

# Post Graduate Curriculum Framework

With effect from the Academic Session 2026–27, the M.Sc. in Biotechnology programme in the Universities of Bihar shall be offered in accordance with the UGC Curriculum and Credit Framework for Postgraduate Programmes (PGCF) and the provisions of the National Education Policy (NEP), 2020.

The programme provides flexibility to students to pursue either a Two-Year Master's Degree Programme or a One-Year Master's Degree Programme for candidates who have completed a four-year undergraduate degree with the requisite credits and qualifications as prescribed by UGC.

The curriculum is designed under the Choice Based Credit System (CBCS) and comprises a combination of Core Courses (CCs), Discipline Specific Electives (DSEs), Generic Electives (GEs), Skill Enhancement Courses (SECs), Ability Enhancement Courses (AECs), and Value-Added Courses (VACs). The programme seeks to impart advanced theoretical knowledge, computational proficiency, research aptitude, and practical skills in Statistics and its applications.

Each academic year shall consist of two semesters. Students shall be required to successfully complete the prescribed combination of Core, Elective (Discipline/Generic/Open), Skill Enhancement, Ability Enhancement, and Value-Added Courses in each semester to fulfil the credit requirements of the programme.

The curriculum incorporates contemporary developments in Biotechnology, including IPR and Biopiracy, Environmental Biotechnology, Nanotechnology and Advanced tools and Techniques in Biotechnology. The syllabus and reading materials shall be reviewed periodically to ensure alignment with emerging developments in academia, research, industry, and public policy.

Teaching-learning methodologies may include lectures, tutorials, seminars, laboratory sessions, statistical computing exercises, case studies, project work, field-based applications, and research assignments. Practical training shall provide hands-on experience in the use of statistical software packages, data analysis techniques, computational tools, and real-world problem-solving.

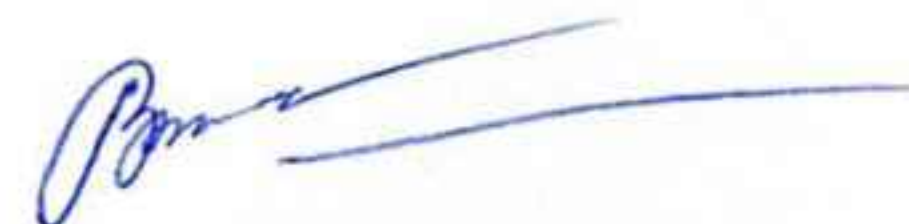
Assessment shall be conducted through a combination of continuous evaluation and end-semester examinations, including assignments, presentations, practical examinations, projects, viva-voce examinations, and written tests, as prescribed by the authorities concerned from time to time.

Students shall have the opportunity to choose elective and generic courses in accordance with their academic interests, subject to the availability of courses and institutional regulations, thereby promoting interdisciplinary learning and specialization within the broad domain of Biotechnology.

KB 24/07/26

Kalpana Srivastava  
Officer on special duty (Judicial)

Y/S 100



| COURSE OF STUDIES    |                                                                      |
|----------------------|----------------------------------------------------------------------|
| BIOTECHNOLOGY        |                                                                      |
| Programme Level      | Master of Science (M. Sc.)                                           |
| Subject / Discipline | Biotechnology                                                        |
| Faculty              | Faculty of Science                                                   |
| University           | Universities of Bihar Established under the BSU AC 1976/PU Act 1976. |
| Duration             | Two Years / Four Semesters                                           |
| NHEQF Level          | Level 6.5                                                            |
| Effective from       | 2026-27 onwards                                                      |

A

**PART A — PROGRAMME OVERVIEW & OBJECTIVES****A.1 Graduate Attributes (GAs)**

The programme nurtures the following Graduate Attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

- Disciplinary expertise and interdisciplinary awareness
- Analytical reasoning and evidence-based judgement
- Independent research and inquiry orientation
- Digital and information literacy
- Effective communication and collaborative skills
- Ethical conduct and responsible citizenship
- Global awareness and cross-cultural competence

**A.2 Programme Outcomes (POs)**

The Programme Educational Objectives describe the career and professional accomplishments that graduates are expected to attain within three to five years of graduation.

**PO 1 — Scientific Knowledge and Technical Competence**

Apply advanced knowledge of biological sciences and biotechnology, together with modern laboratory techniques, bioinformatics tools, and analytical methodologies, to investigate biological systems and address scientific and technological challenges.

**PO 2 — Research, Critical Thinking, and Problem-Solving**

Design and conduct experiments, analyze and interpret scientific data, demonstrate critical thinking, and undertake independent research to solve complex biological and biotechnological problems through innovative and evidence-based approaches.

**PO 3 — Professional Skills, Communication, and Ethics**

Communicate scientific information effectively, collaborate in multidisciplinary teams, and exhibit professional competence, ethical responsibility, biosafety awareness, and understanding of intellectual property rights in academic, research and industrial settings.

**PO 4 — Innovation, Sustainability, and Lifelong Learning**

Develop innovative and sustainable biotechnological solutions for challenges in healthcare, agriculture, industry, and environmental management while engaging in continuous learning, professional development, and adaptation to emerging scientific advancements.

**A.3 Programme Specific Outcomes (PSOs)**

Upon successful completion of this programme, a student shall demonstrate the following learning outcomes:

**PSO 1** — Demonstrate advanced knowledge and understanding of molecular biology, cell biology, genetics, microbiology, biochemistry, immunology, and allied areas of biotechnology to explain biological processes at molecular, cellular, and organismal levels.

**PSO 2** — Apply modern biotechnological tools, laboratory techniques, instrumentation, bioinformatics resources, and analytical methods for experimentation, data collection, interpretation and problem-solving in biological sciences.

**PSO 3** — Design, conduct, and evaluate research investigations independently by employing scientific methodologies, statistical analysis, critical thinking, and ethical research practices in biotechnology.

**PSO 4** — Utilize principles of bioprocess technology, environmental biotechnology, agricultural biotechnology, and industrial biotechnology for the development of sustainable solutions addressing challenges in health, agriculture, industry, and the environment.

| S.No.                     | Paper Code  | Title of the Course/Paper                   | L         | T        | P        | Credits   | Max. Marks | Type |
|---------------------------|-------------|---------------------------------------------|-----------|----------|----------|-----------|------------|------|
| <b>Total — Semester I</b> |             |                                             | <b>17</b> | <b>5</b> | <b>0</b> | <b>22</b> | <b>600</b> |      |
| <b>SEMESTER II</b>        |             |                                             |           |          |          |           |            |      |
| 1                         | MSBIO-CC201 | Core Course V: Biophysics & Instrumentation | 3         | 1        | 0        | 4         | 100        | CC   |
| 2                         | MSBIO-CC202 | Core Course VI: Biology of Immune System    |           |          |          |           |            |      |



| CLO No. | Course Learning Outcome                                                                                                  |
|---------|--------------------------------------------------------------------------------------------------------------------------|
| CLO 1   | Upon completion, students will be able to recall and describe the foundational concepts of cell biology                  |
| CLO 2   | Students will be able to apply theoretical frameworks to analyse real-world problems in Genetics                         |
| CLO 3   | Students will be able to critically evaluate contending scholarly positions and methodologies.                           |
| CLO 4   | Students will be able to synthesise knowledge and produce independent research outputs in the field of Molecular Biology |

## C.5 Syllabus — Unit-wise Breakdown

| Course Name: CELL & MOLECULAR BIOLOGY AND GENETICS (MSBIO-CC101) |                                          |                          |
|------------------------------------------------------------------|------------------------------------------|--------------------------|
| Unit                                                             | Content                                  | Suggested Lectures hours |
| I                                                                | <p><b>Cell Biology:</b> Diversity of</p> |                          |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| III | <p><b>Transcription:</b> Concept of template surfaces, Transcriptions, Post-transcriptional processing and transport of RNA, Regulation of transcription, Transcription factors; Structures and function of ribonucleoproteins, SiRNA, MiRNA</p> <p><b>Translation:</b> Genetic code; Prokaryotic and eukaryotic translation, regulation of translation, co- and post translational modifications of proteins</p> <p><b>Gene expression and regulation:</b> Operons and regulons, repression and activation of <i>Lac</i> and <i>Trp</i> operons, feed back inhibition; Regulation of eukaryotic gene expression</p> | 12–15 |
| IV  | <p><b>Antisense technology:</b> Molecular mechanism of antisense molecules, application of antisense technologies.</p> <p><b>Mutation and Mutagenesis:</b> Molecular basis of mutations; mutagens; Spontaneous and induced mutation; Ames test for mutagenesis; Biochemical mutation; One gene-one enzyme hypothesis.</p> <p><b>Transposons:</b> Structure and types of transposons (Prokaryotic and Eukaryotic); Mechanism of transposition (replicative and non-replicative); Application of transposon&lt;/</p>                                                                                                   |       |

4. Karp, G. (2019). Cell and Molecular Biology: Concepts and Experiments. Wiley.

5. De Robertis, E.D.P. (2017). Cell and Molecular Biology. Lippincott Williams & Wilkins

### C.8 Suggested E-Resources / Digital Repositories

- SWAYAM: Cell Biology
- SWAYAM: Molecular Biology
- e-PG Pathshala: Cell Biology
- e-PG Pathshala: Genetics
- NDL India Digital Repository

### C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions ( $10 \times 2$  marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions ( $4 \times 5$  marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions ( $3 \times 10$  marks = 30 marks) — Attempt 3 out of 5.

### Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

## C.1 Paper Identification

| PAPER PROFILE           |                                         |
|-------------------------|-----------------------------------------|
| Paper Code              | MSBIO-CC102                             |
| Title of the Paper      | Core Course II: Microbiology            |
| Programme / Subject     | MSc — Biotechnology                     |
| Semester                | Semester I                              |
| Nature of Course        | Core Course (CC)                        |
| L – T – P               | 3 – 1 – 0                               |
| Credits                 | 4                                       |
| Maximum Marks           | 100 (ESE: 70 + Internal Assessment: 30) |
| Duration of Examination | 3 Hours                                 |

## C.2 Marks Distribution



|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| III | <b>Eukarya-</b> Fungi, slime mold and protozoa<br><b>Viruses-</b> A general idea of structure of different kinds of viruses; Plant viruses: tobacco mosaic virus; structure of bacteriophages belonging to 'T' series; Lytic cycle and its regulation; lysogeny and its regulation in lambda phage<br>Prions and viroids: Recent development in research                                                                                                                                                                                                                                                                                                          | 12–15 |
| IV  | <b>Host-parasite relationships:</b> Entry of pathogens into the host, colonization and factors predisposed to infections; types of toxins (Exo-, endo- and entero-) and their structure, mode of action, virulence and pathogenesis<br><b>Microbial diseases:</b> Overview of microbial diseases; diseases caused by Gram positive cocci - pneumonia; diseases caused by Gram negative cocci - gonorrhea; diseases caused by Gram positive bacilli - tuberculosis, tetanus; diseases caused by Gram negative bacteria of family Enterobacteriaceae - enteric fever; diseases caused by other Gram negative bacilli - cholera; sexually transmitted diseases; AIDS | 12–15 |
| V   | <b>Antibiotics:</b> Different types of antimicrobial agents, Mode of action;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |

**C.8 Suggested E-Resources / Digital Repositories**

- SWAYAM: General Microbiology
- SWAYAM: Industrial Microbiology
- e-PG Pathshala: Microbiology
- Shodhganga Theses on Microbiology
- NDL India

**C.9 Assessment Pattern & Question Paper Design**

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions ( $10 \times 2$  marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions ( $4 \times 5$  marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions ( $3 \times 10$  marks = 30 marks) — Attempt 3 out of 5.

**Internal Assessment (30 marks) breakdown:**

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks





|                                 |                                                                                                                                                                                                                                                                                               |                                 |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| V                               | <b>Enzymes:</b> Characteristics, Co-enzymes, kinetics, determination of $K_m$ and $V_{max}$ using different plots; mechanism of action - binding of substrate and lowering of activation energy, covalent catalysis, acid-base catalysis; regulation- general concepts, allosteric regulation | 12–15                           |
| <b>Total Suggested Lectures</b> |                                                                                                                                                                                                                                                                                               | <b>60 (For 4 Credit Course)</b> |

**C.6 Prescribed Textbooks**

1. Nelson, D.L. (2021). *Lehninger Principles of Biochemistry*. W.H. Freeman.
2. Voet, D. (2019). *Biochemistry*. Wiley.
3. Berg, J.M. (2019). *Biochemistry*. W.H. Freeman.
4. Satyanarayana, U. (2022). *Biochemistry*. Elsevier.
5. Stryer, L. (2019). *Biochemistry*. W.H. Freeman.

**C.7 Reference Books & Readings**

1. Segel, I.H. (1993). *Enzyme Kinetics*. Wiley.
2. Palmer, T. (2012). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. Horwood.
3. Dixon, M. (2018). *Enzymes*. Academic Press.
4. Copeland, R.A. (2000). *Enzymes: A Practical Introduction*. Wiley.
5. Price, N.C. (2018). *Fundamentals of Enzymology*. Oxford University Press.

**C.8 Suggested E-Resources / Digital Repositories**

- SWAYAM: Biochemistry
- SWAYAM: Enzyme Science and Technology
- e-PG Pathshala: Biomolecules
- e-PG Pathshala: Enzymology
- NDL India

**C.9 Assessment Pattern & Question Paper Design**

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions ( $10 \times 2$  marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions ( $4 \times 5$  marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions ( $3 \times 10$  marks = 30 marks) — Attempt 3 out of 5.

**Internal Assessment (30 marks) breakdown:**

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| III | 12. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.<br>13. To prepare an Acetic-Na Acetate Buffer system and validate the Henderson-Hasselbach equation.<br>14. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-VIS Spectrophotometer.<br>15. To determine an unknown carbohydrate concentration by plotting a standard graph of glucose using UV-VIS Spectrophotometer. | 24-30 |
| IV  | 16. Separation of aliphatic, aromatic and polar amino acids by TLC.<br>17. AN ENZYME PURIFICATION THEME (such as <i>E.coli</i> any enzyme of the institutions choice).<br>(i) Preparation of cell-free lysates<br>(ii) Ammonium Sulfate precipitation<br>(iii) Ion-exchange Chromatography<br>(iv) Gel Filtration<br>(v) Affinity Chromatography                                                                                                                                                   | 16-20 |
| V   | 18. Separation of protein                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |

1. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2020). Prescott's Microbiology (11th ed.). New York, NY: McGraw Hill Education
5. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). Brock Biology of Microorganisms (16th ed.). New York, NY: Pearson Education

### C.7 Reference Books & Readings

1. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K. (Eds.). (1995). Current Protocols in Molecular Biology. New York, NY: **John Wiley & Sons**
2. Gallagher, S. R., & Wiley, E. A. (2008). Short Protocols in Molecular Biology (5th ed.). Hoboken, NJ: **John Wiley & Sons**
3. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell, J. E. (2000). Molecular Cell Biology (4th ed.). New York, NY: **W. H. Freeman and Company**
4. Nelson, D. L., & Cox, M. M. (2021). Lehninger Principles of Biochemistry (8th ed.). New York, NY: **W. H. Freeman and Company**
5. Wilson, K., & Walker, J. (2010). Practical Biochemistry: Principles and Techniques (6th ed.). Cambridge, UK: **Cambridge University Press**

### C.8 Suggested E-Resources / Digital Repositories

- NPTEL Biotechnology and Microbiology Courses
- SWAYAM Portal
- e-PG Pathshala (Biotechnology and Life Sciences)
- National Digital Library of India (NDLI)
- Virtual Labs (Biotechnology and Biochemistry)

### C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

### Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks







- Section A: Short Answer Questions ( $10 \times 2$  marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions ( $4 \times 5$  marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions ( $3 \times 10$  marks = 30 marks) — Attempt 3 out of 5.

**Internal Assessment (30 marks) breakdown:**

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks









## C.4 Course Learning Outcomes (COs)

| CLO No. | Course Learning Outcome                                                                                                                    |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------|
| CLO 1   | Upon completion, students will be able to recall and describe the foundational concepts of bioenergetics and spectroscopy                  |
| CLO 2   | Students will be able to apply theoretical frameworks to analyse real-world problems in microscopy and imaging data.                       |
| CLO 3   | Students will be able to critically evaluate electrophoretic and immunological separation methods.                                         |
| CLO 4   | Students will be able to synthesise knowledge and produce independent research outputs in analytical instruments for research applications |

## C.5 Syllabus — Unit-wise Breakdown

| Course Name: BIOPHYSICS AND INSTRUMENTATION (MSBIO-CC201) |  |
|-----------------------------------------------------------|--|
|-----------------------------------------------------------|--|

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| V                               | <b>Electrophoresis:</b> Principles and types [Polyacrylamide gel electrophoresis (PAGE), SDS-PAGE, agarose gel electrophoresis, 2D electrophoresis and their applications; Gradient Gel Electrophoresis (DGGE); Temperature Gradient Gel Electrophoresis (TGGE); Pulsed field gel electrophoresis<br><b>Immuno-electrophoresis:</b> Types (crossed, rocket) and their applications<br><b>Isoelectric focusing (IEF):</b> Principles and applications | 8–10                            |
| <b>Total Suggested Lectures</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>60 (For 4 Credit Course)</b> |

### C.6 Prescribed Textbooks

1. Cotterill, R. (2018). *Biophysics: An Introduction*. Wiley.
2. Rodney, C. (2016). *Biophysics*. Wiley.
3. Upadhyay, A. (2019). *Biophysical Chemistry*. Himalaya Publishing.
4. Wilson, K. (2018). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
5. Freifelder, D. (2015). *Physical Biochemistry*. W.H. Freeman.

### C.7 Reference Books & Readings

1. Skoog, D.A. (2017). *Principles of Instrumental Analysis*. Cengage.
2. Chatwal, G.R. (2018). *Instrumental Methods of Chemical Analysis*. Himalaya Publishing.
3. Pattabhi, V. (2017). *Biophysics*. Narosa Publishing.
4. Van Holde, K.E. (2014). *Physical Biochemistry*. Pearson.
5. Lakowicz, J.R. (2013). *Principles of Fluorescence Spectroscopy*. Springer.

### C.8 Suggested E-Resources / Digital Repositories

- SWAYAM: Biophysical Techniques
- SWAYAM: Bioinstrumentation
- e-PG Pathshala: Biophysics
- NDL India
- Shodhganga (Biophysics Research)

### C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

### Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

## C.1 Paper Identification

| PAPER PROFILE           |                                          |
|-------------------------|------------------------------------------|
| Paper Code              | MSBIO-CC202                              |
| Title of the Paper      | Core Course VI: Biology of Immune System |
| Programme / Subject     | MSc — Biotechnology                      |
| Semester                | Semester II                              |
| Nature of Course        | Core Course (CC)                         |
| L – T – P               | 3 – 1 – 0                                |
| Credits                 | 4                                        |
| Maximum Marks           | 100 (ESE: 70 + Internal Assessment: 30)  |
| Duration of Examination | 3 Hours                                  |

## C.2 Marks Distribution



|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| V                               | <b>Hypersensitivity:</b> Type I, Type II, Type III and Type IV and their significance<br>Autoimmunity; Immunological tolerance; Immunosuppression; Immunodeficiency; Immunotherapy<br><b>Interferon:</b> recent development in research, role in therapy<br><b>Vaccines:</b> Different types of vaccines and its merits and demerits<br><b>Recent advances in immunology:</b> Single-cell immunology, systems immunology, immunogenomics, multi-omics approaches and their applications in disease diagnosis, immunotherapy and vaccine development. | 12–15                           |
| <b>Total Suggested Lectures</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>60 (For 4 Credit Course)</b> |

### C.6 Prescribed Textbooks

1. Murphy, K. (2022). *Janeway's Immunobiology*. Garland Science.
2. Abbas, A.K. (2023). *Basic Immunology*. Elsevier.
3. Goldsby, R.A. (2019). *Kuby Immunology*. W.H. Freeman.
4. Delves, P.J. (2017). *Roitt's Essential Immunology*. Wiley.
5. Kindt, T.J. (2018). *Kuby Immunology*. Macmillan.

### C.7 Reference Books & Readings

1. Abbas, A.K. (2021). *Cellular and Molecular Immunology*. Elsevier.
2. Paul, W.E. (2019). *Fundamental Immunology*. Lippincott.
3. Male, D. (2020). *Immunology*. Elsevier.
4. Peakman, M. (2018). *Basic and Clinical Immunology*. Elsevier.
5. Rich, R.R. (2019). *Clinical Immunology*. Elsevier.

### C.8 Suggested E-Resources / Digital Repositories

- SWAYAM: Immunology
- e-PG Pathshala: Immunology
- NDL India
- Shodhganga: Immunology Theses
- Virtual Labs (Biotechnology)

### C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions ( $10 \times 2$  marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions ( $4 \times 5$  marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions ( $3 \times 10$  marks = 30 marks) — Attempt 3 out of 5.

### Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks





|                                 |                                                                                                                                                                                                                                                                                                                             |                                 |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| IV                              | <b>Downstream processing:</b> Removal of microbial cells and solid matter, foam separation, precipitation, filtration, centrifugation, liquid-liquid extraction, chromatography, drying and crystallization                                                                                                                 | 12–15                           |
| V                               | <b>Process technology for the production of primary metabolites:</b> Baker's yeast, ethanol, beer, wine, distilled spirits, acetone-butanol, citric acid, amino acids (Glutamic acid)<br><b>Microbial production of industrial enzymes:</b> Cellulase and amylase<br><b>Production of secondary metabolites:</b> Penicillin | 8–10                            |
| <b>Total Suggested Lectures</b> |                                                                                                                                                                                                                                                                                                                             | <b>60 (For 4 Credit Course)</b> |

### C.6 Prescribed Textbooks

1. Shuler, M.L. (2017). Bioprocess Engineering: Basic Concepts. Pearson.
2. Doran, P



## C.4 Course Learning Outcomes (COs)

| CLO No. | Course Learning Outcome                                                                                                               |
|---------|---------------------------------------------------------------------------------------------------------------------------------------|
| CLO 1   | Upon completion, students will be able to recall and describe the foundational concepts of biophysical and immunological experiments. |
| CLO 2   | Students will be able to apply theoretical frameworks to analyse real-world problems in analytical instruments and interpret results. |
| CLO 3   | Students will be able to critically evaluate experimental outcomes and troubleshoot protocols                                         |
| CLO 4   | Students will be able to design and execute laboratory experiments independently                                                      |

## C.5 Syllabus — Unit-wise Breakdown

| Course Name: PRACTICAL (MSBIO-PC204) |  |  |
|--------------------------------------|--|--|
| Unit                                 |  |  |



1. Dubey, R. C., & Maheshwari, D. K. (2002). Practical Microbiology. New Delhi: **S. Chand Publishing**
2. Aneja, K. R. (2003). Experiments in Microbiology, Plant Pathology and Biotechnology. New Delhi: **New Age International Publishers**
3. Jayaraman, J. (2011). Laboratory Manual in Biochemistry. New Delhi: **New Age International Publishers**
4. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual (4th ed.). Cold Spring Harbor, NY: **Cold Spring Harbor Laboratory Press**
5. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual (2nd ed.). Cold Spring Harbor, NY: **Cold Spring Harbor Laboratory Press**

### C.8 Suggested E-Resources / Digital Repositories

- NPTEL (National Programme on Technology Enhanced Learning)
- Cold Spring Harbor Protocols
- Addgene Protocols & Educational Resources
- FAO (Food and Agriculture Organization) Mushroom Resources
- JoVE (Journal of Visualized Experiments)
- SWAYAM Portal
- e-PG Pathshala (Biotechnology)

### C.9 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions ( $10 \times 2$  marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions ( $4 \times 5$  marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions ( $3 \times 10$  marks = 30 marks) — Attempt 3 out of 5.

### Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

## C.1 Paper Identification

| PAPER PROFILE           |                                                          |
|-------------------------|----------------------------------------------------------|
| Paper Code              | MSBIO-GE205                                              |
| Title of the Paper      | Generic Elective Course III: Environmental Biotechnology |
| Programme / Subject     | MSc — Biotechnology                                      |
| Semester                | Semester II                                              |
| Nature of Course        | Generic Elective (GE)                                    |
| L – T – P               | 3 – 1 – 0                                                |
| Credits                 | 4                                                        |
| Maximum Marks           | 100 (ESE: 70 + Internal Assessment: 30)                  |
| Duration of Examination | 3 Hours                                                  |

## C.2 Marks Distribution



|                                 |                                                                                                                                                                                                                                  |                                 |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| V                               | <b>Biopesticides:</b> Bacterial, viral and fungal biopesticides and their applications, Integrated Pest Management<br><b>Microbial mining:</b> Microbial enhanced recovery of mineral resources; Use of microbes in oil recovery | 8–10                            |
| <b>Total Suggested Lectures</b> |                                                                                                                                                                                                                                  | <b>60 (For 4 Credit Course)</b> |

### C.6 Prescribed Textbooks

1. Chatterji, A.K. (2018). Introduction to Environmental Biotechnology. PHI Learning.
2. Sayler, G.S. (2019). Environmental Biotechnology. McGraw-Hill.
3. Rittmann, B.E. (2020). Environmental Biotechnology: Principles and Applications. McGraw-Hill.
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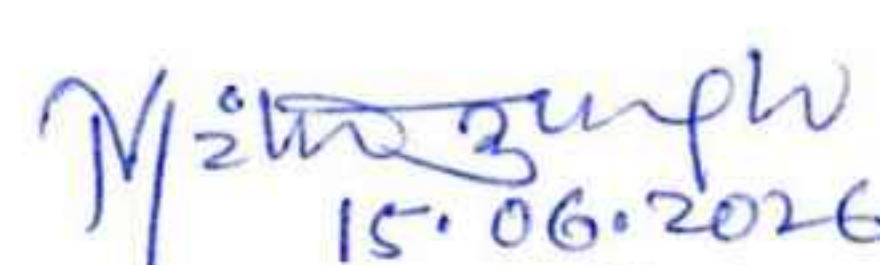
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### C.8 Suggested E-Resources / Digital Repositories

- SWAYAM: Laboratory Techniques in Biology
- e-PG Pathshala: Biochemical Techniques4545
- e-PG Pathshala: Molecular Biology Techniques
- NDL



## E.2 Authentication

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| <b>Subject Expert-1</b><br><br><b>Prof. Birendra Prasad</b><br>Department of Biotechnology<br>Patna University, Patna<br>Date: 14.06.2026 | <b>Subject Expert-2</b><br><br><b>Dr. Mithilesh Kumar Singh</b><br>Dr. Rajendra Prasad Central Agricultural<br>University, Pusa, Samastipur<br>Date: 14.06.2026 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

24/07/26

Kalpana Srivastava  
Officer on special duty (Judicial)