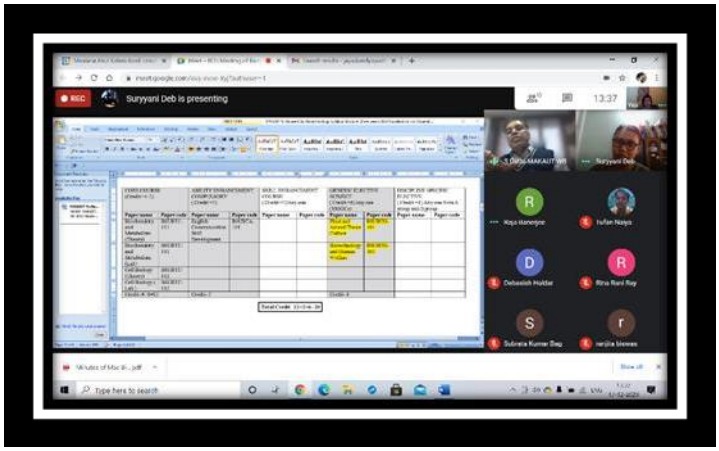
The following points were discussed and noted in the meeting.

1. At the outset the Minutes of the Meeting of December 03, 2019 on MSc Biotechnology syllabus was read out and subsequently confirmed.
2. The **M.Sc Biotechnology syllabus of 2020** was placed before the committee with incorporation of all changes as proposed in the last meeting.
3. That the syllabus has been adopted and modified from the MSc Biotechnology syllabus of DBT (GOI) shall be mentioned at the beginning.
4. The **M.Sc Biotechnology syllabus of 2019** was thereafter placed before the committee for consideration of distribution of the credit points and subjects to make best of the syllabus keeping in mind the credit distribution was slightly uneven compared to the final form of 2020 syllabus. This uneven distribution had to be made in practice as the course was newly introduced in 2019 and the papers had to be adjusted with the ongoing courses to maintain parity.
5. **The total credits of MSc Biotechnology have been revised to 96.**
6. The **MTech Biotechnology syllabus** was placed before the committee. The Elective papers were assigned with proper unique codes following the University norms.
7. That the majority of syllabus has been adopted following guidelines of DBT (GOI) shall henceforth be mentioned at the beginning.
8. The Code of the Elective paper for Sem IV has been rectified and henceforth shall now read as **MUBT- 401 followed by letters as designated for the subjects as per rules.**
9. The **BSc Biotechnology syllabus (Syllabus each of 2019 and 2020)** was placed before the committee by the Course Coordinator Dr. Suryyani Deb.
10. The CBCS structure has been completely adopted for the BSc Biotechnology.
11. Dr. Subhasish Datta (COE) rectified the credit distribution wherever needed and explained the modality of choosing the Generic Elective papers (having a wide coverage of subjects from different disciplines) through MOOCs basket and offline mode of teaching, whichever is convenient to best suit the student's interest.

12. Prof. Subrata Bag and Prof. Debasish Haldar also recommended that the **Elective basket (for all MSc courses; viz Molecular Biology, Microbiology, Genetics, & Biotechnology)** should be such that it should have a wide coverage of subjects from different disciplines keeping abreast the students with new information and also cater to their interest.
13. The committee decided that the recommended practice of MOOCs for Generic Elective shall prevail. However, classes in offline mode are also not ruled out.
14. **The Elective subjects were reviewed and the codes were reincorporated for Molecular Biology, Microbiology, Genetics, & Biotechnology (all M.Sc programs)**.







15. **All the recommendations for BSc (Biotechnology), MSc (Biotechnology, Molecular Biology, Genetics & Microbiology) and MTech (Biotechnology) syllabi were duly approved by the committee.**

The Meeting ended with a vote of Thanks.

Jaya Bandyopadhyay

Dr. Jaya Bandyopadhyay, Head, Biotechnology / December 17, 2020

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Maulana Abul Kalam Azad University of Technology, West Bengal
Department of Industrial Engineering and Management
Haringhata-741249, Nadia, West Bengal, India

Minutes of the 2nd BOS *(Industrial Engineering and Management (PG)/ Production Engineering (PG)/ Manufacturing Technology (PG))* Meeting of MAKAUT, WB held on 28th July 2021 at 7.00 pm through *Google Meet.*

Members present:

1. Prof. Bijan Sarkar, *Convener*
2. Prof. Pradip Kumar Ray, *Member*
3. Prof. Santanu Das, *Member*
4. Prof. Dipankar Bose, *Member.*
5. Prof. Amitava Ray, *Member*
6. Prof. Subhash Chandra Panja, *Member*
7. Mr. Debatosh Paul, *Member*
8. Dr. Manik Chandra Das, *Member*
9. Dr. Bivash Mallick, *Member*
10. Dr. Sourav Das, *Member*
11. Dr. Ankita Ray, *Member*

Prof. Bijan Sarkar, Convener-BOS, initiated the discussion by expressing warm welcome to all members present in the meeting. He asked Dr. Bivash Mallick, HOD-IEM to start talking on items as per the agenda of the meeting. Thereafter following items were presented by Dr. Mallick for discussion.

Item No. 1 of agenda: Confirmation of the minutes of the 1st BOS (IEM/PE/MT) Meeting of MAKAUT, WB held on 20th May 2021.

- HOD-IEM presented the minutes of the 1st BOS meeting for observation and confirmation by the members. During discussion on the points of the 1st minutes, Prof P K Ray suggested modification on PSO1 set by IEM Department. All members accepted the same.
- Dr. Mallick presented the alumni feedback form received from Jalpaiguri Govt. Engg. College. Members requested Dr. Mallick to circulate the same through mail.
- There being no other observations, all members confirmed the minutes of the 1st BOS meeting.

Item No. 2 of agenda: Revision of syllabus with the inclusion of Programme Educational Objectives (PEO), Programme Specific Outcomes (PSO), Programme Outcomes (PO) and Course Outcome (CO) corresponding to each M.Tech programme under the purview of this BOS.

In the context of revision of syllabus for three M.Tech programmes under this BOS, the following points were discussed.

- HOD-IEM presented the syllabus structure of M.Tech programme Industrial Engineering and Management in the beginning. He mentioned all the changes into it including the *Application of Optimal Control Theory in Management Science* and renaming of Product Development Laboratory as *Design Thinking Laboratory*. In this

context, Prof Ray mentioned that experiments in Design Thinking Lab should be explicitly made. All members accepted the proposal. Then, he informed all the members that syllabus with details of individual courses with COs will be circulated among the members through mail for their perusal.

- Regarding the syllabus of M.Tech programme in Production Engineering, Prof Santanu Das requested Dr. Mallick to provide format of the course structure and sample PEOs, PSOs, COs etc. following which he would make the revised syllabus including two newly introduced programme elective courses shortly.
- Dr. Dipankar Bose presented the revised syllabus of M.Tech programme in Manufacturing Technology in front of the members. He was requested to make the detail syllabus in the format followed by IEM department so that the look of the syllabus document of 3 programmes becomes uniform.
- It was decided that the detailed syllabi for three M.Tech programmes namely Industrial Engineering and Management, Production Engineering and Manufacturing Technology which have been finalised in this meeting, will be circulated through mail among the members for their final observations.

Item No. 3 of agenda: Miscellaneous / Any other points

- Members requested Dr. Mallick to circulate office order regarding appointment of BOS members and University notification regarding assessment of Audit courses at the earliest.

There being no other issues to discuss, the meeting ended with a vote of thanks to the chair.

Sd/-
Prof. Bijan Sarkar
Convener, BOS (IEM/PE/MT) of MAKAUT, WB
Professor and Former Head, Department of Production Engineering, Jadavpur University

Maulana Abul Kalam Azad University of Technology, West Bengal
Department of Industrial Engineering and Management
Haringhata-741249, Nadia, West Bengal, India

Minutes of the 1st BOS *(Industrial Engineering and Management (PG)/ Production Engineering (PG)/ Manufacturing Technology (PG))* Meeting of MAKAUT, WB held on 20th May 2021 at 7.00 pm through *Google Meet.*

Members present:

1. Prof. Bijan Sarkar, *Convener*
2. Prof. Pradip Kumar Ray, *Member*
3. Prof. Santanu Das, *Member*
4. Prof. Dipankar Bose, *Member.*
5. Prof. Amitava Ray, *Member*
6. Prof. Subhash Chandra Panja, *Member*
7. Mr. Debatosh Paul, *Member*
8. Dr. Sibamay Dasgupta, Member
9. Dr. Manik Chandra Das, *Member*
10. Dr. Bivash Mallick, *Member*
11. Dr. Sourav Das, *Member*
12. Dr. Ankita Ray, *Member*
13. Mr. Saurav Mitra, (Representative of Mr. Debdutta Guha, *Member*)

Prof. Bijan Sarkar, Convener-BOS, initiated the discussion by expressing warm welcome to all members present in the meeting. He mentioned that this meeting was intended to review syllabi of MTech programme in Industrial Engineering and Management offered by MAKAUT, MTech programme in Production Engineering offered by Kalyani Govt. Engg. College and MTech programme in Manufacturing Technology offered by NITTTR Kolkata. He asked Dr. Bivash Mallick, HOD-IEM to start talking on first item of agenda. In the beginning, Dr. Mallick introduced all members and then following points were discussed.

Item No. 1 of agenda: Revision of syllabi with the inclusion of PEO, PO, CO and PSO.

HOD-IEM started his presentation by showing draft vision, mission statement of the department followed by programme educational objectives (PEOs), programme outcomes (POs) and programme specific outcomes (PSOs) corresponding to MTech programme in Industrial Engineering and Management. He requested the opinion of the members for finalizing these items. Members suggested to review and compare these with the similar items of benchmark institutions for final drafting. Then, the same can be circulated among members for their opinion.

To revise the existing syllabus of MTech programme in Industrial Engineering and Management following points were proposed.

1. The courses namely Operations Research-1 and Product Design and Development which are now offered in 1st and 2nd semester respectively, have been proposed to be reshuffled i.e., first course will come in 2nd semester and the second course will come in 1st semester. The members approved the proposal.
2. Similarly, the laboratory courses namely Simulation Laboratory and Product Development Laboratory which are now offered in 1st and 2nd semester respectively, have been proposed to be reshuffled i.e., first laboratory course will come in 2nd semester and the second laboratory course will come in 1st semester. The members approved the proposal.
3. Understanding the need of students, an audit course on Statistics and Probability Using R was proposed to be included in the 1st year syllabus. The members approved the proposal.

4. Similarly, another audit course on Circular Economy was proposed to be included in the 2nd year syllabus. The members suggested to check whether similar type of course exists in benchmark institutions and sufficient amount of learning resources are available or not etc. If all requirements are fulfilled then only the course will be offered.
5. Prof. Sarkar, Convener-BOS proposed to check the feasibility of introducing a course on Control Theory of Management in the curriculum.
6. A point was raised to convert the coding system of the courses as per AICTE nomenclature (Like PCIEM101, PEIEM102 etc.).

Regarding the syllabus of MTech programme in Production Engineering, Prof. Santanu Das proposed to include 2 Nos elective courses namely safety and Occupational Health in Management and Industrial Pollution Management to be offered in 2nd and 3rd semester respectively. Members of the BOS gave their opinion on detail syllabi of those two courses. The same will be finalized in the next meeting.

Regarding the syllabus of MTech programme in Manufacturing Technology, Prof. Dipankar Bose informed that the structure of the syllabus which was finalized in earlier meeting is available but to prepare detail syllabus, some more time is needed keeping in mind this pandemic situation. It was noted that the same will be placed in the next meeting.

It was further decided to prepare Programme Educational Objectives (PEO), Programme Outcomes (PO), Course Outcome (CO) and Programme Specific Outcomes (PSO) corresponding to each M.Tech programme under the purview of this BOS.

Item No. 2 of agenda: Modality of conducting Audit courses

As per the discussion took place in Academic Council of MAKAU, HOD-IEM explained that the evaluation of the Audit Courses will be conducted through internal assessment only. The assessment procedure will be decided by BoS/DC of the concerned program. No end semester examination will be held for this. However, an Office Order No.5.19/off ord. MOOCs. Aud. crs/ 2021dated 19.05.2021 has been issued from the office of the Registrar in this regard.

Item No. 3 of agenda: Modality of taking structured feedback for design and review of syllabus from different stakeholders

In the meeting it was discussed that online feedback from stakeholders for designing and review of syllabus can be taken by developing an appropriate feedback form. In this context Prof. Amitava Ray, Principal-Jalpaiguri Govt. Engg. College informed that similar form exists in his institution and the same can be shared for the purpose.

Item No. 4 of agenda: Miscellaneous / Any other points

There being no other issues to discuss, the meeting ended with a vote of thanks to the chair.

Sd/-
Prof. Bijan Sarkar
Convener, BOS (IEM/PE/MT) of MAKAUT, WB
Professor and Former Head, Department of Production Engineering, Jadavpur University

BOS Meeting on 13.08.2020 at 2.30 PM through Google Meet Date: 20.08.2020

Department of CSE

Members Present:

1. Prof. Mita Nasipuri
2. Prof. Sankhyayan Chowdhury
3. Mr. Diptiman Dasgupta
4. Prof. Sriyankar Acharya
5. Prof. Debashis De
6. Dr.Santanu Phadikar
7. Dr. Koushik Majumder
8. Mr. Subhanjan Sarkar
9. Ms. Rupali Patua
10. Dr. Amiya Karmakar
11. Dr.Sriparna Saha
12. Dr. Suparna Biswas
13. Mr. Mihir Sing
14. Dr.Saikat Basu
15. Mr. Santanu Chatterjee
16. Dr.Pradyut Sarkar
17. Dr. Sujoy Mistry

Agenda:

1. Finalization of detailed semester wise syllabus of 2nd year, 3rd year and 4th year of B.Tech, Computer Science & Engineering (1st year syllabus uploaded)
2. Finalization of detailed semester wise syllabus of 1st year and 2nd year of M.Tech, Computer Science & Engineering
3. Finalization of detailed semester wise syllabus of 1st year and 2nd year of M.Tech, Software Engineering
4. Departmental Vision, Mission Statement Finalization

Resolution:

1. **B.Tech Syllabus finalization:**
   a) AICTE model curriculum for Computer Science & Engineering accepted with minor changes have been finalized. Credit to hours mapping : 4 credit – 48 hrs., 3 credit-36 hrs., 1 credit – 12 hrs., 0 credit – 12 hrs.(Mandatory Course/Audit Course),
   b) 1st Year, already approved and uploaded in University website, modification required –1st Year, 1st Sem, ESC 101, subject name to be Basic Electrical & Electronics Engineering, credit 5, L-4, T-0, P-2 from 2020-2021 session.
   c) 2nd Year: PCC 301, Principles of Programming Language is being offered in place of ESC 301, Analog Electronics Circuits. Subject code of other PCC subjects will be changed accordingly, from 2021-2022 session.
   d) 3rd Year: PCC 501, Software Engineering is being offered in place of ESC 501, Signals & Systems, from current year, 2020-2021.
   e. For current 5th to 8th Sem, appropriate syllabus as discussed to be sent by Dr. Saikat Basu as available in University website.

e) Professional Electives:

Elective I: 5th Sem
A. Graph Theory
B. Signals & Networks
C. Artificial Intelligence
D. Image Processing
E. Soft Computing

Elective II: 6th Sem
A. Advanced Algorithms
B. Distributed Database
C. Real Time Systems
D. Information Retrieval
E. Advanced Computer Architecture

Elective III: 6th Sem
A. Computer Graphics
B. Optimization Techniques
C. Information Theory & Coding
D. Parallel & Distributed Algorithm
E. Internet of Things

Elective IV: 7th Sem
A. Adhoc and Sensor Networks
B. Machine Learning
C. Neural Networks & Deep Learning
D. Advanced Operating System
E. Computational Geometry
F. Web & Internet

Elective V: 7th Sem
A. Speech & Natural Language Processing
B. Human Computer Interaction
C. VLSI Design
D. Data Analytics
E. Theory of Computation
F. System Software & Administration

Elective VI: 8th Sem
A. Cyber Security
B. Quantum Computing
C. Cryptography & Network Security
D. Cloud Computing
E. Embedded Systems
F. Data Mining

d) Complete 4 Year syllabus for upload for session starting from 2020-2021 will be as follows:

1st Year: New syllabus, with change
2nd Year: Same as AICTE model curriculum syllabus (No Change)
3rd Year: University Syllabus (Applicable from the academic session 2018-2019)
4th Year: University Syllabus (Old, applicable from academic session 2010-2011)

2. Semester wise syllabus of 1st year and 2nd year of M.Tech, Computer Science & Engineering – Finalized with a suggestion to offer a subject named "Industry Overview (Enterprise & Solution Architecture)" as one of the Open Electives.
3. Semester wise syllabus of 1st year and 2nd year of M.Tech, Software Engineering - Finalized with a suggestion to add a subject named "Industry Overview (Enterprise & Solution Architecture)" as one of the Open Electives.

4. Departmental Mission Vision Statements Finalized

139(CSE)
01/10/19

Resolution of the 1st BOS meeting of Dept. of CSE(in-house courses) held on 31-07-2019

Members Present

1. Prof. Debashis De
2. Dr. Santanu Phadikar
3. Prof. Sriyankar Acharyya
4. Miss. Rupali Patua
5. Mr. Mihir Sing
6. Dr. Pradyut Sarkar → Rajarshi 23.09.2019
7. Dr. Sriparna Saha
8. Dr. Madhumita Das (Sarkar)
9. Mr. Santanu Chatterjee
10. Mr. Saikat Basu
11. Dr. Sujoy Mistry
12. Dr. Suparna Biswas
13. Dr. Koushik Majumder
14. Prof: Sankhayan Choudhury
15. Prof. Mita Nasipuri
16. Mr. Arpan Singha
17. Mr. Diptiman Dasgupta
18. Dr. Amiya Karmakar
19. Dr. Subhanjan Sarkar
20. Dr. Atreyee Biswas (invitee)
21. Dr. Sankar Prasad Mondal (invitee)

Honourable Vicechancellor
BOS meeting resolution of
is placed before you for
your kind approval.
Debashis D
23.9.20

Resolution:

1. Syllabus of 1st year(first & second semester) B. Tech. Computer Science & Engineering (CSE) in-house Course is finalized and attached in Annexure-I
2. Syllabus of 1st year (first Semester) M. Tech. Computer Science & Engineering (CSE) in-house Course is finalized and attached in Annexure-II
3. Syllabus of 1st year (first Semester) M. Tech in software Engineering (SE) in-house Course is finalized and attached in Annexure-III
4. A discussion was made on Mission & vision of the department and the Program Educational Outcome (PEO) available in the department website. Honourable members have provided their valuable suggestions. Committee has requested Prof. Sriyankar Acharyya to incorporate the suggestions and place it before the committee for finalization.

Mike Nasipuri 23.09.2019
23.09.2019
23.09.2019
D. De 23.9.2019
23/09/2019
23-09-19
23/09/2019

Maulana Abul Kalam Azad University of Technology, West Bengal

Department of Bioinformatics

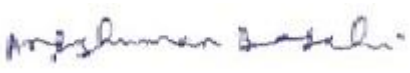
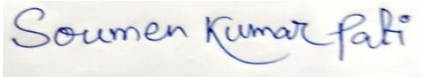
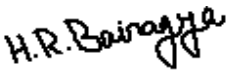
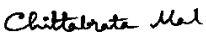
Minutes of the BOS meeting

A meeting of BOS was held on 15th September, 2021for the course **M.Tech. in Bioinformatics**. The proposed syllabus has been approved by the External and Internal members with some minor modifications after a detailed discussion–

(1) The external members proposed that instead of Grand Viva the total credits need to be allocated on Major Project Work in the 4th Semester and enormously it was accepted by the all members.

(2) The external members also proposed that the name of the paper (MBIN 103) should be modified as Mathematics and Statistics and it was also proposed the emphasis should be given on the statistical part.

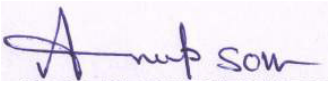
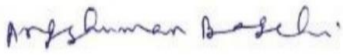
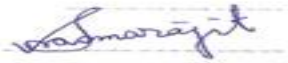
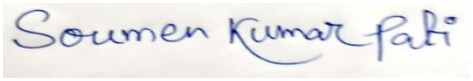
(3) The BOS members also advised instead of specific programming language lab it will be generalized by any programming language.

Members Present:	Signature:
(1) Dr. Anup Som (University of Allahabad)	
(2) Dr. Angshuman Bagchi (University of Kalyani)	
(3) Dr. Smarajit Das (MAKAUT, WB)	
(4) Dr. Soumen Kumar Pati (MAKAUT, WB)	
(5) Dr. Hridoy Ranjan Bairagya (MAKAUT, WB)	
(6) Chittabrata Mal (MAKAUT, WB)	

Maulana Abul Kalam Azad University of Technology, West Bengal
Department of Bioinformatics
Minutes of the BOS meeting

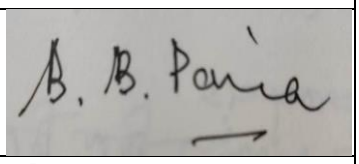
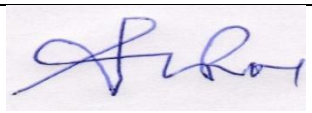
A meeting of BOS was held on 28th February, 2021for the new course **B.Sc. in Bioinformatics**. The proposed syllabus has been approved by the External and Internal members with some minor modifications after a detailed discussion–

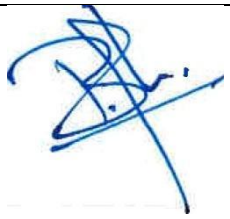
(1) The modifications are Basic Mathematics and Basic Physics should be introduced as a core subject in the syllabus.
(2) The syllabus of Microbiology little bit of heavy, the members suggested that this syllabus should be truncated.
(3) The Python, R languages should be introduced as a main paper in some consecutive semesters.
(4) In this syllabus, the credits of the 4th semester is 20 whereas in the 3rd semester the credit is 26. It is generally norm that higher semester should have higher credits. The External members raises this point and told the University whether this parity should be nullified.

Members Present:	Signature:
(1) Dr. Anup Som (University of Allahabad)	
(2) Dr. Angshuman Bagchi (University of Kalyani)	
(3) Dr. Jaya Bandopadhyay (MAKAUT, WB)	
(4) Dr. Smarajit Das (MAKAUT, WB)	
(5) Dr. Soumen Kumar Pati (MAKAUT, WB)	
(6) Dr. Suryyani Deb (MAKAUT, WB)	

Date: 04.03.2022

Members present for online BOS Meeting

Sl.No.	Designation	Name of the Members	Signature
1.	Chairman	Prof. Saikat Maitra, Vice Chancellor, MAKAUT	Absent
2.	Vice- Chairman	Prof. B.B.Paira, Academic Advisor, MAKAUT	
3.	Co-ordinator	Dr .S Dutta, Controller of Exams, MAKAUT	Absent
4.	Convener	Dr. Sebak Ranjan Roy, Head, Department of Food Science & Technology ,MAKAUT	
5.	Hon'ble Member	Prof. Pranabesh Chakroborty, Director, School of Pharmacy, Food Science & Technology & Medical Science Email id:pchakroborty@rediffmail.com	Absent
6.	External Member & Expert(Academic)	Prof. Subrata Kumar Bag Professor, Dairy Engineering Department F/O Dairy Technology West Bengal University of Animal & Fishery Sciences Mohanpur Campus P.O. Krishiviswavidyalaya Dist Nadia – 741252, West Bengal India Mobile No 9903602982 Email id:bagksub@gmail.com	
7.	External Member & Expert(Academic)	Prof. Prasant Biswas, Department of Food Technology & Biochemical Engineering, Jadavpur University, Kolkata – 700 032. Mob.No.7003747965 Email id:pkbiswas@yahoo.com /prasantakumar.biswas@jadavpuruniversity.in	
8.	External Member & Expert(Academic)	Dr. Kazi Layla Khalid, Assistant Professor, Department of Home Science. University of Calcutta Mob. No 9038624171 Email id: kazilaylakhaled04@gmail.com	Absent

9.	**External Member & Expert(Academic)**	**Prof. Debashis Halder, Chemical Sciences, IISER, KOLKATA (Mob No : 9748487503). Email id:deba_h76@iiserkol.ac.in**	Debasish Haldar
10.	**External Member & Expert (Industry)**	**Dr.Balwinder Bajwa, Director & CEO, Eduward Food Research and Analysis Centre Limited, Mob: 9836269043 Email id:balwinderbajwa@efrac.org**	

Agenda:

1. Revision and finalisation of some parts of the MSc Food Science and Technology Syllabus namely

- **MSUFT 481 – Project Work (Credit 20)**
- **MSUFT 482 – Industry/Laboratory Visit (Credit 1)**
- **MSUFT 483 – Journal Club and Seminar Presentation (Credit 1)**
- **MSUFT 491 – Grand Viva (Credit 2)**

Resolutions:

Comments received from respected Members

1. Dr. Prasanta Kumar Biswas (HoD, FTBE, JU)

The COs and the detailed syllabus of all the four courses seem alright.

2. **Dr. Balwinder Bajwa (Director & CEO, Eduward Food Research and Analysis Centre Limited)**

I have gone through the revised syllabus of all the four courses. The syllabus is fine.

3. Prof. Debasish Haldar (Department of Chemical Sciences, IISER Kolkata)

The change regarding practical to sessional for all the three subjects (MSUFT 482, 483, 491) is appreciated. The syllabus of all the four subjects seems fine.

4. Prof. Bibhuti Paira (Academic Advisor, MAKAUT, W.B)

Syllabus regarding the particular topics has been prepared meticulously. This is up to the mark. The alteration of the papers (MSUFT 482, 483, 491) from practical to sessional is quite justified.

5. Prof. S.K. Bag (HoD, Dept. of Dairy Technology, WBUFAS)

I find the proposed changes regarding the four subjects (MSUFT 481, 482, 483, 491) updated.

6. **After receiving the comments of the members the syllabus was finalized to be placed in the forthcoming AC.**

MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

MINUTES OF THE MEETING OF BOARD OF STUDIES OF

B.Sc. in ROBOTICS AND 3D PRINTING

July 19, 2020

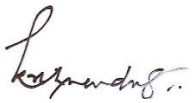
Members Present:

1. Prof Sibamay Dasgupta, Director School of Engineering Science and Head, The Centre of Robotics and 3D Printing, MAKAUT WB
2. Prof Krishnendu Sarkar, Director, NSHM Knowledge Campus Kolkata
3. Mr. Debabrata Roy, Assistant Prof, Department of Mechanical Engineering, NSHM Durgapur, WB
4. Mr. Amit Karmakar, Faculty member, The Centre of Robotics and 3D Printing, MAKAUT WB
5. Mr. Anjan Choudhury, Faculty member, The Centre of Robotics and 3D Printing, MAKAUT WB
6. Mr. Shambo Chatterjee, Faculty member, The Centre of Robotics and 3D Printing, MAKAUT WB

Resolution:

In the meeting of the Board of Studies of the program B.Sc. in Robotics and 3D Printing, held on July 19, 2020, the **CBCS version** (total structural change according to CBCS format) of the syllabus of the said program was discussed and finalized. The final syllabus is duly approved by the present Board of Studies as attached with this Minutes of Meeting.

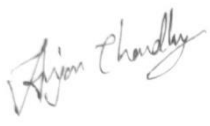
Prof Sibamay Dasgupta



Prof Krishnendu Sarkar

Debabrata Roy

Amit Karmakar



Anjan Choudhury

Shambo Chatterjee

1ST SEMESTER											
Subject Type			**Course Code**	**Course Name**	**Credit Points**	**Credit Distribution**			**Mode of Delivery**		
						Th	Pr	Tu	Offline	Online	Blended
Core course	CC1	CC 1.1	RBEE101	Basic Electrical Engineering	4	4	0	0	✓	✓	✓
		CC1.2	RBEE191	Basic Electrical Engineering Lab	2	0	2	0	✓	✓	✓
	CC2	CC2.1	RBMS101	Engineering Mechanics	4	4	0	0	✓	✓	✓
		CC2.2	RBMS191	Engineering Graphics	2	0	2	0	✓	✓	✓
GE		GE1.1	RBM101	Engineering Mathematics I	4	4	0	0	✓	✓	✓
		GE1.2	RBMT101	Engineering Mathematics I Tutorial	2	0	0	2	✓	✓	✓
AECC		AECC 1	RBHS101	Communicative English	2	2	0	0	✓	✓	✓
	Semester Credits				**20**						

2nd SEMESTER											
Subject Type			**Course Code**	**Course Name**	**Credit Points**	**Credit Distribution**			**Mode of Delivery**		
						Th	pr	Tu	Offline	Online	Blended
CC	CC3	CC3.1	RBEE201	Analog & Digital Electronics	4	4	0	0	✓	✓	✓
		CC 3.2	RBEE291	Analog & Digital Electronics lab	2	0	2	0	✓	✓	✓
	CC4	CC4.1	RBMS201	Strength of Materials for Mechanical Engineers	4	4	0	0	✓	✓	✓
		CC4.2	RBMS291	Strength of Materials for Mechanical Engineers lab	2	0	2	0	✓	✓	✓
GE		GE2.1	RBM201	Engineering Mathematics II	4	4	0	0	✓	✓	✓
		GE2.2	RBMT201	Engineering Mathematics II Tutorial	2	0	0	2	✓	✓	✓
AECC		AECC 2	RBPR201	Environmental Science	2	2	0	0	✓	✓	✓
	Semester Credits				**20**						

Subject Type			Course Code	Course Name	Credit Points	Credit Distribution			Mode of Delivery		
						Th	Pr	Tu	Offline	Online	Blended
CC	CC5	CC5.1	RBEC301	Electrical Machines	4	4	0	0	✓	✓	✓
		CC5.2	RBEC391	Electrical Machines Lab	2	0	2	0	✓	✓	✓
	CC6	CC6.1	RBEC302	Microprocessors, Embedded Controllers and Real time Operating Systems	4	4	0	0	✓	✓	✓
		CC6.2	RBEC392	Microprocessors, Embedded Controllers and Real time Operating Systems lab	2	0	2	0	✓	✓	✓
	CC7	CC7.1	RBMS301	Kinematics & Dynamics of Machines	4	4	0	0	✓	✓	✓
		CC7.2	RBMS391	Kinematics & Dynamics of Machines lab	2	0	2	0	✓	✓	✓
GE		GE 3.1	RBPH301	Digital signal processing (DSP)	4	4	0	0	✓	✓	✓
		GE 3.2	RBPHT301	Digital signal processing (DSP) Lab	2	0	0	2	✓	✓	✓
SEC		SEC1.1	RBCS301	Introduction to python *	2	2	0	0	✓	✓	✓
	Semester Credits				**26**						

3RD SEMESTER											
Subject Type			**Course Code**	**Course Name**	**Credit Points**	**Credit Distribution**			**Mode of Delivery**		
						Th	Pr	Tu	Offline	Online	Blended
CC	CC5	CC5.1	RBEC301	Electrical Machines	4	4	0	0	✓	✓	✓
		CC5.2	RBEC391	Electrical Machines Lab	2	0	2	0	✓	✓	✓
	CC6	CC6.1	RBEC302	Microprocessors, Embedded Controllers and Real time Operating Systems	4	4	0	0	✓	✓	✓
		CC6.2	RBEC392	Microprocessors, Embedded	2	0	2	0	✓	✓	✓

				Controllers and Real time Operating Systems lab							
	CC7	CC7.1	RBMS301	Kinematics & Dynamics of Machines	4	4	0	0	✓	✓	✓
		CC7.2	RBMS391	Kinematics & Dynamics of Machines lab	2	0	2	0	✓	✓	✓
GE		GE 3.1	RBPH301	Digital signal processing (DSP)	4	4	0	0	✓	✓	✓
		GE 3.2	RBPHT301	Digital signal processing (DSP) Lab	2	0	0	2	✓	✓	✓
SEC		SEC1. 1	RBCS301	Introduction to python *	2	2	0	0	✓	✓	✓
	Semester Credits				**26**						

4TH SEMESTER										
`Subject Type			**Course Code**	**Course Name**	**Credit Points**	**Credit Distribution**			**Mode of Delivery**		
						Th	Pr	Tu	Offline	Online	Blended
CC	CC 8	CC8.1	RBEE401	Power Electronics and Drives	4	4	0	0	✓	✓	✓
		CC8.2	RBEE491	Power Electronics and Drives Lab	2	0	2	0	✓	✓	✓
	CC9	CC9.1	RBEC401	Sensors and Instrumentation	4	4	0	0	✓	✓	✓
		CC9.2	RBEC491	Sensors and Instrumentation Lab	2	0	2	0	✓	✓	✓
	CC 10	CC10. 1	RBPR401	Principles of Robotics I	4	4	0	0	✓	✓	✓
		CC10. 2	RBPR491	Principle Robotics Lab I	2	0	2	0	✓	✓	✓
GE		GE 4.1	RBHU401	Values & Ethics*	4	4	0	0	✓	✓	✓
		GE 4.2	RBHUT401	Values & Ethics Tutorial *	2	0	0	2	✓	✓	✓
SEC		SEC1. 1	RBCS401	Machine Learning,*	2	2	0	0	✓	✓	✓
	Semester Credits				**26**						

5TH SEMESTER

Subject Type			Course Code	Course Name	Credit Points	Credit Distribution			Mode of Delivery		
						Th	Pr	Tu	Offline	Online	Blended
CC	CC11	CC11.1	RBEE501	Control System	4	4	0	0	✓	✓	✓
		CC 11.2	RBEE591	Control System Lab	2	0	2	0	✓	✓	✓
	CC12	CC12.1	RBPR501	Introduction to Robotics II	4	4	0	0	✓	✓	✓
		CC12.2	RBPR592	Robotics II Lab	2	0	2	0	✓	✓	✓
DSE		DSE 1.1	RBPR502	Industrial Design And Applied Ergonomics	4	4	0	0	✓	✓	✓
		DSE1.2	RBPR592	Industrial Design And Applied Ergonomics lab*	2	0	2	0	✓	✓	✓
DSE		DSE 2.1	RBMS501	Mechanical design	4	4	0	0	✓	✓	✓
		DSE2.2	RBMS591	Mechanical Design lab	2	0	2	0	✓	✓	✓
	Semester Credits				**24**						

6TH SEMESTER											
Subject Type			**Course Code**	**Course Name**	**Credit Points**	**Credit Distribution**			**Mode of Delivery**		
						Th	Pr	Tu	Offline	Online	Blended
CC	CC13	CC13.1	RBPR601	3D Printing	4	4	0	0	✓	✓	✓
		CC 13.2	RBPR691	3D Printing Lab	2	0	2	0	✓	✓	✓
	CC14	CC14.1	RBCS601	Machine Vision	4	4	0	0	✓	✓	✓
		CC14.2	RBCS691	Machine Vision Lab	2	0	2	0	✓	✓	✓
DSE		DSE 3.1	RBCS602	Internet of things*	4	4	0	0	✓	✓	✓
		DSE3.2	RBCS692	Internet of things Lab *	2	0	2	0	✓	✓	✓
DSE		DSE 4.1	RBPR692	Project	6	4	0	0	✓	✓	✓
	Semester Credits				**24**						
	GRAND TOTAL Credits				**140**						

MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

MOM and Resolutions of BoS Meeting (Department of Applied Statistics)

Date: 19/05/2022
Time: 6:30 pm
Venue: Online

A BoS meeting was Chaired by Prof. Sukhendu Samajdar (Director, SoAST) with the permission of Hon'ble Vice Chancellor. The agenda for the meeting are as follows:

1. Confirmation of the proceedings of the last BoS meeting held on 05.08.2021.
2. Review of 1st and 2nd semester curriculum for B.Sc. in Statistics.
3. Discussion and finalisation of the curriculum of 3rd - 6th semester for B.Sc. in Statistics.
4. Miscellaneous

Members Present:

1. Prof. Sukhendu Samajdar, Director SoAST , MAKAUT, WB (Chair of the BoS)
2. Prof. Rahul Bhattachrya, HoD, Dept. of Statistics
3. Prof. Atanu Biswas, Applied Statistics Unit, ISI Kolkata
4. Dr. Avijit Bhattacharyya, External expert of Corporate sector
5. Ms. Anwesha Sengupta, HoD, Dept. of Applied Statistics, MAKAUT, WB
6. Prof. P.N.Dutta, Academic Coordinator, Dept. of Applied Statistics, MAKAUT, WB
7. Dr. Indrani Mukherjee, Dept. of Applied Statistics, MAKAUT, WB
8. Dr. Sushovon Jana, Dept. of Applied Statistics, MAKAUT, WB
9. Mr. Taranga Mukherjee, Dept. of Applied Statistics, MAKAUT, WB (Invitee)
10. Mr. Chandan Chakraborty, Dept. of Applied Statistics, MAKAUT, WB (Invitee)

After elaborate discussions on the curriculum the following resolutions were accepted unanimously and the corresponding modifications have been done in the said meeting.

1. The resolutions and minutes of the last BoS meeting held on 05.08.2022 was read out and the same were accepted by all the members.
2. It has been noted that some course code in the previous version of the curriculum were detected as erroneous and the same have been corrected accordingly.
3. The term project in the semester-V has been reordered as the last course in that particular semester (courses in 6th and 7th positions were interchanged).
4. It has been accepted that the capstone project in semester-VI which was previously under the category DSE has been recategorized as RAEC (Research Ability Enhance Course) in followance with recent UGC notification.
5. In Unit 4 of the course BSTAT 302 (CC6: Statistical Inference), some generic nomenclatures are introduced in lieu of particular nomenclatures.

6. In Unit 3 of the course BSTAT303 (CC7: Linear Algebra), the "evaluation of determinants" was mentioned, excluding its particular order (which was previously mentioned as "evaluation of determinants of order three or more").

7. In Unit 1 of the course BSTAT 305A (SEC 1: Python for Data Analysis), the detailed portion has been shortened as "Review of basic concepts of Python". It has been mentioned that the curriculum should be complemented by corresponding computer intensive methods.

8. In Unit 4 of the course BSTAT305C (SEC 1: Statistical Techniques for Research Methods), there is no need to mention particular problems related to Economics.

9. It has been decided that the theoretical portion of the course BSTAT 305D (SEC 1 : Database Management Systems) is to be augmented by application of ORACLE/SQL or equivalent server relational database. It has been decided that this paper will be recast with the help of Dr. Avijit Bhattacharyya.

10. It was also resolved that in the laboratory courses all the lab sessions are to be carried out with the suggested problems from the given list of practicals. In addition, the name of the laboratory courses should be written in an uniform format.

11. It has been resolved that the course (SEC 2: BSTAT 405: Statistical techniques for research methods) being a replication of previously taught courses has been totally omitted.

12. It was resolved that BSTAT 305C (SEC 1: Statistical Techniques for Research Methods) and BSTAT 305D (SEC 1: Database Management Systems) will be considered as BSTAT 405 A(SEC 2: Statistical Techniques for Research Methods) and BSTAT 405B (SEC 2: Database Management Systems) respectively.

13. The probability distribution part from Unit I of the course (CC 11: BSTAT 501: Stochastic Process and Queuing Theory) is to be excluded.

14. The name of the course CC 12: BSTAT 502: Computer Age Statistical Techniques is also to be renamed as "CC 12: BSTAT 502: Modern Statistical Techniques" and correspondingly, the related laboratory course is also to be renamed.

15. In DSE courses where Theory and laboratory courses are combined together, there is no need for separate COs' for the theory and laboratory part, instead, there will be a common CO before the Theory portion of that particular course.

16. The courses DSE2: (BSTAT 504 3B: Financial Statistics) (Unit 4), (CC 13: BSTAT 601: Design of Experiments) (Unit 2 and 4), (DSE 3: BSTAT 603A: Survival Analysis and Biostatistics), (DSE 3 B: BSTAT 603 B: Operations Research**)** have been shortened as it appeared to be a vast syllabus compared to that of a standard UG course. The "Basics concepts of Big data and its statistical approach" has been incorporated in (DSE2: 504 3B: Financial Statistics) as per suggestion of Dr. Avijit Bhattacharyya.

17. It has been decided that the internal experts would be entitled to incorporate minor editorial changes, if required.

18. The BOS unanimously resolved that the curriculum structure of six semesters and detailed syllabus of all semesters of B.Sc (Statistics) have been accepted after the incorporation of necessary corrections and now is ready for implementation.

The meeting was concluded with a vote of thanks to the BOS members and to the chair.

Anwesha Sengupta.

Ms. Anwesha Sengupta
HoD, Dept. of Applied Statistics

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City Campus: BF-142, Sector -I, Salt Lake, Kolkata -700 064

Minutes of Meeting

BoS meeting of School of Management Sciences was held on 01/03/2022 at 8 p.m. in Zoom Meeting Platform (Zoom Meeting ID: 970 1682 6862) to finalize the curriculum framework of BBA (CBCS) 5th to 6th SEM, BBA in Business Analytics (CBCS) 5th to 6th SEM, BBA in Digital Marketing (CBCS) 5th to 6th SEM.

Members present in the BoS Meeting

1. Prof. Amitava Sarkar
2. Prof. Krishnendu Sarkar
3. Prof. Nandan Sengupta
4. Prof. Indranil Mukherjee
5. Prof. Sujit Mukherjee
6. Ms. Debadrita Panda
7. Mr. Subrata Ghosh

Honourable BoS Members observed the curriculum framework of syllabus and made valuable comments. These are as follows:

1. CBCS Curriculum framework of 5th and 6th semester for BBA, BBA in Business Analytics, and BBA in Digital Marketing has been finalized. Focus has been emphasized on emerging technologies, data analytics, and industry-academia interaction through internship or project.
2. It has been mutually decided that the detailed CBCS syllabus of 5th and 6th semester BBA, BBA in Business Analytics, and BBA in Digital Marketing will be finalized by circulation of the detailed syllabus among all the BoS Members.

3. Detailed syllabus of MBA in Business Analytics 4th Semester has been finalized and approved.
4. Detailed Non-CBCS syllabus of BBA in Business Analytics 6th Semester has been finalized and approved.
5. It has been proposed that the student will be offered an array of subjects (at least two subjects) under DSE.
6. BBA(DM) 104: English Communication has been re-named as Business Communication.
7. Minor changes have been carried out in some papers from the previous semesters for BBA, BBA BA, BBA DM courses.
8. Course outcomes will be incorporated for each paper of BBA, BBA-BA and BBA-DM.

BoS meeting ends with vote of thanks.

01/3/22

Dr. SUJIT MUKHERJEE
Professor & HOD (MBA)
School of Management Sciences
Maulana Abul Kalam Azad University
Of Technology, West Bengal
(Formerly Known as West Bengal University Of Technology)
Haringhata, Nadia - 741249

Indranil Mukherjee
01/03/2022

Director
SoMS
Maulana Abul Kalam Azad University
of Technology, West Bengal
(Formerly Known as West Bengal University of Technology)
Haringhata, Nadia - 741249, India

Minutes of the meeting with BOS Expert committee held on 25/03/2022 at 07:30 pm on ZOOM (Meeting ID: 970 1682 6862).

Members present:

1. Prof. (Dr.) Sujit Mukherjee
2. Prof. J.P.Shaw
3. Dr. Dilip Kumar Das
4. Prof. Krishnendu Sarkar
5. Ms. Debadrita Panda
6. Ms. Sarani Bhaumik
7. Dr. Prosenjit Ghosh
8. Dr. Soma Hazra
9. Mr. Arabinda Sarangi

1) Prof. Krishnendu Sarkar has advised to add some content details of Post Event Management area in module no 5 from course BBA TTM: 501: Event Tourism & Public Relations.
2) Dr. Prosenjit Ghosh has advised to reduce some contents from paper BBA TTM: 503 (C) & BBA TTM: 603 (C): Airline & Cargo Management I & Airline & Cargo Management II, both are Discipline Specific Elective (DSE) papers.
3) All other BOS members, who present virtually, mutually approved the BBA TTM CBCS Syllabus till 6th semester.

Meeting ended with Thanks to the chair.

25/03/2022

Dr. SUJIT MUKHERJEE
Professor & HOD (MBA)
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The Board of Studies (BoS) meeting was held on 05.10.2021 through ZOOM app at 7:30 p.m. chaired by Prof. (Dr.) Indranil Mukherjee, Director of SOMS and Prof. (Dr.) Sujit Mukherjee, HoD, MBA Studies. This BoS meeting was called to discuss and finalize the syllabus of BBA(HM) CBCS of 3rd and 4th semester along with few other issues .
The Following external BoS members were present:

1. Dr. Nandan Sengupta
2. Dr. J. K .Das
3. Dr. Subhrojyoti Bhowmik
4. Dr. Krishnendu Saha
5. Dr. Jhilam Rudra De

Amongst others present from the SoMS was Ms. Sayantani Ray, Ms. Debadrita Panda, HoD BBA Studies and Mr. Biswanath Saha.
The meeting discussed on the following points:

I. The paper Data Analysis using R has been changed to Basic Healthcare Analytics BBA(HM)-405 with some changes in curriculum Framework. The decided credit is 2L.
II. One extra module Current Trends in Healthcare has been incorporated by the experts in the existing syllabus of Healthcare Marketing.
III. In the Previously uploaded draft syllabus of BBA HM there was a minor discrepancy in the credit distribution for computer applications paper BBA(HM) – 305. This issue has been resolved and now the credit has been collectively finalised with 2 L.
IV. The latest relevant reading material has been incorporated for the benefits of the students in the pre-existing Syllabus.
V. The Credit for Computer Applications: BBA -405 has been decided as 2L
VI. The Subject name of Data Analysis Lab using R has been suggested as Data Analysis using R: BBA (BA) 405 with credit distribution 2L.
VII. BBA (A) Non CBCS Syllabus of 5th semester was also approved by the panel of experts.
VIII. The syllabus of Introduction to Media and Computer Application in Business - practical BBA (DM) 191 has been approved.

Indranil Mukherjee
05/10/2021

Meeting ends with vote of thanks.

Dr. SUJIT MUKHERJEE
Professor & HOD (MBA)
School of Management Sciences
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VI. The Subject name of Data Analysis Lab using R has been suggested as Data Analysis using R: BBA (BA) 405 with credit distribution 2L.
VII. BBA (A) Non CBCS Syllabus of 5th semester was also approved by the panel of experts.
VIII. The syllabus of Introduction to Media and Computer Application in Business - practical BBA (DM) 191 has been approved.

Indranil Mukherjee
05/10/2021

Meeting ends with vote of thanks.

Dr. SUJIT MUKHERJEE
Professor & HOD (MBA)
School of Management Sciences
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Director
SoMS
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of Technology, West Bengal
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Minutes of the Meeting of the Department of Biotechnology
Date & Time: December 17, 2020, 12:00 noon thro' Google Meet
https://meet.google.com/asq-inow-kyj?hs=224

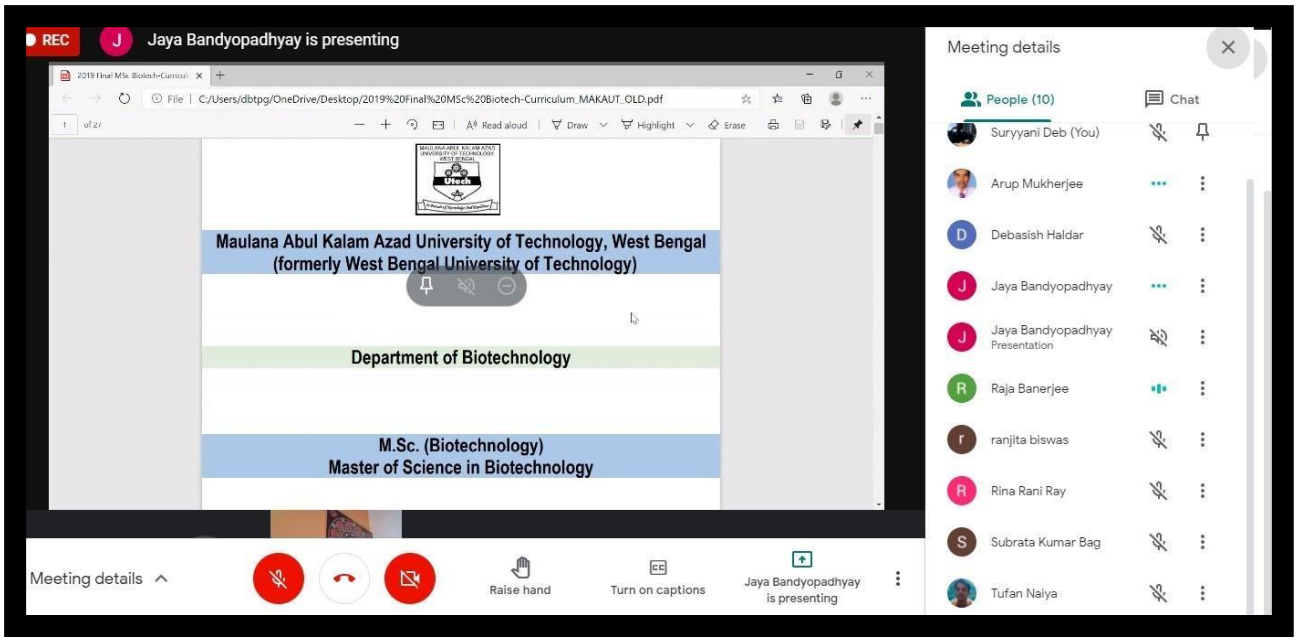
Members present:

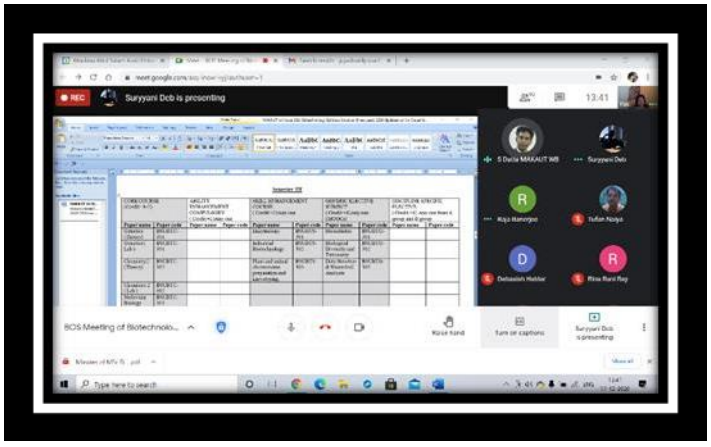
1) **Professor Debasish Haldar, IISERK (External Expert)**
2) **Professor Subrata Bag, WBUAFS, Kalyani (External Expert)**
3) **Dr. Subhashis Datta, COE & Coordinator, BOS**
4) **Dr. Jaya Bandyopadhyay, Head, Dept. of Biotechnology & Convenor**
5) **Prof. Raja Banerjee**
6) **Prof. Arup Mukherjee (Course Coordinator of MTech Biotechnology)**
7) **Dr. Rina Rani Ray**
8) **Dr. Tufan Naiya**
9) **Dr. Debdut Naskar**
10) **Dr. Ranjita Biswas (Course Coordinator of MSc Biotechnology)**
11) **Suryyani Deb (Course Coordinator of BSc Biotechnology)**
12) **Ms. Sayantani Majumder**

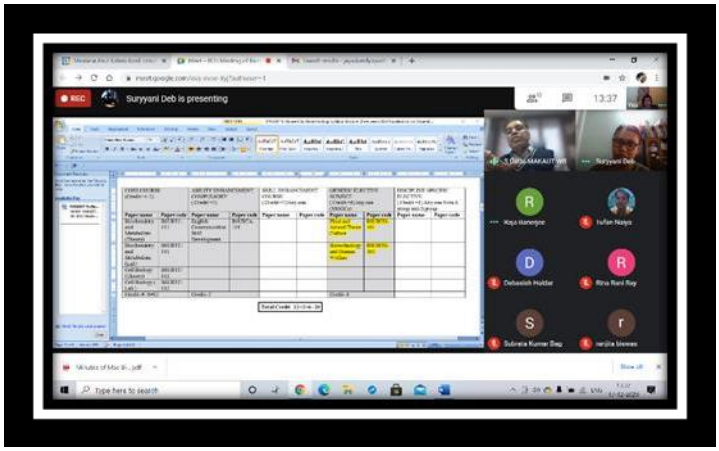
The following points were discussed and noted in the meeting.

1. At the outset the Minutes of the Meeting of December 03, 2019 on MSc Biotechnology syllabus was read out and subsequently confirmed.
2. The **M.Sc Biotechnology syllabus of 2020** was placed before the committee with incorporation of all changes as proposed in the last meeting.
3. That the syllabus has been adopted and modified from the MSc Biotechnology syllabus of DBT (GOI) shall be mentioned at the beginning.
4. The **M.Sc Biotechnology syllabus of 2019** was thereafter placed before the committee for consideration of distribution of the credit points and subjects to make best of the syllabus keeping in mind the credit distribution was slightly uneven compared to the final form of 2020 syllabus. This uneven distribution had to be made in practice as the course was newly introduced in 2019 and the papers had to be adjusted with the ongoing courses to maintain parity.
5. **The total credits of MSc Biotechnology have been revised to 96.**
6. The **MTech Biotechnology syllabus** was placed before the committee. The Elective papers were assigned with proper unique codes following the University norms.
7. That the majority of syllabus has been adopted following guidelines of DBT (GOI) shall henceforth be mentioned at the beginning.
8. The Code of the Elective paper for Sem IV has been rectified and henceforth shall now read as **MUBT- 401 followed by letters as designated for the subjects as per rules.**
9. The **BSc Biotechnology syllabus (Syllabus each of 2019 and 2020)** was placed before the committee by the Course Coordinator Dr. Suryyani Deb.
10. The CBCS structure has been completely adopted for the BSc Biotechnology.
11. Dr. Subhasish Datta (COE) rectified the credit distribution wherever needed and explained the modality of choosing the Generic Elective papers (having a wide coverage of subjects from different disciplines) through MOOCs basket and offline mode of teaching, whichever is convenient to best suit the student's interest.

12. Prof. Subrata Bag and Prof. Debasish Haldar also recommended that the **Elective basket (for all MSc courses; viz Molecular Biology, Microbiology, Genetics, & Biotechnology)** should be such that it should have a wide coverage of subjects from different disciplines keeping abreast the students with new information and also cater to their interest.
13. The committee decided that the recommended practice of MOOCs for Generic Elective shall prevail. However, classes in offline mode are also not ruled out.
14. **The Elective subjects were reviewed and the codes were reincorporated for Molecular Biology, Microbiology, Genetics, & Biotechnology (all M.Sc programs)**.







15. **All the recommendations for BSc (Biotechnology), MSc (Biotechnology, Molecular Biology, Genetics & Microbiology) and MTech (Biotechnology) syllabi were duly approved by the committee.**

The Meeting ended with a vote of Thanks.

Jaya Bandyopadhyay

Dr. Jaya Bandyopadhyay, Head, Biotechnology / December 17, 2020

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Maulana Abul Kalam Azad University of Technology, West Bengal

Department of Biotechnology

M. Sc in Microbiology
Syllabus 2019-20

Semester I

Code	Course Title	Contact Hrs./Wk	Credit
A	**Theory**	**L-T-P**	
MSUMC-101	Biochemistry	3-0-0	3
MSUMC-102	Laboratory Technique & safety	3-0-0	3
MSUMC-103	Cell & Molecular Biology	3-0-0	3
MSUMC-104	Biostatistics	3-0-0	3
MSUMC-105	General Microbiology	3-0-0	3
B	**Practical**		
MSUMC-191	Biochemistry & Analytical Techniques	0-0-6	3
MSUMC-192	Microbiology	0-0-6	3
MSUMC-193	Data analysis by software	0-0-4	2
C			
MSUMC-181	Seminar		1
Semester Total			**24**

Semester II

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUMC-201	Agricultural & Soil Microbiology	3-0-0	3
MSUMC-202	Industrial Microbiology & Fermentation Technology	3-0-0	3
MSUMC-203	Immunology	3-0-0	3
MSUMC-204	Genetic Engineering	3-0-0	3
MSUMC-205	Applied Bioinformatics	3-0-0	3
MSUMC-206	Choice based courses (from MOOCS basket)		2
B	**Practical**		
MSUMC-291	Genetic engineering	0-0-6	3
MSUMC-292	Immunology	0-0-6	3
C			
MSUMC-281	Seminar		1
Semester Total			**24**

Semester III

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUMC-301	Virology	3-0-0	3
MSUMC-302	Environmental Microbiology	3-0-0	3
MSUMC-303	Medical Microbiology	3-0-0	3
MSUMC-304	IPR, Biosafety & Bioethics	3-0-0	3
MSUMC-305	Choice Based course (From Elective Basket) *	2-0-0	2
MSUMC-306	Choice Based course (from MOOCS basket)		2
B	**Practical**		
MSUMC-391	Applied Bioinformaticslab	0-0-6	3
MSUMC-392	Fermentation technology lab	0-0-6	3
C			
MSUMC-381	Project Proposal Presentation		2
Semester Total			**24**

*** Elective subjects Basket**

Code	Subject
MSMC-305A	Principles of Ecology
MSMC- 305B	Research methodology and Writing
MSMC-305C	Molecular diagnostics
MSMC-305D	Enzyme technology
MSMC-305E	Plant Molecular Biology

Semester – IV

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
MSUMC-481	Project Work		22
MSUMC-482	Industry/ lab visit		1
MSUMC-483	Journal Club Presentation		1
Semester Total			**24**
Total Course Credit			**96**

During form fill up for the semester examination no specific subject name and code will be listed except mentioning MOOCs. ~~Where students will qualify the examination successfully & certificates will be obtained, name & code for the MOOCs subjects will be recorded.~~

The name & code for the specific MOOCs subject will be recorded only when students will qualify the examination successfully & ~~completion~~ obtain ~~completed~~ certificate

Tanya B
3/12/19

3/12/19

03/12/2019.

Minutes of the Meeting of the BOS (M.Sc in Microbiology) held on December 03, 2019

Members Present **Signature**

1. Professor Samir Kumar Mukherjee (External Expert)
2. Professor Tarakdas Basu (External Expert)
3. Dr. Rina Rani Ray (Head of Dept. of Biotechnology & Convenor)
4. Prof. Arup Mukherjee (Academic Coordinator)
5. Dr. Ranjita Biswas
6. Dr. Jaya Bandyopadhyay
7. Dr. Tufan Naiya
8. Dr. Debdut Naskar (Subject Coordinator for M.Sc Microbiology)
9. Dr. Suryyani Deb
10. Dr. Smarajit Das

The following points were discussed and noted in the meeting.

1. Prof Samir K. Mukherjee suggested the reaming of one lab based subject in the 1st semester course, Data analysis using statistical software (Code:MSUMC-193) as **Data analysis by software.**
2. Prof Samir K. Mukherjee also suggested the paper Laboratory techniques should be renamed as **Laboratory Techniques & Safety (Code:MSUMC102).** He insisted that students should learn the safety aspect of laboratory and that's why a one extra unit need to be incorporated at the beginning named as Unit 1 : Laboratory safety.
3. Prof Tarakdas Basu recommended that last unit (Unit-7) of this paper should be renamed as **advanced molecular biology technique.**
4. Both the external experts suggested to reduce the content of the paper **MSUMC-103: Cell and Molecular Biology**. However they agreed to keep the current content for the forthcoming examination. They suggested another meeting to finalize the content of this paper after the examination.
5. Prof Tarakdas Basu suggested to incorporate one reference book Principles of Molecular Biology by Tropp et al, for the this paper.
6. Prof Samir K Mukherjee recommended the renaming of unit 3 of theory paper MSUMC-104: Biostatistics as Tests of hypothesis.
7. Both expert suggested the renaming of unit 1 and 2 of paper Immunology (MSUMC-203) as Immune system and Immune responses respectively.
8. Prof. Samir K Mukherjee suggested the addition of one unit (Unit 1 Disease epidemiology) at the beginning of the paper **MSUMC-303: Medical Microbiology** and recommended to modify the content of that unit.
9. He also advised the incorporation of few addition in the paper (**MSUMC304: IPR, Biosafety & Bioethics)** such as **importance of IPR and bioweapons** etc.
10. Regarding the credit earned through the MOOCS courses, they suggested that students should be given permission to earn credit through MOOCS courses throughout the course period. However they have to earn the required credit/s from subjects of their choice (CBCS) before appearing the final semester examination.
11. For the MOOCS courses, the external experts further suggested that during form fill up for the semester examination, no specific subject name and code will be listed except mentioning MOOCS. The name and code for the specific MOOCS subject will be recorded only when students will qualify the examination successfully and obtain certificate.
12. Any further modification may be considered through separate BOS meetings in the future.

The Meeting Ended with a Vote of Thanks.

Board of Studies Meeting (Subject: M Sc Microbiology); Date: 3/12/19 ; Time: 12:30 pm at Biotech Building, Haringhata

Sl No	Name	Mobile Number	Email ID	Signature
	External members			
1	Prof. Tarakdas Basu, KU	9433501504	tarakdb@yahoo.com	03/12/19
2	Prof. Samir Kumar Mukherjee, KU	9433156617	dr.samirmukherjee@gmail.com	3/12/19
3	Prof. Raja Bannerjee			
4	Dr. Rina Rani Ray, HOD			3/12/19
5	Prof. Arup Mukherjee	9433475981		
6	Dr. Jaya Bandyopadhyay			
7	Dr. Tufan Naiya			
8	Dr. Ranjita Biswas			3/12/19
9	Dr. Surjyani Deb			
10	Dr. Debdut Nandan	8336183382		03/12/19
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Maulana Abul Kalam Azad University of Technology, West Bengal

Department of Biotechnology

M. Sc in Microbiology

Syllabus 2019-20

Code	Course Title	Contact Hrs./Wk	Credit
A	Theory	L-T-P	
MSUMC-101	Biochemistry	3-0-0	3
MSUMC-102	Laboratory Technique & safety	3-0-0	3
MSUMC-103	Cell & Molecular Biology	3-0-0	3
MSUMC-104	Biostatistics	3-0-0	3
MSUMC-105	General Microbiology	3-0-0	3
B	Practical		
MSUMC-191	Biochemistry & Analytical Techniques	0-0-6	3
MSUMC-192	Microbiology	0-0-6	3
MSUMC-193	Data analysis by software	0-0-4	2
C			
MSUMC-	Seminar		1

Semester I

181			
Semester Total			24

Code	Course Title	Contact Hrs./wk	Credit
A	Theory	L-T-P	
MSUMC-201	Agricultural & Soil Microbiology	3-0-0	3
MSUMC-202	Industrial Microbiology & Fermentation Technology	3-0-0	3
MSUMC-203	Immunology	3-0-0	3
MSUMC-	Genetic Engineering	3-0-0	3

Semester II

204			
MSUMC-205	Applied Bioinformatics	3-0-0	3
MSUMC-206	Choice based courses (from MOOCS basket)		2
B	**Practical**		
MSUMC-291	Genetic engineering	0-0-6	3
MSUMC-292	Immunology	0-0-6	3
C			
MSUMC-281	Seminar		1
Semester Total			**24**

Semester III

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	L-T-P	
MSUMC-301	Virology	3-0-0	3
MSUMC-302	Environmental Microbiology	3-0-0	3
MSUMC-303	Medical Microbiology	3-0-0	3
MSUMC-304	IPR, Biosafety & Bioethics	3-0-0	3
MSUMC-305	Choice Based course (From Elective Basket) *	2-0-0	2
MSUMC-306	Choice Based course (from MOOCS basket)		2
B	**Practical**		
MSUMC-391	Applied Bioinformatics lab	0-0-6	3
MSUMC-392	Fermentation technology lab	0-0-6	3
C			
MSUMC-381	Project Proposal Presentation		2

Semester Total	24

* Elective subjects Basket

Code	Subject
MSMC-305A	Principles of Ecology
MSMC- 305B	Research methodology and Writing
MSMC-305C	Molecular diagnostics
MSMC-305D	Enzyme technology
MSMC-305E	Plant Molecular Biology

Semester – IV

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
MSUMC-481	Project Work		22
MSUMC-482	Industry/ lab visit		1
MSUMC-483	Journal Club Presentation		1
Semester Total			24
Total Course Credit			96

Semester – I

MSUMC-101: Biochemistry credits 3

Unit 1: Basic chemistry

Formation of chemical bonds, molecular orbital (MO) theory and linear combination of atomic orbitals (LCAO), basics of mass spectrometry, molecules, Avogadro number, molarity, chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid- base pairs, buffers and buffering action etc; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

Unit 2 : Protein Structure

Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding.

Unit 3: Enzyme

Enzyme Classification, Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of haemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit 4: Glycobiology

Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose. lipids-structure and properties of important members of storage and membrane.

Unit 5: Nucleic acid

Nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure.

Unit 6: Bioenergetics

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; Ca++ signaling pathways; glycolysis and gluconeogenesis; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation, Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.

Unit 7: Vitamins & cofactors

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

Texts/References:

1. David L. Nelson; Michael M. Cox. Lehninger Principles of Biochemistry
2. L Stryer, Biochemsitry, Freeman publishing.

MSUMC-102: Laboratory Techniques & Safety

credits 3

Unit 1 : Laboratory safety- Basic goal of Chemical hygiene and lab safety, Occupational Safety and health administration (OSHA), Safety precaution, Health hazard, Chemical and biological hazard, Personal protective equipment.

Unit 2: Chromatography - Paper Chromatography, Thin-layer chromatography, Displacement chromatography, Gas chromatography, High performance / pressure liquid chromatography, Ion exchange chromatography, Size-exclusion chromatography, Affinity chromatography.

Unit 3: Electrophoresis and blotting - Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Immunoelectrophoresis, Isoelectric focussing, Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis, Western blot, Eastern blot, Southern blot, Northern blot.

Unit 4 :Radioactivity - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Applications of isotopes in biochemistry; Autoradiography.

Unit 5 :Centrifugation - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge, Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit 6: Microscopy

Optical microscopy, Electron microscopy, Confocal microscopy, AFM, Flow cytometry, Instrumentation, Applications.

Unit 7: Advanced molecular biology techniques

DNA and Amino acid Sequencing, DNA CHIP, Microarray, Substractive Hybridization, RNase protection assay, ELISA, Mass spectroscopy, Infra red spectroscopy, NMR, Circular Dichroism, Microarray, Flow cytometry.

Text/References :

1. Cantor & Schimmel : Biophysical Chemistry (Part I, II & III)
2. A. Lehninger : Principles of Biochemistry
3. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
5. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

MSUMC-103: Cell and Molecular Biology

credits 3

Unit 1: Organization of cell :Universal features of eukaryotic cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit 2: Chromatin structure :Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of

selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes- composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso- accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code.

Unit 3: Cellular signalling, transport and trafficking: Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

Unit 4: Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

Unit 5: Manipulating and studying cells: Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.

Unit 6: Genome instability and cell transformation: Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

Unit 7: Genetics: Mendel's experiments, monohybrid and dihybrid cross, sexual reproduction applications of chi square test, deviation from Mendelian segregation, linkage, genetic map, Mendelism in human genetics: pedigree analysis, dosage compensation and sex determination, inheritance characteristics of sex-linked and autosomal traits, chromosome discovery, chromosomes as physical basis of inheritance, Polytene and lampbrush chromosomes, chromosomal aberrations and genetic load, sex-linked

deleterious genes, extrachromosomal/non-Mendelian inheritance(episomes, mitochondria and chloroplasts), parental imprinting, Population Genetics-Variation and its modulation, effect of sexual reproduction on variation (Hardy-Weinberg Equilibrium), sources of variation, selection balanced polymorphism, random events.

Text/References

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell. New York: Garland Science.
2. Lodish, H. F. (2000). Molecular Cell Biology. New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2009). The Cell: a Molecular Approach. Washington: ASM; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston: Benjamin Cummings.
6. Watson, J. D. (1987). Molecular Biology of the Gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.
7. Tropp et al, Principles of Molecular Biology

MSUMC-104: Biostatistics credits 3

Unit 1: Introduction to Biostatistics

Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias and sampling techniques. Sample distribution. Data collection and presentation: Types of data, methods of collection of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram.

Unit 2: Measures of central tendency and Measure of dispersion

Mean, Medium and mode. Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient of variation. Correlation and regression: Positive and negative correlation and calculation of Karl- Pearsons co-efficient of correlation. Linear regression and regression equation and multiple linear

regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation.

Unit 3: Tests of hypothesis

Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error. Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviation. Randomized block design, complete block design.

Text/References:

1. Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science.
2. Billingsley, P. (1986). Probability and Measure. New York: Wiley.
3. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
4. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.

MSUMC-105: General Microbiology3 Credits

Unit 1: Microbial Characteristics

Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, Microbial fermentation, Microbial energetics, biosynthesis of enzymes , activation energy, endergonic and exergonic reaction, autotrophic and heterotrophic generation of ATP, Photophosporylation, fermentation vs respiration, bacterial growth curve, bacterial culture methods; antimicrobial resistance.

Unit 2: Microbial diversity and taxonomy:

Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma; Archaea: Halophiles, Methanogens, Hyperthermophilic archaea, Thermoplasm; Eukaryotes: algae, fungi, slime molds and

protozoa; extremophiles and unculturable microbes, Molecular Taxonomy, Identification and characterization of unknown microbes.

Unit 3: Bacterial genetics:

Mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; Transposon, Prokaryotic gene expression.

Unit 4: Interaction of microbes with biotic and abiotic stress:

Antibiotic, Probiotic, Prebiotic, drug resistance, multiple drug resistance, Host-pathogen interaction.

Text/ Reference

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.
2. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill.
3. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.
5. Microbial Genetics- David Freifelider

MSUMC-191: Biochemistry and Analytical Techniques credits 3

1. To prepare an Acetic-Na Acetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. An enzyme purification theme (such as E.coli Alkaline phosphatase or any enzyme of the institutions choice).

a) Preparation of cell-free lysates
b) Ammonium Sulfate precipitation

c) Ion-exchange Chromatagraphy
d) Gel Filtration
e) Affinity Chromatography
f) Generating a Purification Table
g) Assessing purity by SDS-PAGE Gel Electrophoresis
h) Assessing purity by 2-D gel Electrophoresis
i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.

5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry

MSUMC-192: Microbiology credits 3

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
6. Antibiotics assay and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.

MSMB193: Data analysis by software

credits 2

1. Introduction to different statistical software.

2. Determination of mean, median, mode of given data set.

3. Determination of standard deviation and standard error of a given data set.

4. Preparation of different types of graph from a given data set.

5. Determination of statistical significance of the experimental data: Paired and unpaired t test and p value determination

5. Nonparametric Mann-Whitney test, including confidence interval of difference of medians.

6. Wilcoxon test with confidence interval of median.

7. Usage of two and three way anova.

8. Kaplan-Meier survival analysis

Semester II

MSUMC-201: Agricultural and soil Microbiology

Credits 3

Unit I

History of soil microbiology, Soil microbiology- Stages of Soil Formation, Soil microbes, soil texture, structure, Soil pH, Conductivity etc.

Unit II

Microbial Metabolism - Biological N_2-fixation by Free living anaerobic (Clostridium), facultatively anaerobic (Azospirillum) and aerobic (Azotobacter), N_2-fixers associated with stem, root and leaf, Symbiotic N_2-fixation in legumes and non- legumes by Rhizobium and Frankia, N_2-fixation by cyanobateria. Requirement of ATP, O2-sensitivity and inhibition by ammonia and nitrogenous substance in the case of nitrogenase, Peculiarity of alternate nitrogenase of *Streptomyces thermoautotrophicus*.

Unit III

Biofertilizers and Biopesticides- Physical and Biological Nitrogen fixation- symbiotic and asymbiotic, mass production by Rhizobium, Azotobacter and Cyanobacteria, nitrifying and ammonifying bacteria, Denitrification of nitrate fertilizers to N2 and N2O (a green house gas) by denitrifying bacteria, free living and in association with Azolla, Phosphate solubilizing bacteria, PGPR, Mycorrhiza, Soil anerobic methanogens in rice field. Integrated nutrient management.

Unit IV

Effect of soil pH and heavy metals on microorganisms, Microbial antagonism in soil, Biological control of soil-borne microbial pathogens. Biopesticides, integrated pest management, organic farming, organic village etc. Eco-friendly Microbes; –Utilization of beneficial Microorganisms in sustainable Agriculture, Ice minus bacteria and microbial pesticides.

Text/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.
2. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill.
3. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.
5. A.J. Salle Fundamental Principles of Bacteriology, Tata McGraw-Hill Education

MSUMC-202: Industrial Microbiology & Fermentation technology

Credits 3

Unit I Introduction to industrial microorganisms - History of industrial microbiology, Isolation, screening and maintenance of industrially important microbes; microbial growth kinetics (with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit 2: Methods in fermentation- Batch, fed-batch and continuous operations; chemostat and Turbidostat systems; immobilized cell systems; media formulation and optimization; sterilization of media and air; oxygen transfer and kLa in fermentation

Unit 3: Downstream process for microbial products- Separation of insoluble products : filtration, centrifugation, sedimentation, flocculation; cell disruption; Separation

of soluble products: liquid- liquid extraction, precipitation, chromatography, reverse osmosis, crystallization , ultra and micro filtration; drying and packaging.

Unit 4: Fermented foods and beverages- Food ingredients and additives by fermentation; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours, flavours and alcoholic beverages; process wastes- whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria: production and applications in food preservation; probiotics, prebiotics and synbiotics and food additives.

Unit 5: Industrial products- Titre, yield and productivity; Raw materials for industrial production; Bioethanol, Baker's yeast, Lactic acid, Amino acids (L-Lysine and L-Glutamic acid), Citric acid, Penicillin, Glutathione, Insulin, Amylase, Protease, High-fructose corn syrup and vaccines.

Text/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.
2. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill.
3. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.
5. A.J. Salle Fundamental Principles of Bacteriology, Tata McGraw-Hill Education
6. Casida L.E.J.R. Industrial Microbiology
7. E. M. T. El-Mansi, C. F. A. Bryce, Arnold L. Demain, A.R. Allman (2012) Fermentation Microbiology and Biotechnology

MSUMC-203: Immunology credits 3

Unit 1 : Immune system

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT); Mucosal Immunity; Antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

Unit 2: Immune responses

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; VDJ Recombination, B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Immunological basis of self - non-self discrimination; Kinetics of immune response, memory; $_B$ cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten- carrier system.

Unit 3: Antigen-antibody interactions

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay,

immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasma resonance, Biosenor assays for assessing ligand -receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptotosis, Microarrays, Transgenic mice, Gene knock outs, CD nomenclature, Identification of immune Cells; Principle of Immunofluorescence Microscopy, Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications.

Unit 4: Vaccinology

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

Unit V Clinical Immunology

Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity - Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation-Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology - Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency- Primary immunodeficiencies, Acquired or secondary immunodeficiencies. Immunoglobulin therapy, Specific and nonspecific immunotherapy for Asthma and allergic diseases.

Text/ Reference

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.

2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.

3. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven

MSUMC-204: Genetic Engineeringcredits 3

Unit 1: Tools for genetic engineering:

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes; hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

Unit 2: Vectors

Plasmids; Bacteriophages; M13 vectors; PUC19 and pBluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression: expression vectors, pMal, GST, pET- based vectors; Protein purification: His-tag; GST-tag; MBP-tag etc. Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

Unit 3: PCR and cloning:

primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; TA cloning vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of

oligonucleotides; mutation detection: SSCP, DGGE, RFLP, RAPD, AFLP, DNA microsatellite, DNA marker, Polymorphism, Positional cloning, functional cloning, therapeutic cloning.

Unit 4: cDNA analysis

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNaseI footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit 5: Gene silencing and genome editing technologies

Gene silencing techniques; Transposon and jumping gene, introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics- gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS9 with specific emphasis on Chinese and American clinical trials.

Texts/References

1. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's Gene XII,
2. David Baltimore and Harvey Lodish Molecular cell Biology, 6th Edition
3. James D. Watson (2017) Molecular Biology of the Gene (2017) Pearson Publisher
4. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub
5. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited; 7th Edition
6. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold

Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

7. Selected Papers from Scientific Journals, particularly Nature & Science.

8. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

MSUMC-205: Applied Bioinformatics credits 3

Unit 1: Sequence-alignment related problems

Sequence databases; Similarity matrices; Pairwise alignment; BLAST; Statistical significance of alignment; Sequence assembly, Multiple sequence alignment; Clustal; Phylogenetics: distance based approaches, maximum parsimony.

Unit 2: Pattern analysis in sequences

Motif representation: consensus, regular expressions; PSSMs; Markov models; Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding.

Units 3: Structure-related problems

Representation of molecular structures (DNA, mRNA, protein), secondary structures, domains and motifs; Structure classification (SCOP, CATH); Visualization software (Pymol, Rasmol etc.); Experimental determination of structures (X-ray crystallography, NMR); Structure databases; Secondary structure prediction; RNA structure prediction; Mfold; Protein structure prediction by comparative modelling approaches(homology modelling, threading); Ab initio structure prediction: force fields, backbone conformer generation by Monte Carlo approaches, side-chain packing; Energy minimization; Molecular dynamics; Rosetta; Structure comparison (DALI, VAST etc.); CASP; Protein-ligand docking; Computer-aided drug design (pharmacophore identification); QSAR; Protein-Protein interactions.

Unit 4: System-wide analyses

Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics:13C NMR based metabolic flux analysis.

Text/References:

1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring
Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken,

NJ: Wiley-Liss.
3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.

MSUMC- 291: Genetic Engineering credits 3

1. Isolation of total genomic DNA from bacteria and plants samples.
2. PCR amplification of a candidate gene from the isolated genomic DNA and analysis of the PCR product by agarose gel electrophoresis.
3. Cloning of the PCR amplified product in pGEM-T Easy vector.
4. Preparation of E. Coli (DH5 α) competent cells.
5. Transformation of plasmid DNA in E.coli DH5α. 1. Designing of primers for directional cloning.
6. Cloning of a candidate gene by directional cloning method.
7. Plasmid isolation by Alkaline Lysis method.
8. Isolation of plant total protein from plant leaves and analysis of the isolated protein by SDS-PAGE

9. Screening of recombinant clones by blue white screening.

MSUMC- 292: Immunology credits 3

1. Antibody titre by ELISA method.
2. Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion. Complement fixation test.
3. SDS-PAGE, Immunoblotting, Dot blot assays
4. Demonstration of Phagocytosis of latex beads
5. Separation of mononuclear cells by Ficoll-Hypaque
6. Flow cytometry, identification of T cells and their subsets
7. Culture of Macrophage cell and demonstration of Phagocytosis of latex beads
8. Determination of Blood group of an individual and differential leucocyte count under a microscope.
9. Cryopreservation of cultured cells and cell revival.

Semester III

MSUMC-301: Virology credits 3

Unit 1. Nomenclature & classification systems of viruses and Morphology of Viruses

Structure of Viruses- Enveloped and Non enveloped viruses, Capsid symmetries – Icosohedral, Polyhedral and Helical, Structural components of virus – Protein - Envelope proteins, Matrix proteins and Lipoproteins, Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense), linear, circular, segmented.

Unit 2: Cultivation and assay of viruses

Cultivation of viruses using embryonated eggs, experimental animals and cell cultures (Cell- lines, cell strains and transgenic systems). Purification of viruses by adsorption, precipitation, enzymes, serological methods – haeme agglutination and ELISA. Assay of viruses – Physical and Chemical methods (Electron Microscopy and Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point) Genetic analysis of viruses by classical genetic methods.

Unit 3: Entry and Replication of viruses

Mechanism of virus adsorption and entry into host cell, Genome replication, Post transcriptional processing, Translation of viral proteins, Protein nucleic acid interactions and genome packaging Assembly, exit and maturation of progeny virions, Replicative strategies employed by animal DNA viruses. Replicative strategies employed by animal RNA viruses.

Unit 4: Pathogenesis of Viruses

Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Hepatitis virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant (TMV) and insect viruses (NPV). Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

Unit 5: Control of Viruses and Emerging Viruses

Control of viral infections through vaccines, interferons and chemotherapeutic agents. Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus.

Text/References:

1. Flint et al. Principles of Virology 4th Edition ASM publisher
2. Vinod Singh. Text Book of Virology (2010).
3. Leonard C. Norkin. Virology: Molecular Biology and Pathogenesis (2010)

MSUMC-302: Environmental Microbiology Credits3

Unit 1 Environmental factors

Introduction to environment; pollution and its control; pollution indicators; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; Influence on growth and distribution of Microbes, Temperature, Ph, Radiation, osmotic and salt stress etc, BOD, COD, POC, Ammonia, Nitrate, Phosphate etc.

Unit 2 Waste management

Solid and liquid waste management, water treatment plant, waste disposal system, Food spoilage, Food preservation and food safety management.

Unit 3 Biofuel

Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological

interventions for optimization of production; Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi. Bioremediation and Phytoremediation.

Text/Reference

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (1999) Environmental Biotechnology. Pearson Education Limited.

MSUMC-303: Medical Microbiology credits 3

Unit 1 Disease epidemiology

Disease surveillance, disease transmission, Gene reservoir, Pathogenesis and virulence. Difference virulence factor related to bacterial diseases (enzymes, toxin, LPS, siderpohore). Opportunistic infections and Normal microflora of human.

Unit 2

Gram-positive cocci, disease produced by them and diagnostic approach; Gram-negative cocci, disease produced by them and diagnostic approach; Epidemiology, etiology, symptomatology, prevention and control of the following diseases: Cholera, Typhoid, tuberculosis; Prion related diseases, Protozoan disease (Malaria, leishmaniasis).

Unit 3

Introduction to medical mycology; Superficial & subcutaneous mycosis; Systemic & opportunistic mycosis; Introduction to parasitic diseases; Protozoan parasites of the intestines

Unit 4

Hospital Acquired infection control program & biological waste management.

Text/Reference

1. Murray Patrick R. Basic Medical Microbiology (2017) Elsevier
2. Ansari J (2012) Text Book of Medical Microbiology

MSUMC-304: IPR, Biosafety & Bioethics

credits 3

Unit I Intectual property rights

Iintectual property right and its importance. Types of IPR. PATENTS Macro economic impact of the patent system Patent and kind of inventions protected by a patent. Patent document and protection inventions. Granting of patent Rights of a patent. Searching a patent. Drafting of a patent. Filing of a patent. The different layers of the international patent system (national, regional and international options) COPYRIGHT General Additional Reading: Latest editions of Designs Act, Copyright RELATED RIGHTS. Distinction between related rights and copyright. Rights covered by copyright.
TRADEMARKS and its importance, Rights of trademark. INDUSTRIAL DESIGNS Industrial design. Protection provided by industrial designs.

Unit II Bioethics

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy. Bioweapons.

Unit III Biosafety

Biosafety and Biosecurity - introduction; historical background; Introduction to biological safety cabinets; primary containment for biohazards; biosafety levels, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts

of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

Text/References:

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy.
New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007).
Snow White Publication Oct.
4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.

MSUMC-391: Applied Bioinformatics Lab credits 3

1 Downloading macromolecular sequences from the NCBI database in different file formats.
2 Creating a non-redundant database of sequences using CD-HIT.
3Identification of relatives from the database using BLAST search. Creation of a data-set on the basis of the E-value.
3 Using EMBOSS for local and global alignment of proteins.
4 Determination of domains present in proteins and comparison of domain architecture (DA) across different proteins.
5 Identification of repeats in proteins using Pfam.
6 Further identification of repeats left undetected by Pfam using multiple sequence analysis.
7 Construction of phylogenetic tree using PHYLIP.

MSUMC-392: Fermentation technology lab

credits 3

1. Isolation and screening of industrially important microorganisms
2. Plot microbial growth kinetics of an industrially important microorganism
3. Identify different parts of a bioreactor and understand their functions
4. Understanding of dissolved oxygen (DO) measurement system of a bioreactor and its calibration.
5. Microbial production of industrially important bioproduct and determine its yield and productivity.

Elective subjects:

1. MSUMC-305A Principles of Ecology Credit: 2

Unit I

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.

Unit II

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.

Unit III

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 Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian

ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Unit IV:

Applied Ecology

Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Text/References:

1. Chapman and Reiss. Ecology: Principles And Applications, 2nd Edition
2. Pd Sharma. Ecology and Environment. 13th edition
3. Eugene Odum. Fundamentals of Ecology.

2. MSUMC-305B Research methodology and Writing Credit:2

Unit I

History of science and science methodologies

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Unit II

Preparation for research

Choosing a mentor, lab and research question; maintaining a lab notebook. Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness. Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions;

Unit III

Scientific communication

Technical writing skills – types of reports; layout of a formal report; scientific writing skills – importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers – peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Text/References:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

3. MSUMC-305C Molecular diagnostics Credit:2

Unit I

Genome: resolution, detection and analysis

PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis.

Unit II

Detection and identity of microbial diseases

Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

Unit III

Detection of inherited diseases

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in the growing number of familial cancer syndromes.

Unit IV

Molecular oncology

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

Text/References:

1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
4. Coleman, W. B., & Tsongalis, G. J. (1997). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

4. MSUMC-305D Enzyme technology Credit:2

Unit I

Enzymes, coenzymes and cofactors

Enzymes: Classification, mode of action, activation, specificity, Source of enzymes; production, isolation and purification of enzymes; Characterization in terms of pH,

temperature, ionic strength, substrate and product tolerance, effects of metal ions; Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate, B12-coenzyme), role of cofactors with specific examples.

Unit II

Enzyme kinetics

Enzyme as biological catalysts; Enzyme action, active site, functional group, enzyme substrate complex, cofactors, Michaelis-Menten equation, Km and Vmax, enzyme inhibition; order of reaction, methods of plotting enzyme kinetics data; Enzyme turnover number. competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half life, activation and deactivation energy etc, Cross-linked enzyme aggregates, Cross linked enzymes, enzyme crystals, their use and preparation; Solution of numerical problems; Energy yielding and energy-requiring reactions; Calculation of equilibrium constants; Activation energy etc.; Multisubstrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects.

Unit III

Applications of enzyme technology

Immobilized enzyme technology: Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors; Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; starch conversion; APA production, biotransformations using soluble as well as immobilized enzymes; Calculation of diffusional resistances and Thiele's modulus, multi-step immobilized enzyme systems; Solution of numerical problems; Application and future of immobilized enzyme technology; Enzyme in organic solvents and ionic liquids: Various organic solvents and ionic liquids used in biocatalysis; Potential in organic solvents and ionic liquids; Applications of enzymes in analysis.

Text/References

1. Stryer, L. (2002). Biochemistry. Freeman. New York.
2. Lehninger, A. L. (2004). Principles of Biochemistry (4th ed.). Worth. New York, NY

3. Voet, D., & Voet, J. G. (2004). Biochemistry (4th ed.). Wiley & Sons. Hoboken, NJ: J

4. Rehm, H. & J. Reed, G., (1986). Enzyme Technology. Volume 7a. John Wiley & Sons.

5. Irwin H. Segel, (1976). Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd revised Ed. John Wiley & Sons.

6. Biotol, (1992). Bioreactor Design & Product Yield. Butterworth-Heinemann

7. Wang, D. I. C. (1979). Fermentation and Enzyme Technology. Wiley. New York.

4. MSUMC-305E Plant Molecular Biology Credit:2

Unit I: Plant tissue culture

Plasticity and Totipotency, The culture environment, Plant Cell culture media, Plant growth regulators and function, Culture types- Callus, Cell-suspension culture, Protoplast culture, Root culture, Shoot tip and Meristem culture, Embryo culture, Somaclonal variation, Somatic Embryogenesis, Polyploidy, Androgenesis, Artificial Seed, Agrobacterium mediated transformation.

Unit II: Plant Transcription Factor

Introduction to Transcription factor structure and function, Methods to study transcription factor structure and function, Different plant specific transcription factors and their functions, Different Plant transcription factors and their functions.

Unit III: Plant Physiology

Molecular mechanism of seed germination, significance of ABA and GA in seed germination, light control on flower development, short day plants and long day plants, ABC model of flowering, plant stress physiology, drought stress, salt stress, biotic stress, viral stress.

Unit IV: Plant Disease

How pathogen attack plants, Mechanism of plant defence against pathogen, Effect of pathogen on plant physiological functions, causative agent of plant disease like virus, fungi, bacteria, nematodes etc.

Semester IV

MSUMC- 481 Project Work Credit 22

Unit 1: Planning & performing Experiments

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project.

Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Unit 2: Thesis Writing

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Minutes of the Meeting of the Department of Biotechnology
Date & Time: December 17, 2020, 12:00 noon thro' Google Meet
https://meet.google.com/asq-inow-kyj?hs=224

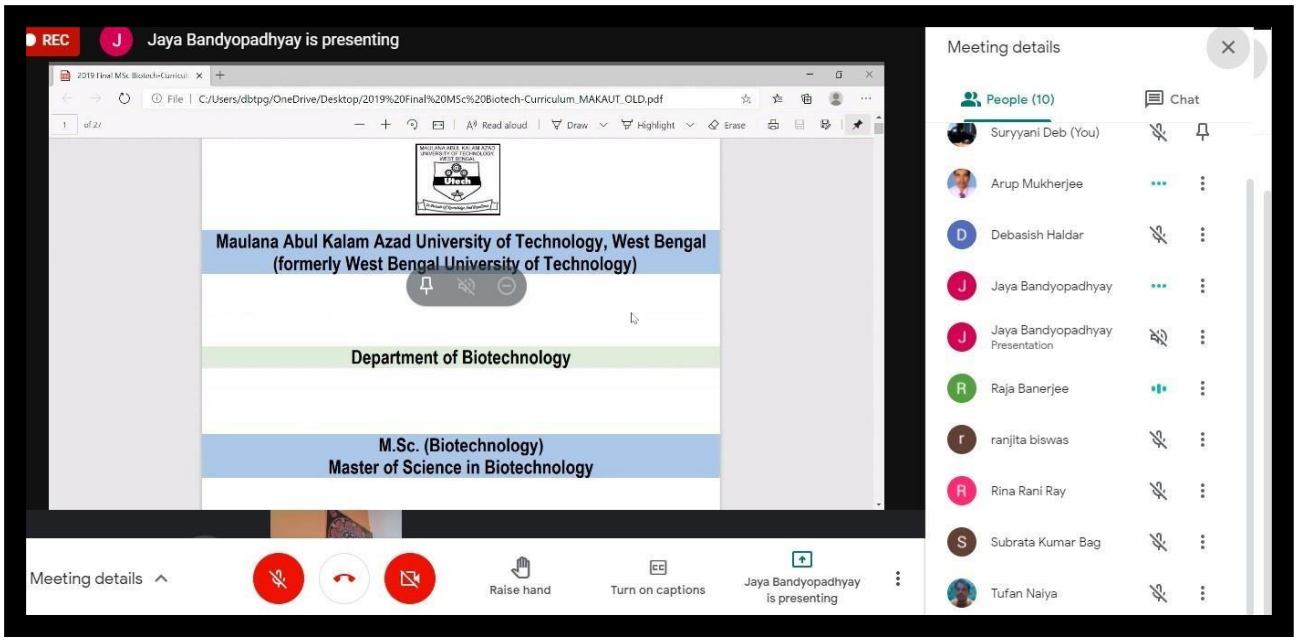
Members present:

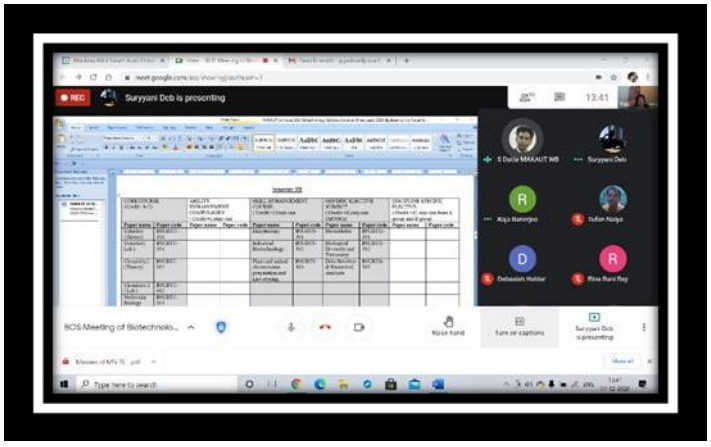
1) **Professor Debasish Haldar, IISERK (External Expert)**
2) **Professor Subrata Bag, WBUAFS, Kalyani (External Expert)**
3) **Dr. Subhashis Datta, COE & Coordinator, BOS**
4) **Dr. Jaya Bandyopadhyay, Head, Dept. of Biotechnology & Convenor**
5) **Prof. Raja Banerjee**
6) **Prof. Arup Mukherjee (Course Coordinator of MTech Biotechnology)**
7) **Dr. Rina Rani Ray**
8) **Dr. Tufan Naiya**
9) **Dr. Debdut Naskar**
10) **Dr. Ranjita Biswas (Course Coordinator of MSc Biotechnology)**
11) **Suryyani Deb (Course Coordinator of BSc Biotechnology)**
12) **Ms. Sayantani Majumder**

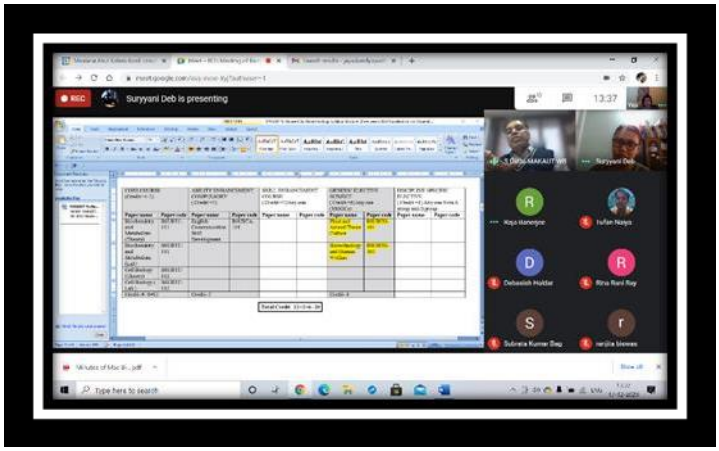
The following points were discussed and noted in the meeting.

1. At the outset the Minutes of the Meeting of December 03, 2019 on MSc Biotechnology syllabus was read out and subsequently confirmed.
2. The **M.Sc Biotechnology syllabus of 2020** was placed before the committee with incorporation of all changes as proposed in the last meeting.
3. That the syllabus has been adopted and modified from the MSc Biotechnology syllabus of DBT (GOI) shall be mentioned at the beginning.
4. The **M.Sc Biotechnology syllabus of 2019** was thereafter placed before the committee for consideration of distribution of the credit points and subjects to make best of the syllabus keeping in mind the credit distribution was slightly uneven compared to the final form of 2020 syllabus. This uneven distribution had to be made in practice as the course was newly introduced in 2019 and the papers had to be adjusted with the ongoing courses to maintain parity.
5. **The total credits of MSc Biotechnology have been revised to 96.**
6. The **MTech Biotechnology syllabus** was placed before the committee. The Elective papers were assigned with proper unique codes following the University norms.
7. That the majority of syllabus has been adopted following guidelines of DBT (GOI) shall henceforth be mentioned at the beginning.
8. The Code of the Elective paper for Sem IV has been rectified and henceforth shall now read as **MUBT- 401 followed by letters as designated for the subjects as per rules.**
9. The **BSc Biotechnology syllabus (Syllabus each of 2019 and 2020)** was placed before the committee by the Course Coordinator Dr. Suryyani Deb.
10. The CBCS structure has been completely adopted for the BSc Biotechnology.
11. Dr. Subhasish Datta (COE) rectified the credit distribution wherever needed and explained the modality of choosing the Generic Elective papers (having a wide coverage of subjects from different disciplines) through MOOCs basket and offline mode of teaching, whichever is convenient to best suit the student's interest.

12. Prof. Subrata Bag and Prof. Debasish Haldar also recommended that the **Elective basket (for all MSc courses; viz Molecular Biology, Microbiology, Genetics, & Biotechnology)** should be such that it should have a wide coverage of subjects from different disciplines keeping abreast the students with new information and also cater to their interest.
13. The committee decided that the recommended practice of MOOCs for Generic Elective shall prevail. However, classes in offline mode are also not ruled out.
14. **The Elective subjects were reviewed and the codes were reincorporated for Molecular Biology, Microbiology, Genetics, & Biotechnology (all M.Sc programs)**.







15. **All the recommendations for BSc (Biotechnology), MSc (Biotechnology, Molecular Biology, Genetics & Microbiology) and MTech (Biotechnology) syllabi were duly approved by the committee.**

The Meeting ended with a vote of Thanks.

Jaya Bandyopadhyay

Dr. Jaya Bandyopadhyay, Head, Biotechnology / December 17, 2020

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TO

The vice Chancellor

MAKAUT WB

date : 30.12.2019

Subject: Requesting approval for M.Tech. Syllabus as finalized in BOS held on 3.12.19

Sir,

Please permit me to bring it up to your notice that a Board of Studies meeting for the M.Tech. Biotechnology program was conducted on the 3rd December 2019 in the computational Biology room, Department of Biotechnology.

Professor S.K. Bag, Professor of Dairy Technology, WBUAFS, Mohonpur and Professor Debasis Halder, Professor of Chemical Sciences, IISERK,Mohonpur were present in the meeting. The syllabus, course code and course structures were finalized on the same day.

Please find enclosed relevant documents and the minutes of the meeting for your approval and necessary notification.

Sincerely Yours

Professor Arup Mukherjee

Course Coordinator

M.Tech. Biotechnology

Minutes of the Board of Studies for M.Tech. Biotechnology, held on 3.12.2019 in the Computation Biology Laboratory, Department of Biotechnology, MAKAUT WB, at 12.30 PM Haringhata, Nadia.

Members present

1. Chairman Professor Saikat Maitra, Vice Chancellor MAKAUT WB

2. External Member Professor S.K. Bag Professor Dairy Engineering, faculty of Dairy Technology, West Bengal University of Animal and Fishery Sciences, Mohonpur, Kolkata- 741252

3. External Member Prof Debasis Halder, Department of Chemical Science, Indian Institute of Science Education and Research Kolkata, Mohanpur-741 246, India

4. External Member Dr. Ambika C Banerjee, Advisor, East India Pharmaceuticals limited, Kolkata

5. Convener and Member, Dr Rina Rani Ray, Head of the Department of Biotechnology, MAKAUT WB 3/12/19

6. Member, Prof. Raja Banerjee, Director, School of Biological Sciences, MAKAUT WB

7. Member Dr Jaya Bandyopadhyay, Department of Biotechnology, MAKAUT WB 3/12/19

8. Member, Dr Ranjita Biswas, Department of Biotechnology, MAKAUT WB 3/12/19

9. Member, Dr Tufan Naiya, Department of Biotechnology, MAKAUT WB 3/12/19

10. Member, Dr Smarajit Das, Department of Biotechnology, MAKAUT WB

11. Member, Dr Debdut Naskar, Department of Biotechnology, MAKAUT WB 3/12/19

12. Member, Dr Suryyani Deb, Department of Biotechnology, MAKAUT WB 3/12/19.

13. Member, Dr Amit Kumar Chakraborty, Department of Biotechnology, MAKAUT WB

14. Professor Arup Mukherjee, Academic Coordinator, Department of Biotechnology, MAKAUT WB

15. Dr. Subhashis Datta, Controller of Examination, MAKAUT WB

1. The M.Tech. Biotechnology program in MAKAUT WB is fully supported by DBT, Govt. of India. The DBT approved syllabus and course structure were placed and discussed. Credit assignments in Bioentrepreneurship ourse appeared anomalous, which was corrected. The course structure, course code and syllabus content were approved.
2. DBT has announced for new course proposals. The Department will apply for M.Tech. program in 1. Pharmaceutical Biotechnology and 2. Environmental Biotechnology. Honourable Vice Chancellor has also consented in that line. The syllabus and course structure to be discussed in next BOS meeting.

Debasish Haldar

Maulana Abul Kalam Azad University of Technology, West Bengal
M. Tech Biotechnology

1st Semester

Code	Course Title	Credit
A	**Theory**	
MUBT-101	Biochemistry	3
MUBT-102	Cell and Molecular Biology	3
MUBT-103	Introduction to Engineering Principles	3
MUBT-104	Microbiology	2
MUBT-105	Plant and Animal Cell Technology	2
MUBT-106	Basics of Mathematics and Statistics	2
MUBT-107	Basics of Chemistry and Physics	2
B	**Practical**	
MUBT-191	Biochemistry & Analytical Techniques Lab	4
MUBT-192	Microbiology Lab	4
Semester Total credit		**25**

2nd Semester

Code	Course Title	Credit
A	**Theory**	
MUBT-201	Genetic Engineering	3
MUBT-202	Immunology	3
MUBT-203	Bioprocess Engineering and Technology	3
MUBT-204	Downstream Processing in Biotechnology	3
MUBT-205	Bioreactor Operations	3
MUBT-206	Computational Biology	3
B	**Practical**	
MUBT-291	Molecular Biology and Genetic Engineering	4
MUBT-292	Immunology	3
Semester Total credit		**25**

3rd Semester

Code	Course Title	Credit
A	**Theory**	
MBT-301	Bioprocess Equipment Design and Economics	3
MBT-302	Bioentrepreneurship	3
MBT-303	Instrumentation and Control	2
MBT-304	Intellectual Property Rights, Biosafety & Bioethics	2
MBT-305	Research Methodology and Scientific Communication Skills	2
MBT-306	Elective	2
B	**Practical**	
MBT-391	Downstream Processing in Biotechnology	2
C		
MBT-381	Project Proposal Preparation and Presentation	2
MBT-382	Dissertation	6
Semester Total Credit		**24**

4th Semester

Code	Course Title	Credit
C		
MBT-481	Dissertation	20
MBT-482	Elective	2
Semester Total Credit		**22**

Total Credit **96**

N.B. Course Codes will be aligned as per University Norms.

Preface

Background

Promotion of Indian Biotechnology sector is high on policy agenda of Government of India. Biotechnology has also been recognized as one of the key priority sectors under 'Make in India', 'Skill India' and 'Startup India' initiatives of Government of India, as it is one of sectors expected to contribute towards enterprise creation, innovation and economic growth. Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India has immensely contributed to this dynamism through various policies and initiatives, establishment of innovation clusters, academia-industry partnerships, increasing capabilities for technology development, etc. The National Biotechnology Development Strategy (2015 – 2020) released by DBT provides a strategic roadmap for India's emergence as a global biotechnology innovation and manufacturing hub. It has also highlighted importance of human resource development and need for nurturing tailor-made human capital for advanced scientific research and entrepreneurship.

DBT has taken a number of initiatives aimed at integrated human resource development to evolve an ecosystem where scientists, innovators and future entrepreneurs can be nurtured. Keeping in mind requirement for trained manpower in various areas of Biotechnology, DBT initiated Post-Graduate Teaching Programme way back in 1985 with 5 universities which has expanded to 74 universities imparting M.Sc./M.Tech./M.V.Sc. degrees in general, agricultural, animal, food, environmental, industrial marine, medical, neuroscience and pharmaceutical biotechnology. 10 programmes are being phased out. These universities and institutes are provided liberal financial support towards strengthening of laboratory facilities, equipment, consumables, fellowships to students, dissertation grant per student etc. Post-Graduate Teaching Programme selects best students and trains them to join research or industry workforce contributing significantly to biotechnology workforce.

About the Course Curriculum Revision Exercise

Taking into cognizance the changing needs of the economy and to keep abreast with latest developments in the field of biotechnology, DBT proactively initiated revision of course curricula of Post-Graduate Programmes in biotechnology. The present exercise has been undertaken by Biotech Consortium India Limited (BCIL), New Delhi. Earlier exercise was carried out in 2008. The Course Curriculum Revision Exercise has been carried out for 13 Post-Graduate programmes in Biotechnology supported by DBT.

The revision of course curriculum of M.Tech. Biotechnology aims to address mismatch between 'knowledge' gained by students and appropriate skill set required for technology development and implementation including present contemporary needs of economy.

Methodology

A meticulous and structured approach has been adopted to accomplish the Course Curriculum Revision exercise.

BCIL had initiated the exercise with a review of literature of relevant national and international documents on curriculum design and planning for biotechnology programmes of premier national as well as international universities, guidelines by University Grants Commission, recent curricular guidelines released by Indian Council of Agricultural Research, Ministry of Health and Family Welfare and Indian Institute of Science Education & Research and other relevant research papers on curriculum development in peer-reviewed journals.

The findings of the literature review were adopted to design questionnaires for eliciting feedback from stakeholders of Biotechnology community i.e. academicians, scientists, industry representatives and students. Feedback was received from 165 experts and 20 students belonging to academic institutions, research organizations and industry regarding addition of advanced topics, deletion of elementary, redundant and overlapping topics, updation of laboratory practicals, re-adjustment of credit load, incorporating 'technology' component in the curriculum, among others. It was also suggested that re-orientation of curricula should be done keeping in view the needs of the industry.

Strategic Approach

A Core Committee along with 9 subject specific subcommittees comprising of 63 academicians, scientists and industry representatives were constituted to revise and update the curricula. The constitution of subject specific subcommittee for M.Tech. Biotechnology is given at Annexure-1.

The salient recommendations identified from stakeholder survey were presented to the Committee. Several brainstorming discussion sessions were held for achieving the desired balance between the foundation courses, recent developments in biotechnology and updation needs identified during the stakeholder survey. Core Committee finalized broad contours for revising all the course curricula. The guidelines set by the Core Committee were taken up by the subject specific subcommittee of M.Tech. Biotechnology for updating the curriculum. The subject specific subcommittee incorporated latest advancements in areas of Biotechnology and Biochemical Engineering in the curriculum. Separate meeting was held to discuss and deliberate the updations to be made in the curriculum. The revised curriculum was vetted and finalized by the Core Committee.

Course Curriculum Revision

The members of Committee agreed that revised course curriculum should provide skill and outcome based education and help the students to gain domain knowledge, ability to design and interpret research experiments and acquire effective communication skills. The course curriculum has been re-designed accordingly to promote skill-based and outcome-based education. The revised course curriculum totals to 96 credits comprising of theory, practical, technology-based topics, electives and dissertation. Each course includes learning objectives, student learning outcomes, course plan (number of lectures/ unit) and reference textbooks/resources. Theory and practical courses include relevant examples, case scenarios and tutorials for inculcating critical thinking against rote learning. Several new courses have been included and content for existing courses has also been updated. Specialized courses such as Bioprocess Engineering and Technology, Downstream Processing in Biotechnology, Bioreactor Operations, Bioprocess Equipment Design and Economics and Instrumentation and Control have been introduced to give more focus in the revised curriculum. With importance of students being able to execute research projects independently, separate credits have been allotted for proposal preparation and presentation before initiating dissertation and also credits for dissertation have been increased accordingly.

We hope that model course curriculum shall serve as guidelines for academicians and researchers from different parts of the country for adoption in their institutions with modifications as per availability of expertise, infrastructure and specific needs.

We wish to put on record our sincere appreciation for constant guidance and encouragement received from Dr. K. VijayRaghavan, Secretary, DBT for bringing out this publication. We wish to acknowledge whole-hearted support of Core Committee and subject specific subcommittees members. Sincere thanks are due to Dr. Manoj Singh Rohilla, Scientist- D, DBT, Ms. Shweta for creative design, Mrs. Rita Bhatla, DBT and Shri. Dilip Joy, BCIL.

M.Tech. Biotechnology

S.No.	Title		Credits
	SEMESTER ONE		
1	Biochemistry		3
2	Cell and Molecular Biology		3
3	Introduction to Engineering Principles		3
4	Microbiology		2
5	Plant and Animal Cell Technology		2
6	Basics of Mathematics and Statistics		2
7	Basics of Chemistry and Physics		2
8	Laboratory I: Biochemistry and Analytical Techniques		4
9	Laboratory II: Microbiology		4
		TOTAL	25
	SEMESTER TWO		
1	Genetic Engineering		3
2	Immunology		3
3	Bioprocess Engineering and Technology		3
4	Downstream Processing in Biotechnology		3
5	Bioreactor Operations		3
6	Computational Biology		3
7	Laboratory III: Molecular Biology and Genetic Engineering		4
8	Laboratory IV: Immunology		3
		TOTAL	25
	SEMESTER THREE		
1	Bioprocess Equipment Design and Economics		3
2	Bioentrepreneurship		3
3	Instrumentation and Control		2
4	Research Methodology and Scientific Communication Skills		2
5	Intellectual Property Rights, Biosafety and Bioethics		2
6	Project Proposal Preparation and Presentation		2
7	Laboratory V: Downstream Processing in Biotechnology		2
8	Dissertation		6
9	Elective		2
		TOTAL	24
	SEMESTER FOUR		
1	Dissertation		20
2	Elective		2
		TOTAL	22
		TOTAL CREDITS	96

Recommended Electives:
1. Bioreaction Engineering | 2. Computational Programming | 3. Environmental Biotechnology | 4. Enzyme Engineering and Technology | 5. Metabolic and Systems Biology | 6. Medical Devices | 7. Molecular Diagnostics | 8. Nanobiotechnology | 9. Production of Biotherapeutics | 10. OMICS Technologies

Semester One

Biochemistry

Credits

3

Course Objectives

The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

Student Learning Outcomes

On completion of this course, students should be able to:

- Gain fundamental knowledge in biochemistry;
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Unit I
Protein structure
7 lectures

Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*, basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit II
Enzyme kinetics
6 lectures

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit III
Glycobiology
2 lectures

Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules-glycoproteins and glycolipids; lipids- structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit IV
Structure and functions of DNA, RNA and Lipids
3 lectures

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit V
Bio-energetics
8 lectures

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources

of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F_1-F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.

Unit VI
Role of vitamins & cofactors in metabolism
12 lectures

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism, entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; TOR (target of rapamycin) & autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.

Recommended Textbooks and References:

1. Stryer, L. (2015). *Biochemistry*. (8th ed.) New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Cell and Molecular Biology

Credits
3

Course Objectives

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.

Student Learning Outcomes

Student should be equipped to understand three fundamental aspects in biological phenomena: a) what to seek; b) how to seek; c) why to seek?

Unit I
Dynamic organization of cell
6 lectures

Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit II
Chromatin structure and dynamics
12 lectures

Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, trancriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through

	interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code.
Unit III **Cellular signalling, transport and trafficking** 3 lectures	Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.
Unit IV **Cellular processes** 8 lectures	Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.
Unit V **Manipulating and studying cells** 3 lectures	Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.
Unit V **Genome instability and cell transformation** 8 lectures	Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

Recommended Textbooks and References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). *Molecular Biology of the Cell*. New York: Garland Science.
2. Lodish, H. F. (2000). *Molecular Cell Biology*. New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2009). *The Cell: a Molecular Approach*. Washington: ASM; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell*. Boston: Benjamin Cummings.
6. Watson, J. D. (1987). *Molecular Biology of the Gene* (7th ed.). Menlo Park, CA: Benjamin/Cummings.

Introduction to Engineering Principles

Credits

3

Course Objectives

The objectives of this course are to provide an introduction to the essentials of material and energy balances, properties of materials and transport phenomena.

Student Learning Outcomes

Students should be able to execute material and energy balances over a variety of biochemical systems and model systems which simultaneously involve momentum, heat and mass transport.

Unit I **Energy and material balances** 6 lectures	Unit operations and unit processes: historical and recent developments in chemical engineering; Process variables and degrees of freedom; Differential and integral balances; Lumped and distributed balances; Balances in systems involving physical changes.
Unit II **Steady state energy and material balances** 8 lectures	Balances in reacting systems; Balances in systems involving recycle, purge and bypass; Computer aided calculations; Generalization to unsteady state balances.
Unit III **Properties of substances** 6 lectures	Single component and multicomponent systems; Single and multiphase systems.
Unit IV **Introduction to transport phenomena: momentum transfer** 10 lectures	Viscosity; Molecular theory of Gases and Liquids; Shell balance: Falling film, Circular tube; Equations of Change for isothermal systems: Continuity, Motion, Energy, Substantial derivatives; Unidirectional flows: Pipe flow, Variable viscosity falling film, Couette viscometer, Rotating Sphere; Unsteady flows: Startup Plate flow, Parallel plates *etc.*
Unit V **Introduction to transport phenomena: heat and mass transfer** 10 lectures	Thermal conductivity and mechanism of energy transport; Shell energy balances and temperature distributions in solids and laminar flow; Diffusivity and the mechanisms of mass transport; Concentration distributions in solids and laminar flow; Equations of change for multicomponent systems; Introduction to the concept of heat and mass transfer coefficients; Dimensional Analysis (Buckingham Pi theorem).

Recommended Textbooks and References:

1. R.M. Felder and R.W. Rousseau, (2015) *Elementary Principles of Chemical Processes*, 4th Edition, J. Wiley, New York.
2. D.M.Himmelblau, (2003), *Basic Principles and Calculations in Chemical Engineering*, 7th Edition, Prentice Hall of India. New Delhi.
3. B.I. Bhatt and S.M.Vora, (1996)., *Stoichiometry*, 3rd Edition, Tata McGraw Hill. New Delhi.
4. R. B. Bird *et al.*, (2006), *Transport Phenomena*, 2nd Edition, Wiley

Microbiology

Credits

2

Course Objectives

The objectives of this course are to introduce students to the field of microbiology with emphasis on microbial diversity, morphology , physiology and nutrition, methods for control of microbes and host- microbe interactions.

Student Learning Outcomes

On completion of this course, students should be able to:

- Identify the major categories of microorganisms and understand their classification, diversity, and ubiquity;
- Describe the structural, physiological, and genetic similarities and differences of the major categories of microorganisms;
- Demonstrate how to control microbial growth;
- Evaluate the interactions between microbes, hosts and environment.

Unit I **Microbial characteristics** 6 lectures	Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance, drug resistance.
Unit II **Microbial diversity** 5 lectures	Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma; Archaea: Halophiles, Methanogens, Hyperthermophilic archaea, Thermoplasm; Eukaryotes: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes, introduction to metagenomics.
Unit III **Control of microorganisms** 3 lectures	Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.
Unit IV **Virology** 5 lectures	Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.
Unit V **Interaction of microbes with its environment** 6 lectures	Host-pathogen interaction, ecological impacts of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; biofilms, bacterial quorum sensing; microbial fuel cells.

Recommended Textbooks and References:

1. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) *Prescott's Microbiology*, McGraw Hill.
2. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) *Microbiology by Pelczar*. McGraw Hill.
3. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); *Microbiology by Tortora*. Pearson Education.

Plant and Animal Cell Culture Technology

Credits

2

Course Objectives

The objectives of this course is to educate students about the fundamental concepts of animal and plant cell system, bioprocess technology using eukaryotic system and their related applications, thus, preparing them to meet challenges of new and emerging areas of biotechnology industry.

Student Learning Outcomes

Student should be able to gain strong understanding of plant and animal based cell cultures system. This will help them to take up animal/plant based biological research as well as placement in relevant biotech industry. They will be able to analyse bioprocess from an economics/ market point of view.

Unit I **Animal cell culture** 15 lectures	Animal cell culture; media composition and growth conditions; Animal cell and tissue preservation; Anchorage and non-anchorage dependent cell culture; Primary and secondary culture; Animal cell growth characteristics and kinetics; Micro & macro-carrier culture; Hybridoma technology; Stem cell technology; Transgenic animals; Animal cloning; Mechanisms of drug resistance and cell death.

Unit II
Plant cell culture
15 lectures

Totipotency; Plant growth regulators; Regeneration and micropropagation of plants: clonal propagation, organogenesis, shoot-tip and meristem culture, haploid culture, triploid culture, protoplast culture; Somaclonal variation; Tissue culture and Cell suspension culture system: methodology, growth kinetics and nutrient optimization; Precursors and elicitors; Plant Transformation methods (emphasis on *Agrobacterium* mediated transformation); Hairy root culture; Plant products of industrial importance, Production of secondary metabolites.

Unit III
Secondary metabolite production
10 lectures

Principles, design and operation of bioreactors: specific design criteria for mammalian and plant systems; Strategies for fermentation with recombinant organisms; Isolation, characterization and production of secondary metabolites from different plant cell types; Bioprocess monitoring and control: current practices in the bioprocess industries, advanced methodologies; Overview of downstream processing: centrifugation, filtration and chromatographic techniques.

Recommended Textbooks and References:

1. Butterworth Heinemann Ltd., (1994) Biotol Series, *In vitro Cultivation of Plant cell.*
2. Bhojwani S.S. and Razdan M.K. (1996) *Plant Tissue Culture: Theory and Practice*, a Revised Edition, Elsevier Science
3. T. A. Brown, (2001) *Gene Cloning and DNA Analysis: an Introduction*, Blackwell Science.
4. M. L Shuler and F. Kargi. (2002), *Bioprocess Engineering*, Prentice Hall Inc.
5. A. Slater, N. Scott and M. Fowler (2003), *Plant Biotechnology: the Genetic Manipulation of Plants*, Oxford University Press.
6. M. M. Ranga (2007), *Animal Biotechnology*, 3rd Revised Edition, Agrobios
7. Freshney. (2016) Culture of Animal Cells.
8. Meyer, Handschel, Wiesmann (2009). *Fundamentals of Tissue Engineering and Regenerative Medicine.*
9. Selected Papers from Scientific Journals, particularly Nature & Science

Basics of Mathematics and Statistics

Credits
2

Course Objectives

The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to students.

Student Learning Outcomes

On completion of this course, students should be able to:

- Gain broad understanding in mathematics and statistics;
- Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

Unit I
Algebra
6 lectures

Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models *etc.*), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.

Unit II
Calculus
4 lectures

Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series *etc.*)

Unit III
Mathematical models in biology
3 lectures

Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

Unit IV
Statistics
5 lectures

Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Recommended Textbooks and References:

1. Stroud, K. A., & Booth, D. J. (2009). *Foundation Mathematics*. New York, NY: Palgrave Macmillan.
2. Aitken, M., Broadhursts, B., & Haldky, S. (2009) *Mathematics for Biological Scientists*. Garland Science.
3. Billingsley, P. (1986). *Probability and Measure*. New York: Wiley.
4. Rosner, B. (2000). *Fundamentals of Biostatistics*. Boston, MA: Duxbury Press.
5. Daniel, W. W. (1987). *Biostatistics, a Foundation for Analysis in the Health Sciences*. New York: Wiley.

Basics of Chemistry and Physics

Credits
2

Course Objectives

The objectives of this course are to cover all essentials required to appreciate physico-chemical principles underlying biological processes.

Student Learning Outcomes

Students should be able to have a firm foundation in fundamentals and application of current chemical and physical scientific theories.

Unit I
Basic physics for biologists
12 lectures: 10 hrs teaching + 2 hrs tutorials

Physical quantities and their dynamics: definitions and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque *etc.* force, power, work, energy (kinetic & potential/electric charge separation, electromagnetic spectrum, photons *etc.*); springs & Hookes laws; elastic and inelastic collisions; Newton's law of motions (centripetal and centrifugal forces *etc.*); simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP); Coulomb's law, conductors and insulators, electric potential energy of charges, nerve impulses, voltage gated channels, ionic conductance; Ohms law (basic electrical quantities: current, voltage & power), electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology *i.e.* enzymes, allostery and molecular motors (molecules to cells and organisms).

Unit II
Basic chemistry for biologists

Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers, basics of mass spectrometry, molecules, Avogadro number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomic

2 lectures: 10 hrs teaching + 2 hrs tutorials

ions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate-determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action etc; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

Recommended Textbooks and References:

1. Baaquie, B. E. (2000). *Laws of Physics: a Primer.* Singapore: National University of Singapore.
2. Matthews, C. P., & Shearer, J. S. (1897). *Problems and Questions in Physics.* New York: Macmillan Company.
3. Halliday, D., Resnick, R., & Walker, J. (1993). *Fundamentals of Physics.* New York: Wiley.
4. Ebbing, D. D., & Wrighton, M. S. (1990). *General Chemistry.* Boston: Houghton Mifflin.
5. Averill, B., & Eldredge, P. (2007). *Chemistry: Principles, Patterns, and Applications.* San Francisco: Benjamin Cummings.
6. Mahan, B. H. (1965). *University Chemistry.* Reading, MA: Addison-Wesley Pub.
7. Cantor, C. R., & Schimmel, P. R. (2004). *Biophysical Chemistry.* San Francisco: W.H. Freeman.

Laboratory I: Biochemistry & Analytical Techniques

Credits

4

Course Objectives

The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach utility of experimental methods in biochemistry in a problem oriented manner.

Student Learning Outcomes

Students should be able to:

- Elaborate concepts of biochemistry with simple experiments;
- Understand principle and working of basic laboratory instruments.

Syllabus

1. Estimation of sugars – Reducing and non-reducing sugars.
2. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.

3. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of institution's choice).
   a. Preparation of cell-free lysates
   b. Ammonium Sulfate precipitation
   c. Ion-exchange Chromatography
   d. Gel Filtration
   e. Affinity Chromatography
   f. Generating a Purification Table (protein concentration, amount of total protein)
   g. Computing specific activity of the enzyme preparation at each stage of purification
   h. Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
   i. Enzyme Kinetic Parameters: Km, Vmax and Kcat.
   j. Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
4. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools.
5. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

Laboratory II: Microbiology

Credits

4

Course Objectives

The objective of this laboratory course is to provide practical skills in basic microbiological techniques.

Student Learning Outcomes

On completion of this laboratory course, students should be able to:

- Isolate, characterize and identify common bacterial organisms;
- Determine bacterial load of different samples;
- Perform antimicrobial sensitivity test;
- Preserve bacterial cultures.

Syllabus

Basic techniques

1. Sterilization, disinfection and safety in microbiological laboratory, good laboratory practices
2. Preparation of media for cultivation of bacteria, liquid and agar.

Syllabus

Culture techniques

1. Spread plate method
2. Pour plate method
3. Streaking
4. Bacterial growth curve
5. Bacterial plate count method
6. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.

Syllabus

Staining techniques

1. Preparation of bacterial smear and Gram's staining
2. Acid fast staining
3. Endospore staining
4. Capsule staining
5. Negative staining
6. Flagellar staining.

Syllabus

Microscopy-related techniques

1. Bright field light microscopy
2. Hanging drop slide preparation
3. Motility of bacteria
4. Dark field light microscopy
5. Phase contrast microscopy
6. Fluorescence microscopy.

Syllabus

Biochemical and antibiotic tests

1. MR test
2. VP test
3. Sucrose fermentation
4. Lactose fermentation
5. Indole test
6. Antimicrobial sensitivity test and demonstration of drug resistance
7. Zone of clearance, zone of inhibition.

Syllabus

Environmental factors

1. Effect of pH and temperature on microbial growth
2. Determination of phenol co-efficient of antimicrobial agents
3. Determination of Minimum Inhibitory Concentration (MIC)
4. Isolation and identification of bacteria from soil/water samples.

Recommended Textbooks and References:

1. Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual.* Benjamin -Cummings Publishing Company.
2. LM Prescott, JP Harley, DA Klein, (2002), *Laboratory Exercises in Microbiology.*

Semester Two

Genetic Engineering

Credits

3

Course Objectives

The objectives of this course are to teach various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of principles of molecular biology and this is reflected in contents of this course.

Student Learning Outcomes

Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with practicals in molecular biology and genetic engineering, students should be able to take up biological research as well as placement in relevant biotech industry.

Unit I

Introduction and tools for genetic engineering

6 lectures

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes; hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

Unit II

Different types of vectors

7 lectures

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression: expression vectors, pMal, GST, pET-based vectors; Protein purification: His-tag; GST-tag; MBP-tag *etc.*

Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

Unit III
Different types of PCR techniques
7 lectures

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; TA cloning vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit IV
cDNA analysis
7 lectures

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNaseI footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit V
Gene silencing and genome editing technologies
13 lectures

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

Recommended Textbooks and References:

1. Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub
2. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), *Principles of Gene Manipulation and Genomics*, Blackwell Publishing Limited; 7th Edition
3. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Selected Papers from Scientific Journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab *etc.*

Immunology

Credits

3

Course Objectives

The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Student Learning Outcomes

On completion of this course, students should be able to:

- Evaluate usefulness of immunology in different pharmaceutical companies;
- Identify proper research lab working in area of their own interests;
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Unit I **Immunology: fundamental concepts and anatomy of the immune system** 5 lectures	Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility.
Unit II **Immune responses generated by B and T lymphocytes** 8 lectures	Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.
Unit III **Antigen-antibody interactions** 6 lectures	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.
Unit IV **Vaccinology** 8 lectures	Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.
Unit V **Clinical immunology** 8 lectures	Immunity to infection: bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.
Unit VI **Immunogenetics** 5 lectures	Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Recommended Textbooks and References:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology*. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology*. New York: Garland Science.
4. Paul, W. E. (1993). *Fundamental Immunology*. New York: Raven Press.
5. Goding, J. W. (1986). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology*. London: Academic Press.
6. Parham, P. (2005). *The Immune System*. New York: Garland Science.

Bioprocess Engineering & Technology

Credits

3

Course Objectives

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Student Learning Outcomes

Students should be able to:

- Appreciate relevance of microorganisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;
- Calculate yield and production rates in a biological production process, and also interpret data;
- Calculate the need for oxygen and oxygen transfer in a bioproduction process;
- Critically analyze any bioprocess from an economics/market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Unit I

Basic principles of biochemical engineering

4 lectures

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit II

Stoichiometry and models of microbial growth

6 lectures

Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth, MATLAB basics for modelling and solving the equations.

Unit III

Bioreactor design and analysis

8 lectures

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation *vs* biotransformations; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit IV
Downstream processing and process economics
4 lectures

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

Unit V
Applications of enzyme technology in food processing
4 lectures

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucose oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

Unit VI
Applications of microbial technology in food processing and biorefineries
4 lectures

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria: production and applications in food preservation; biofuels and biorefinery; production of antibiotics in a reactor; single cell protein; probiotics and prebiotics.

Unit VII
Applications of biotechnology in production of biologicals
12 lectures

Industrial production of penicillin via fungal route, insulin from recombinant E. coli; Production of metabolites such as shikonin using plant cell culture, astaxanthin from algae, and biotransformation routes for novel/specialty chemicals; Production of HBsAg using yeast cultures, erythropoietin using CHO cells, monoclonal antibodies such as Humira using mammalian cells.

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (1997). *Principles of Fermentation Technology.* Oxford: Pergamon Press.
3. Pauline Doran (1995) *Bioprocess Engineering Principles.* Elsevier Science & Technology Books
4. Mansi EMTEL, Bryce CFA. *Fermentation Microbiology and Biotechnology,* 2nd Edition, Taylor & Francis Ltd, UK, 2007
5. Harrison, R.G., Todd, P., Rudge, S.R., and Petrides, D.P. (2015). *Bioseparations Science and Engineering.* 2nd Edition. Oxford University Press.)

Downstream Processing in Biotechnology

Credits

3

Course Objectives

The objective of this course is to provide an overview of various aspects of recovery and processing of biological products.

Student Learning Outcomes

Students should be able to identify and design relevant unit operations for recovery of a biological product.

edits 3	bioreactors for microbial, animal and plant cell processes. It covers mechanical design considerations for various kinds of bioreactors.
Unit I **Introduction to bioreactor design** 3 lectures	Introduction; General design information; Material and energy balance calculations; Process Flow.
Unit II **Scale up and scale down processes** 12 lectures	Scale up and scale down issues: Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply; Bioreactor scale-up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients. Scale-up of downstream processes: Adsorption (LUB method); Chromatography (constant resolution *etc.*); Filtration (constant resistance *etc.*); Centrifugation (equivalent times *etc.*); Extractors (geometry based rules). Scale-down related aspects.
Unit III **Bioreactor equipment** 11 lectures	Selection of bioprocess equipment (upstream and downstream); Specifications of bioprocess equipment; Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment; Piping and instrumentation; Materials of construction for bioprocess plants.
Unit IV **Basic bioreactor operations** 8 lectures	Spectrum of basic bioreactor operations: immobilized cell system, animal cells, plant cell cultures and waste management; Enzyme immobilization techniques; Bioconversion using immobilized enzyme preparation; Bioconversion in batch, Fed-batch and continuous bioreactors; Mass transfer in immobilized cell/enzyme reactor.
Unit V **Bioreactor facility design** 6 lectures	Facility design aspects; Utility supply aspects; Equipment cleaning aspects; Culture cell banks; cGMP guidelines; Validation; Safety; Process economics; Case studies.

Recommended Textbooks and References:

1. Roger Harrison *et al.*, (2003), *Bioseparations Science and Engineering*, Oxford University Press.
2. Michael Shuler and Fikret Kargi, (2002), *Bioprocess Engineering: Basic Concepts*, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ.
3. Michael R. Ladisch, (2001), *Bioseparations Engineering: Principles, Practice and Economics*, 1st Edition, Wiley.
4. M. V. Joshi and V.V.Mahajani., (2000). *Process Equipment Design*, 3rd Edition, Macmillan India Ltd
5. Robert H. Perry and Don W. Green (eds.), (1997), *Perry's Chemical Engineers' Handbook*, 7th Edition, McGraw Hill Book Co.
6. Max S. Peters and Klaus, D. Timmerhaus, (1991). *Plant Design and Economics for Chemical Engineers*, 4th Edition, McGrawHill Book Co.
7. J. Bailey and D.Ollis, (1986), *Biochemical Engineering Fundamentals*; McGraw Hill.
8. Relevant articles from Bioprocess Journals.

Computational Biology

Credits

3

Course Objectives

The objective of this course is to provide students with theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.

Student Learning Outcomes

On completion of this course, the students are expected to:

- Develop an understanding of the basic theory of these computational tools;
- Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;
- Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;
- Critically analyze and interpret results of their study with respect to whole systems.

Unit I

Introduction to computational biology basics and biological databases

4 lectures

Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.

Unit II

Pairwise and multiple sequence alignments

5 lectures

Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

Unit III

Genome analysis

6 lectures

Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.

Unit IV

Structure visualization

3 lectures

Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD. , RAS MOL

Unit V

Molecular modelling

6 lectures

Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: *ab initio*, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein Interactions.

Unit VI
Structure-based drug development
6 lectures

Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra-precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.

Unit VII
Ligand-based drug development
6 lectures

Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.

Recommended Textbooks and References:

1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.
3. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education.
5. Oprea, T. (2005). *Chemoinformatics in Drug Discovery*, Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), *Chemoinformatics: a Textbook*, Wiley Online Library.

Laboratory III: Techniques in Molecular Biology and Genetic Engineering

Credits

4

Course Objectives

The objectives of this course are to provide students with the experimental knowledge of molecular biology and genetic engineering.

Student Learning Outcomes

Students should be able to gain hands-on experience on gene cloning, protein expression and purification. This experience would enable them to begin a career in industry.

Syllabus

1. Concept of lac-operon:
   a. lactose induction of β-galactosidase.
   b. Glucose Repression.
   c. Diauxic growth curve of *E. coli*.
2. UV mutagenesis to isolate amino acid auxotroph.
3. Phage titre with λ phage/M13.
4. Genetic Transfer-Conjugation, gene mapping.
5. Plasmid DNA isolation and DNA quantitation.
6. Restriction Enzyme digestion of plasmid DNA.
7. Agarose gel electrophoresis.
8. Polymerase Chain reaction.
9. DNA Ligation.

10. Preparation of competent cells.
11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency.
12. Confirmation of the insert, Miniprep of recombinant plasmid DNA, Restriction mapping.
13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis
14. Purification of His-Tagged protein on Ni-NTA columns
    a. Random Primer labeling
    b. Southern hybridization.

Laboratory IV: Immunology

Credits

Course Objectives

The objectives of this laboratory course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells *etc.* and how they can be used in respective research work.

Student Learning Outcomes

On completion of this course, students should be able to:

- Evaluate the usefulness of immunology in different pharmaceutical companies;
- Identify proper research lab working in the area of their own interests;
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.

Syllabus

1. Handling of animals like rabbits, mice.
2. Preparation of antigens, immunization and methods of blood collection, serum separation and storage.
3. Antibody titre by ELISA method.
4. Double diffusion, Immunoelectrophoresis and Radial Immuno diffusion.
5. Complement fixation test.
6. Isolation and purification of IgG from serum or IgY from chicken egg.
7. SDS-PAGE, Immunoblotting, Dot blot assays.
8. Blood smear identification of leucocytes by Giemsa stain.
9. Culture of Hela/J774 cells and phagocytosis.
10. Separation of mononuclear cells by Ficoll-Hypaque.
11. Differential leucocyte count under a microscope.
12. Cryopreservation of cells.

Semester Three

Bioprocess Equipment Design and Economics

Credits

3

Course Objectives

This is an introductory course to aspects of equipment design and process economics and follows coursework on reactor design and downstream processing.

Student Learning Outcomes

Students should be able to become proficient in applying basic design principles towards implementing bioprocess manufacturing systems.

Unit I **Introduction** 4 lectures	Mechanical design of process equipment: pressure vessels, process piping design; Materials and Fabrication Selection.
Unit II **Economics** 10 lectures	Design Strategy and Optimum Equipment Design: Economic Design criteria; Cost and Asset Accounting; Cost Estimation; Interest and Investment Costs; Taxes and Insurance; Depreciation; Profitability, Alternative Investments and Replacement.
Unit III **Case studies** 14 lectures	Case Study in Process Equipment Design and Costing of Equipment in each of the following categories: Material Transfer, Handling and Treatment Equipment.
Unit IV **Heat transfer equipment** 7 lectures	Shell and tube heat exchangers (Kern and Bell-Delaware design methods), Plate heat exchangers, Evaporators. ; TGA, DSC.
Unit V **Mass transfer equipment** 7 lectures	Absorption/ Stripping columns (packed/tray), Multicomponent distillation column (Fenske-Underwood-Gilliland correlations).
Unit VI **Reaction equipment** 7 lectures	Choice of reactors, non-isothermal reactors, reactor configuration, interstage heating/ cooling, multi-tubular reactors, catalyst deactivation.

Recommended Textbooks and References:

1. M.S. Peters and K.D. Timmerhaus, (1991), *Plant Design and Economics for Chemical Engineers*, McGraw Hill.
2. D.F. Rudd and C.C. Watson, (1969), *Strategy of Process Engineering*, John Wiley.
3. F.C. Jelen and J.H. Black., (1992), *Cost and Optimization Engineering*. 3rd ed, McGraw Hill.
4. Harrison, R.G., Todd, P., Rudge, S.R., and Petrides, D.P. (2015). *Bioseparations Science and Engineering*. 2nd Edition. Oxford University Press.
5. M.V. Joshi, (1976), *Process Equipment Design*, McMillan India, New Delhi.
6. R.K. Sinnot, (1989), *An Introduction to Chemical Engineering Design*,

Pergamon Press, Oxford.
7. R. Smith, (1995), *Chemical Process Design*, McGraw Hill.

Bioentrepreneurship

Credits

2

Course Objectives

Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Student Learning Outcomes

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

Unit I

Innovation and entrepreneurship in bio-business

8 lectures

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II

Bio markets: business strategy and marketing

8 lectures

Negotiating the road from lab to the market (strategies and processes of negotiation with financers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III

Finance and accounting

8 lectures

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV

Technology management

8 lectures

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Recommended Textbooks and References:

1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.

2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. (n.d.). *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.
4. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.
5. Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

Instrumentation and Control

Credits

3

Course Objectives

This is an introductory course to aspects of process control and instrumentation.

Student Learning Outcomes

Students should be able to become proficient in applying the fundamental concepts of process control towards the modeling and control of practical processes.

Unit I **Introduction** 4 lectures	Essentials of mathematical models and modeling considerations.
Unit II **Dynamic processes** 10 lectures	Linearization of non-linear systems; Laplace transforms; Transfer functions and input-output models; Analysis of first, second, and higher-order systems.
Unit III **Feedback control** 10 lectures	Dynamics of feedback-controlled processes; Stability analysis; Controller design; Frequency response analysis and its application.
Unit IV **Advanced control schemes** 7 lectures	Dead time or inverse response systems; Systems with multiple loops; Feedforward and ratio control.
Unit V **Instrumentation** 7 lectures	Devices for measurement of flow, temperature, pH, pressure and liquid level.

Recommended Textbooks and References:

1. D.E. Seborg, T.F. Edgar, D. A. Mellichamp. (2004), *Process Dynamics and Control*, 2nd ed, John Wiley and Sons.
2. B.W. Bequette, (2003), *Process Control: Modeling, Design and Simulation*, Prentice Hall, New Delhi.
3. W.L. Luyben, (1990). *Process Modeling Simulation and Control for Chemical Engineers*, 2nd ed., McGraw Hill.
4. G. Stephanopoulos, (1984), *Chemical Process Control: an Introduction to Theory and Practice*, Prentice Hall, New Delhi.

5. Smith, C.A. and Corripio, A.B. (1997). *Principles and Practice of Automatic Process Control*, Wiley, New York.
6. Johnson, C.D. (2006). *Process Control Instrumentation Technology*, Prentice-Hall, New Delhi

Research Methodology and Scientific Communication Skills

Credits

3

Course Objectives

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Student Learning Outcomes

Students should be able to:

- Understand history and methodologies of scientific research, applying these to recent published papers;
- Understand and practice scientific reading, writing and presentations;
- Appreciate scientific ethics through case studies.

Unit I
History of science and science methodologies
8 lectures

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist *vs* holistic biology.

Unit II
Preparation for research
2 lectures

Choosing a mentor, lab and research question; maintaining a lab notebook.

Unit III
Process of communication
5 lectures

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit IV
Scientific communication
9 lectures

Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Recommended Textbooks and References:

1. Valiela, I. (2001). *Doing Science: Design, Analysis, and Communication of Scientific Research.* Oxford: Oxford University Press.
2. *On Being a Scientist: a Guide to Responsible Conduct in Research.* (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. *The Science of Scientific Writing.* American Scientist, 78(Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). *Speaking English Effectively.* Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

Intellectual Property Rights, Biosafety and Bioethics

Credits

3

Course Objectives

The objectives of this course are:

- To provide basic knowledge on intellectual property rights and their implications in biological research and product development;
- To become familiar with India's IPR Policy;
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;
- To become familiar with ethical issues in biological research.

Student Learning Outcomes

On completion of this course, students should be able to:

- Understand the rationale for and against IPR and especially patents;
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
- Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Unit I
Introduction to IPR
5 lectures

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit II
Patenting
5 lectures

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples;

	commercialization of patented innovations; licensing – outright sale, licensing, royalty, patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.
Unit III **Biosafety** 5 lectures	Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.
Unit IV **National and international regulations** 5 lectures	International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).
Unit V **Bioethics** 5 lectures	Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Recommended Textbooks and References:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. New Delhi: Tata McGraw-Hill Pub.
2. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies*, MIT Press
7. World Trade Organisation. http://www.wto.org
8. World Intellectual Property Organisation. http://www.wipo.int
9. International Union for the Protection of New Varieties of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org
12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf
13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). *Problem Formulation in theEnvironmental Risk Assessment for Genetically*

Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). *An Overview of General Features of Risk Assessments of Genetically Modified Crops*. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8
15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
16. Guidelines and Standard Operating procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/ guidelines1.asp
17. Alonso, G. M. (2013). *Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments*. Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

Project Proposal Preparation & Presentation

Credits

2

Course Objectives

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes

Students should be able to demonstrate the following abilities:

- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal;
- Learn how to present and explain their research findings to the audience effectively.

Syllabus - Project Proposal Preparation

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.
Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Syllabus Poster Presentation

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

Syllabus Oral Presentation

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

Laboratory V: Downstream Processing in Biotechnology

Credits

Course Objectives

The objectives of this course are to provide students with hands on knowledge of primary unit operations involved in downstream processing.

Student Learning Outcomes

Students should be able to gain hands-on experience on approaches to cell disruption, centrifugation, filtration, and precipitation.

Syllabus

1. Conventional filtration
2. Centrifugation in batch and continuous centrifuges
3. Cell disruption
4. Protein precipitation and its recovery
5. Ion-exchange chromatography
6. Membrane based filtration-ultra filtration in cross flow modules and micro filtration
7. Adsorption in batch and continuous mode.

Recommended Textbooks and References:

1. Desai, M. (2000) *Downstream Processing of Proteins: Methods and Protocols*, Humana Press.

Semester Four

Dissertation

Credits

(Semester III: 6 Credits; Semester IV: 20 Credits)

Course Objectives

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

Student Learning Outcomes

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
- Ability to conduct research independently.
- Ability to perform analytical

techniques/experimental methods.
- Project management skills.
- Report writing skills.
- Problem solving skills.
- Communication and interpersonal skills.

Syllabus
Planning & performing experiments

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

Syllabus
Thesis writing

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Recommended Electives

Bioreaction Engineering

Credits

2

Course Objectives

This course aims to introduce bioreaction engineering principles to students.

Student Learning Outcomes

On completion of this course, students should be able to understand:
- Growth kinetics of cell cultures;
- Basic stoichiometry of bioreactions;
- Thermodynamic aspects of bioreactions;
- Metabolic flux analysis;
- Bioreactor design.

Unit I
Growth kinetics of cell cultures
5 lectures

Kinetics of cell growth and product formation, mass and energy balances in biological systems, structured growth models; Compartmental models; Cybernetic models.

Unit II
Biocatalysts
5 lectures

Immobilized biocatalysts: external mass transfer; Internal diffusion; Reaction within catalysts; Kinetic analysis of batch processes.

Unit III
Bioreactor design
5 lectures

Reactor design (batch, continuous, fed-batch, plug flow, packed bed, airlift, immobilized enzyme/cell *etc.*); Optimal bioreactor operation using simple reaction kinetics.

Unit IV
Bioreactor process
5 lectures

Dynamic simulation of bioreactor processes (batch, fed-batch, continuous *etc.*); Reactors in series.

Unit V
Stoichiometry of bioreactions
5 lectures

Pathway analysis: Stoichiometric analysis; Thermodynamics-derived constraints; Fl balancing techniques; Metabolic control analysis.

Recommended Textbooks and References:

1. J. Nielsen,J. Villadsen, G. Liden, *Bioreaction Engineering Principles*, 2nd Edition, Kluwer Academic. 2003.
2. Irving J. Dunn, Elmar Heinzle, John Ingham, Jiri E. Prenosil, *Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples*, 2nd Edition, Wiley-VCH. 2003.

Computational Programming

Credits 2

Course Objectives

The objectives of this course are to teach students about essentials of computer programming using modern languages such as java, C++, python, and PERL.

Student Learning Outcomes

Students should be able to become proficient in applying fundamental concepts of programming in solving problems in science and engineering. This proficiency is critical towards developing research-grade tools in domains such as bioinformatics.

Unit I
Introduction
4 lectures

Higher level programming concepts, assembly level programming concepts, libraries, compilers, STDIN, STDOUT; Integrated programming environments.

Unit II
Variables
5 lectures

Number representations, Variables, data types, declarations, Operators (assignment).

Unit III
Loops & subroutines
5 lectures

Control structures and conditional statements; Do, while, until constructs. Functions, Arrays. Recursive functions.

Unit IV
Object-oriented programming
5 lectures

Structures and Objects; Object-oriented programming and Classes.

Unit V
Applications
7 lectures

Sample problems in science, engineering and text processing.

Recommended Textbooks and References:

1. Ranade, A. (2014) *An Introduction to Programming through C++*, McGraw Hill Education.
2. Lutz, M. (2011) *Programming Python*. O'Reilly media.
3. Schwartz, R.L., Foy, B.D., Phoenix, T. (2011) *Learning Perl*, O'Reilly media.
4. Stroustrup, B. (2013) *The C++ Programming Language*, Addison-Wesley Professional Publishers.

Environmental Biotechnology

Credits

2

Course Objectives

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce students major groups of microorganisms-tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from national and international literature.

Student Learning Outcomes

On completion of the course, students should be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

Unit I **Introduction to environment** 6 lectures	Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology.
Unit II **Bioremediation** 6 lectures	Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT *etc.*), technological aspects of bioremediation (*in situ, ex situ*).
Unit III **Role of microorganisms in bioremediation** 6 lectures	Application of bacteria and fungi in bioremediation: White rot fungi *vs* specialized degrading bacteria: examples, uses and advantages *vs* disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization).
Unit IV **Applications of environmental biotechnology in agriculture** 11 lectures	Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (*e.g. Trichoderma, Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.
Unit V **Biofuels** 11 lectures	Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel, biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

Recommended Textbooks and References:

1. G. M. Evans and J. C. Furlong (2003), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), *Environmental Biotechnology: Principle & Applications*, 2nd Ed., McGraw Hill Science.
3. Scragg A., (1999) *Environmental Biotechnology*. Pearson Education Limited.
4. J. S. Devinny, M. A. Deshusses and T. S. Webster, 1998, *Biofiltration for Air Pollution Control*, CRC Press.
5. H. J. Rehm and G. Reed, (1993), *Biotechnology – a Multi-Volume Comprehensive Treatise*, Vol. 11, 2nd Ed., VCH Publishers Inc.
6. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (1985), *Environmental Engineering*, McGraw-Hill Inc.

Enzyme Engineering & Technology

Credits

2

Course Objectives

The objectives of this course are to teach principles of enzyme engineering and enzyme technology.

Student Learning Outcomes

On completion of this course, students should be able to:

- Understand essential principles of enzyme engineering and technology;
- Become aware of applications in biotechnology processes.

Unit I

Enzymes, coenzymes and cofactors

3 lectures

Enzymes: Classification, mode of action, activation, specificity, Source of enzymes; production, isolation and purification of enzymes; Characterization in terms of pH, temperature, ionic strength, substrate and product tolerance, effects of metal ions; Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate, B12-coenzyme), role of cofactors with specific examples.

Unit II

Enzyme kinetics

8 lectures

Enzyme as biological catalysts; Enzyme action, active site, functional group, enzyme substrate complex, cofactors, Michaelis-Menten equation, Km and Vmax, enzyme inhibition; order of reaction, methods of plotting enzyme kinetics data; Enzyme turnover number, competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half life, activation and deactivation energy etc, Cross-linked enzyme aggregates. Cross linked enzymes, enzyme crystals, their use and preparation; Solution of numerical problems; Energy yielding and energy-requiring reactions; Calculation of equilibrium constants; Activation energy *etc.*; Multisubstrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects.

Unit III

Enzyme engineering

5 lectures

Introduction, Random and rational approach of protein engineering; Directed evolution and its application in Biocatalysis; various approaches of creating variant enzyme molecules; Future of Biocatalysis; Ideal biocatalyst.

Unit IV

Applications of enzyme technology

4 lectures

Immobilized enzyme technology: Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors, Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; starch conversion; APA production, biotransformations using soluble as well as immobilized enzymes; Calculation of diffusional resistances and Thiele's modulus, multi-step immobilized enzyme systems; Solution of numerical problems, Application and future of immobilized enzyme technology; Enzyme in organic solvents and ionic liquids: Various organic solvents and ionic liquids used in biocatalysis; Potential in organic solvents and ionic liquids; Applications of enzymes in analysis.

Recommended Textbooks and References:

1. Stryer, L. (2002). *Biochemistry*. Freeman. New York.
2. Lehninger, A. L. (2004). *Principles of Biochemistry* (4th ed.). Worth. New York, NY
3. Voet, D., & Voet, J. G. (2004). *Biochemistry* (4th ed.). Wiley & Sons. Hoboken, NJ: J
4. Rehm, H. & J. Reed, G., (1986). *Enzyme Technology*. Volume 7a. John Wiley & Sons.
5. Irwin H. Segel, (1976). *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry*, 2nd revised Ed. John Wiley & Sons.
6. Biotol, (1992). *Bioreactor Design & Product Yield*. Butterworth-Heinemann
7. Wang, D. I. C. (1979). *Fermentation and Enzyme Technology*. Wiley. New York.

Debasish Halder

Metabolic and Systems Biology

Credits

2

Course Objectives

This course work will provide essential knowledge to make career in bioprocess industries and in field of computational systems biology.

Student Learning Outcomes

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

- Understand the current advances in systems biology;
- Gain insights into the field of metabolic engineering.

Unit I **Introduction to systems biology** 6 lectures	Systems level understanding of biological systems. Networks and graph theory: Basic properties of Network: Degree, average degree and degree distribution. Adjacency matrix, weighted and unweighted networks, Bipartite network, Paths and distances, Random Networks: Erdos-Renyi model, Small-world effect, clustering coefficient, Scale-free networks: Power laws, Hubs, ultra-small property, degree exponent, Barabasi-Albert Model; Degree correlations: assortativity and disassortativity.
Unit II **Metabolic flux analysis** 5 lectures	Introduction to Flux balance analysis, Construction of stoichiometric matrices, Constraint based models. Network basics, examples of mathematical reconstruction of transcriptional networks and signal transduction networks; Tools for metabolic flux analysis - Monitoring and measuring the metabolome, Methods for the experimental determination of metabolic fluxes by isotope labeling metabolic fluxes using various separation-analytical techniques; GC-MS for metabolic flux analysis, genome wide technologies: DNA /phenotypic microarrays and proteomics; Basics of MATLAB.
Unit III **Kinetic modelling** 6 lectures	Kinetic modelling of biochemical reactions, describing dynamics with ODEs, rate equations, deriving a rate equation, incorporating regulation of enzyme activity by effectors, E-cell platform and erythrocyte modelling, case studies in E. coli, S. cerevisiae metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering; software and databases for genome scale modelling; Use of computational techniques to solve ODEs.
Unit IV **Networks in biological systems** 4 lectures	Network motifs, Feed forward loop network motif. Gene circuits, robustness of models, Chemotaxis model, Integration of data from multiple sources: Building genome scale models.
Unit V **Tools and case studies** 5 lectures	Tools and databases for modelling: Pathway databases KEGG, EMP, Metacyc, Enzyme kinetics database BRENDA, Gene expression databases, Biomodels database, Basics of Systems Biology Markup Language (SBML), SBML editors. Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics: 13C NMR based metabolic flux analysis.

Recommended Textbooks and References:

1. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, (2009). *Systems Biology, a Textbook*, Wiley-BlackWell Publications.
2. Uri Alon, (2007). *An Introduction to Systems Biology: Design Principles of Biological Circuits*, Chapman and Hall / CRC.
3. EddaKlipp, Ralf Herwig, Axel Kowald, Christoph Wierling, Hans Lehrach, 2005. *Systems Biology in Practice: Concepts, Implementation and Application*, Wiley – VCH

4. Hiroaki Kitano, *Foundations of Systems Biology*, MIT Press.
5. Stephanopoulos, G.N. (1998), *Metabolic Engineering: Principles and Methodologies*, Academic Press / Elsevier.
6. Jonathan Pevsner, (2003), *Bioinformatics and Functional Genomics*, 1st Edition, Wiley-Liss.

Medical Devices

Credits

2

Course Objectives

The objective of the course is to familiarize students with emerging trends in medical devices for early detection, selection of appropriate treatment, monitoring treatment effectiveness and disease surveillance.

Student Learning Outcomes

On successfully completing this course, students are expected to be able to:

- Extend principles of engineering to the development of medical devices and design of sensors;
- Appreciate basic configuration and distinction among biosensor systems.

Unit I **Sensors** 5 lectures	Rationale of electronic biosensors; Essence of three types of electronic biosensors (*i.e.*, potentiometric, amperometric, and cantilever-based sensors); Three essential metrics that define modern electronic sensors; detection time, sensitivity, and selectivity; Physics of detection time that allows one to organize every available sensor in a systematic way; Fundamental limits of detection of various classes of sensors; Opportunities and challenges of integrating sensors in a system platform.
Unit II **Transducers** 5 lectures	Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric, based transducers; Biochemical Transducers: Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams.
Unit III **Optical sensors** 5 lectures	Photo detectors, optical fiber sensors, indicator mediated transducers; General principles of optical sensing, optical fiber temperature sensors; Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer.
Unit IV **Bio recognition systems** 5 lectures	Enzymes; Oligonucleotides Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Chemoreceptors.
Unit V **Electrodes and immobilization** 5 lectures	Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization: Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes.
Unit VI **Fundamentals and applications of microfluidics** 5 lectures	Capillary flow and electro kinetics; Micro pump, Micro mixers, Micro reactors, Micro droplets, Micro particle separators; Micro fabrication techniques (different types of lithography methods); Application of micro-fluidics (*e.g.* Lab- in –Chip).
Unit VII **Applications** 5 lectures	Biomarkers: Disease and pathogen specific information, availability by sample type (blood, serum, urine, sputum, saliva, stool, mucus); Specificity, sensitivity, shelf life,

portability; Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable Sensors for long-term monitoring; Drug development and detection; Environmental monitoring; Examples of various diseases (Cancer, HIV/AIDS, Tuberculosis, Malaria, Lymphatic Filariasis, Schistosomiasis, Dengue, Chikungunya).

Recommended Textbooks and References:

1. Alice Cunningham, (1998), *Introduction to Bio Analytical Sensors*, John Wiley & Sons.
2. Jiri Janata, (2009), *Principles of Chemical Sensors*, 2nd Ed., Plenum Press.
3. F. Schellr, F. Schubert, J. Fedrowitz, (1997), *Frontiers in Biosensors*, Birkhauser.
4. F. Ligler, C. Rowe Taitt, (2002), *Optical Biosensors. Present & Future*. Elsevier.
5. Brian Eggins, (2002), *Chemical Sensors and Biosensors*, John Willey & Sons.
6. Graham Ramsay, (1998), *Commercial Biosensors*, John Wiley& Sons.
7. Ursula Spichiger-Keller, (1998), *Chemical Sensors and Biosensors for Medical and Biological Applications*, Wiley-VCH.
8. Berthier Jean, and Silberzan Pascal, (2010), *Microfluidics for Biotechnology*, 2nd Ed. Artech House.
9. Frank A Gomez, (2008), *Biological Applications of Microfluidics*, Wiley.
10. Gareth Jenkins, Colin D. Mansfield, (2013), *Microfluidic Diagnostics: Methods and Protocols*, Springer.
11. J G. Webster, (1998), *Encyclopedia of Medical Devices and Instrumentation*. Vol I, II, III, IV, Wiley-Blackwell.

Molecular Diagnostics

Credits

2

Course Objectives

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Student Learning Outcomes

Students should be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

Unit I **Genome biology in health and disease** 4 lectures	DNA, RNA and Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.
Unit II **Genome: resolution, detection and analysis** 5 lectures	PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS, Bioinformatics data acquisition & analysis.
Unit III **Diagnostic metabolomics** 2 lectures	Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms.

Unit IV
Detection and identity of microbial diseases
4 lectures

Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of *in vitro* cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

Unit V
Detection of inherited diseases
4 lectures

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in the growing number of familial cancer syndromes.

Unit VI
Molecular oncology
5 lectures

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

Unit VII
Quality assurance and control
1 lecture

Quality oversight; regulations and approved testing.

Recommended Textbooks and References:

1. Campbell, A. M., & Heyer, L. J. (2006). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). *Genetics: Analysis & Principles*. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, DC: ASM Press.
4. Coleman, W. B., & Tsongalis, G. J. (1997). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press.

Nanobiotechnology

Credits
2

Course Objectives

The course aims at providing general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with combination of top-down approach of microelectronics and micro-mechanics with bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve everyday life.

Student Learning Outcomes

On successful completion of this course, students should be able to describe basic science behind the properties of materials at the nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

Unit I
Introduction to nanobiotechnology
5 lectures

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II
Nano - films
5 lectures

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III **Nano - particles** 6 lectures	Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.
Unit IV **Applications of nano - particles** 5 lectures	Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.
Unit V **Nano - materials** 6 lectures	Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.
Unit VI **Nano - toxicity** 5 lectures	Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life cycle assessment, containment.

Recommended Textbooks and References:

1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*, Wiley-Liss
3. Neelina H. Malsch, *Biomedical Nanotechnology*, CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Production of Biotherapeutics

Credits: 2

Course Objectives

The objectives of this course are to equip students with essentials of biomanufacturing principles and good manufacturing practices for production of biotherapeutics.

Student Learning Outcomes

Students should develop conceptual clarity and knowledge about systems for quality manufacturing of biotherapeutics (biopharmaceuticals, diagnostics and foods) manufactured for human use. The knowledge of GMP and GLP requirements is critical for students who opt for careers in biomanufacturing.

Unit I **Biomanufacturing principles** 6 lectures	Overview and design of biomanufacturing, quality by design approach, technical considerations, phases and scale up: life cycle of manufacturing, raw material considerations, compliance and quality in biomanufacturing, lean biomanufacturing; Process analytical technology (PAT) during biomanufacturing: background and need tools for data acquisitions (software in fermenters, flow filtrations, chromatography, analysis and design process analyzers, process control tools and continuous improvement and knowledge management; Standard manufacturing operating procedures of biotechnology, including upstream and downstream processing of proteins, and quality control of protein production, and final fill and finish of product; Case studies to be included therapeutic proteins, monoclonal antibodies, human vaccines.
Unit II **Quality system** 4 lectures	Introduction to quality system, main elements of a quality system; Essential of quality system; Practical implementation of a quality system; Structure of quality manual, correlation between GMP requirements (WHO) and ISO 9001:2000.

Unit III

Principles and practice of GMP

10 lectures

Personnel: Principles of human resource management, duties of senior management, organizational structures, qualification and profiles requirement, workplace and job descriptions, health monitoring and occupational health safety, training, functions owners subject to public law; Premises: Official requirements, material & personnel flow and layout, air cleanliness classes and grades, construction elements, barrier systems, isolators and safety cabinets, building services, heating ventilation air conditioning (HVAC), process gases, qualification of premises and HVAC systems, pharma monitoring of HVAC systems, particle monitoring.; Facilities and Equipment: Facility planning, materials, hygienic design in solids handling, system controllers and process control systems, technical documentation, calibration, maintenance, cleaning of facilities, containment (personnel protection) in solids handling; Pharmaceutical water: Water qualities, generation of pharmaceutical water, distribution and storage of pharmaceutical water, qualification of water supplies, operation of water supplies, pure steam systems; Qualification: Official requirements, preparation of the qualification, qualification documentation, design qualification (DQ), Installation qualification (IQ), operational qualification (OQ), Performance qualification (PQ), special cases of qualification; Process Validation: Official requirements, Validation - a key element of quality management, validation planning and procedure, validation documentation, process validation and product lifecycle ; Cleaning Validation: Official requirements, how to validate cleaning procedures, cleaning validation master plan, establishing the scope of validation, acceptance criteria and limit calculation, sampling procedures, analytical procedure, documentation, maintenance of the validated status, cleaning validation documentation; Production: Sanitation, personnel hygiene, production hygiene, sanitation programme, environmental monitoring, GMP in the production process, weigh-in, identification, in-process control prevention of cross-contamination, empty chapter, reworking, warehouse and logistics; Sterile Production and Packaging: Introduction, Air lock concepts, manufacture of terminally sterilised products, sterilisation processes, aseptic processing, freeze-drying, testing for sterility, testing for endotoxins, testing for leakage and for particles, microbiological monitoring, packaging materials, packaging process, qualification of a servo-controlled blister packaging line, blow-fill-seal technology (BFS technology); Documentation: Official requirements, GMP-compliant documentation, batch documentation, standard operating procedures (SOPs), site master file, electronic batch recording and batch release, CAPA, document management systems.

Unit IV

GMP in regulation

2 lectures

Information, national bodies and pharmaceutical associations; Pharmacopeia; EU directives and guidelines, USA: CFR and FDA guidelines, ICH-guidelines, PIC/S guidelines, GMP of other regions, WHO guidelines.

Recommended Textbooks and References:

1. *Introduction to Biomanufacturing*. By Northeast Biomanufacturing Center and collaboration, 2012.
2. *Introduction to Biomanufacturing*, by Mark Witcher. In Encyclopedia of Industrial Biotechnology.
3. *Good Manufacturing Practices for Pharmaceuticals (e-resource): a Plan for Total Quality Control*. Sidney Willig and James Stoker.
4. *Biotechnology Operations: Principles and Practices*; by John M. Centanni, Michael J. Roy; CRC press
5. *Learn Biomanufacturing*, 1st Edition; Author Nigel Smart; Woodhead Publishing
6. *GMP Manual*; Publisher Maas & Peither America, Inc. GMP Publishing.

OMICS Technologies

Credits

2

Course Objectives

The aim of this course is to give an overview of genomics, proteomics and metabolomics to the students. The students should be able to gain working knowledge of these technologies and appreciate their ability to impart a global understanding of biological systems and processes in health and disease.

Student Learning Outcomes

At the end of the course, students should be:

- Understand high throughput analysis;
- Gain knowledge of current cutting edge technologies;
- Know the application of various Omics technologies.

Unit I
Genomics and methods in genomics
5 lectures

Organization and structure of genomes in prokaryotes, eukaryotes, and organelles (chloroplast, mitochondrion); Genome mapping methods (genetic and physical); RAPD , RFLP, SNP analyses; Fluorescence *in-situ* Hybridization (FISH) techniques; Advances in gene finding and functional prediction; Chain termination and chemical degradation sequencing methods. Genome-wide association (GWA) analysis; Comparative Genomic Hybridization(CGH); Massively parallel Signature Sequencing (MPSS); Whole genome shot-gun sequencing and its applications; Introduction of Next Generation Sequencing (NGS).

Unit II
Transcriptomics and methods in transcriptomics
5 lectures

ne expression analysis by cDNA and oligonucleotide arrays; Micro array experimental analysis and data analysis; Bioinformatic analysis of large-scale microarray data for comparative transcriptomics.

Unit III
Proteomics and methods in proteomics
10 lectures

Over-view of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Tissues, Yeast, Bacteria, and Plant Tissues); 2-DE of proteins for proteome analysis; Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion); Enzymatic cleavage of proteins. Analysis of complex protein mixtures using Nano-liquid chromatography (Nano-LC) coupled to Mass-spectrometry analysis. Over-view of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Tissues, Yeast, Bacteria, and Plant Tissues); 2-DE of proteins for proteome analysis; Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion); Enzymatic cleavage of proteins. Analysis of complex protein mixtures using Nano-liquid chromatography (Nano-LC) coupled to Mass-spectrometry analysis. Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LC-MS analyses; Comparative proteomics based on global in-vitro and in-vivo labelling of proteins/peptides followed by Mass-spectrometry. Analysis of post-translational modification (PTM) of proteins; Characterization of protein interactions using yeast two-hybrid system and Protein microarrays; Proteomics informatics and analysis of protein functions.

Unit IV
Metabolomics and methods in metabolomics
8 lectures

Introduction to metabolic engineering, comprehensive models of cellular reactions with stoichiometry and reaction rates; metabolic flux analysis of exactly/over/under determined systems; Shadow price, sensitivity analysis; Monitoring and measuring the metabolome, Methods for the experimental determination of metabolic fluxes by isotope labelling metabolic fluxes using various separation-analytical techniques; GC-MS for metabolic flux analysis.

Recommended Textbooks and References:

1. S.P. Hunt and F. J. Livesey, (2000) *Functional Genomics.*
2. Twyman R. M. (2004), *Principles of Proteomics.* Taylor & Francis.
3. Voit, E.O., 2000 *Computational Analysis of Biochemical Systems: a Practical Guide for Biochemists and Molecular Biologists.* Cambridge University Press.
4. Melanie J Filiatrault, *Progress in Prokaryotic Transcriptomics, Current Opinion in Microbiology,* Volume 14, Issue 5, October 2011, Pages 579-586.
5. Alex Sánchez-Pla, Ferran Reverter, M. Carme Ruíz de Villa, Manuel Comabella, *Transcriptomics: mRNA and Alternative Splicing.* Journal of Neuroimmunology, Volume 248, issues 1-2,15 July 2012, pp 23-31.