

As Per NEP 2020

University of Mumbai



Syllabus for Minor Vertical – 2 (Scheme – III)

Faulty of Science

Board of Studies in Zoology

Second Year Programme in Minor (Zoology)

Semester	III & IV	
Title of Paper	Sem.	Total Credits 4
Cytology	III	2
Laboratory Exercises on Cytology		2
Title of Paper	Sem.	Total Credits 4
Genetics and heredity	IV	2
Laboratory Exercises on Genetics and Heredity		2
From the Academic Year	2025-26	

Semester – III

Minor

**Syllabus
B.Sc. (Zoology)
(Semester – III)**

Title of Paper: Cytology

Sr. No.	Heading	Particulars
1	Description of the course: Including but not limited to:	Cytology is the study of the structure, function, and behavior of cells. Knowledge of cell biology is crucial for advancements in medicine, biotechnology, and genetics. It plays a key role in disease diagnosis, treatment, and addressing environmental challenges. Consequently, it has wide-ranging applications in fields such as cancer research, genetic engineering, agriculture, and many others. This dynamic field continues to evolve with discoveries in molecular biology and bioinformatics. Cell biology is closely linked to genetics, biochemistry, microbiology, biotechnology, and medicine. As a result, there is high demand for cell biologists in pharmaceuticals, healthcare, and biotech industries. Career opportunities include roles as research scientists, biomedical scientists, lab technicians, and positions in academia and biotech firms.
2	Vertical:	Minor (M2)
3	Type:	Theory
4	Credit:	2 credits (1 credit = 15 Hours for Theory in a semester)
5	Hours Allotted:	30 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives: • To discuss the structural and functional organization of cell with an emphasis on nucleus, plasma membrane and mitochondrion. • To describe the endomembrane system and cytoskeletal structures along with their functions.	
8	Course Outcomes: Upon completion of the course, the learners should be able to: • Identify and differentiate the cell organelles on the basis of their structure. • Compare functions of cell organelles and their significance.	

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Module 1: Cytology – I**1.1 Introduction to cell biology**

3hrs

1.1.1 Definition, history and scope of cell biology

1.1.2 Cell theory and its modern version

1.1.3 Prokaryotic and eukaryotic cell: size, shape and structure

1.2 Plasma membrane

4hrs

1.2.1 Plasma membrane – Fluid Mosaic model

1.2.2 Cell Junctions

1.2.3 Trans-membrane transport

1.2.4 Membrane receptors

1.2.5 Exocytosis and Endocytosis

1.2.6 Functions of plasma membrane

1.3 Nucleus

4hrs

1.3.1 Size, shape, and structure

1.3.2 Structure of nuclear membrane and pore complex

1.3.3 Nuclear lamina, formation of nuclear envelope

1.3.4 Nucleolus: General organization and functions

1.3.5 Functions of interphase nucleus

1.4 Mitochondrion

4hrs

1.4.1 Structure of mitochondrion

1.4.2 Functions of mitochondria

1.4.3 Bioenergetics

- Chemical energy & ATP

- Krebs's Cycle

- Electron Transport Chain / Oxidative Phosphorylation

Module 2: Cytology – II**1.5 Endomembrane System**

9hrs

1.5.1 Endoplasmic reticulum – Structure and Functions

- SER

- RER

1.5.2 Golgi apparatus – Structure and Functions

1.5.3 Lysosomes – Structure and Functions

1.5.4 Polymorphism in lysosomes

1.5.5 GERL system

1.5.6 Vacuoles – Structure, Functions and Types

1.5.7 Peroxisomes – Structure and Functions

1.6 Cytoskeletal structures

4hrs

1.6.1 Microtubules, microfilament and intermediate filaments

1.6.2 Cilia, Flagella and Sperm tail

1.6.3 Microvilli

1.7 Cell division

2hrs

1.7.1 Cell cycle

1.7.2 Cell division: Mitosis, and Meiosis

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References:

- De Robertis E.D.P, E.M.F. De Robertis Jr. (2010): Cell and Molecular Biology, Publisher Walters Kluwer, ISBN: 9788184734508.
- Dr. C. B. Powar (2010): Cell Biology, Himalaya Publishing House, ISBN 978-9350246696.
- Dr. P. S. Verma & Dr. V. K. Agarwal (2004): Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S Chand Publishing, ISBN 9788121924429.

	• Dr. P. S. Verma & Dr. V. K. Agarwal (2022): Cell Biology (Cytology, Biomolecules and Molecular Biology) LPSPE, S Chand Publishing, ISBN 978-9355011022. • N. Arumugam (2019): Cell Biology and Molecular Biology, Saras Publication, ISBN 978-9386519627. • P. K. Gupta (2018-19): Cell and Molecular Biology, Rastogi Publications, ISBN 978-9350781548. • P. K. Gupta (2018-19): Cell Biology, Rastogi Publications, ISBN 978-9350781203. • Geoffrey M. Cooper (2018): The Cell: A Molecular Approach, Sinauer Associates is an imprint of Oxford University Press, ISBN 978-1605357072. • S. C. Rastogi (2002): Cell Biology, New Age International Pub, ISBN 978-8122413977. • Singh Tomar, Cell Biology, Rastogi ISBN 9788171339693. • Suruchi Tyagi and Dr. Seema Awasthi (2022): A Textbook of Cytology, Dominant Publishers & Distributors (P) Ltd., ISBN 978-81-78886-16-9. • Veer Bala Rastogi (2021): A Text Book of Cell Biology and Genetics, Kedar Nath Ram Nath, ISBN 978-9380803524.	
11	Internal Continuous Assessment: 40%	External, Semester End Examination 60% Individual Passing in Internal and External Examination
12	Continuous Evaluation through: Quizzes, Class Tests, Presentation, Project, Role play, Creative writing, Assignment etc. (at least 3)	

**Syllabus
B.Sc. (Zoology)
(Semester – III)**

Title of Paper: Laboratory Exercises on Cytology

Sr. No.	Heading	Particulars
1	Description of the course: Including but not limited to:	This hands-on practical course in cytology provides students with essential laboratory skills to study cell structure, and function.
2	Vertical:	Minor (M2)
3	Type:	Practical
4	Credit:	2 credits (1 credit = 30 Hours for Practical work in a semester)
5	Hours Allotted:	60 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives: - To enable learners to identify cell structures of prokaryotes and cell organelles of eukaryotes. - To enable learners to differentiate between prokaryotic cells and eukaryotic cells and measure cell-size by using oculometer. - To acquaint learners to different microscopic techniques used in cell biology.	
8	Course Outcomes: Upon completion of the course, the learners should be able to: - Recognize different cell structures of prokaryotes and cell organelles of eukaryotes. - Differentiate between prokaryotic cells and eukaryotic cells, and calculate cell-size of any given cell. - Justify a particular microscopic technique used to a particular cell type.	
9	1. Measurement of cell-size using oculometer and stage micrometer. 2. Study of the cell organelles (ultrastructure): - Nucleus (Euchromatic and heterochromatic) - Mitochondria (various shapes) - Golgi Bodies (various shapes) - Lysosomes (Multivesicular bodies, Residual Bodies) - Vacuoles - Centrioles - Rough Endoplasmic Reticulum (RER) 3. Study of permeability of cell through plasma membrane (osmosis in blood cells). 4. Study of prokaryotic cells (bacteria) by Crystal violet staining technique. 5. Study of eukaryotic cells (WBCs) from blood smear by Leishman's stain. 6. Study of structure of Prions, Viroids, Bacteriophages and Mycoplasma with examples.	

	7. Study of microscopic techniques: • Simple Microscopy • Compound Microscopy • Phase contrast Microscopy • Fluorescence Microscopy • Scanning Electron Microscopy • Transmission Electron Microscopy • Immuno-Electron Microscopy 8. Mounting of cells for observation of mitosis using suitable material (Onion root tips). 9. Mounting of cells for observation of meiosis using suitable material (<i>Tradescantia</i> buds).	
10	References: • Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., ... & Walter, P. (2015). Essential cell biology. Garland Science. • Celis, J. E. (Ed.). (2006). Cell biology: a laboratory handbook (Vol. 1). Elsevier. • Chaitanya, K. V. (2013). Cell and Molecular Biology: A Lab Manual. PHI Learning Pvt. Ltd. • Cooper, G. M., & Adams, K. (2022). The cell: a molecular approach. Oxford University Press. • https://www.egyankosh.ac.in/bitstream/123456789/68533/3/BBCCL-104.pdf • Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons.	
11	Internal Continuous Assessment: 40%	External, Semester End Examination 60% Individual Passing in Internal and External Examination
12	Continuous Evaluation through: Quizzes, Class Tests, Presentation, Project, Role play, Creative writing, Assignment etc. (at least 3)	

Semester – IV

Minor

Syllabus
B.Sc. (Zoology)
(Semester – IV)

Title of Paper: Genetics and heredity

Sr. No.	Heading	Particulars
1	Description of the course: Including but not limited to:	The course provides a strong foundation in genetics and heredity, covering key topics such as Mendelian inheritance, chromosomal mechanisms, and gene expression. It then progresses to more advanced subjects like mutations, genetic disorders. These concepts are crucial for breakthroughs in medical genetics, biotechnology, and forensic science. With the rising demand in healthcare, pharmaceuticals, and bioinformatics, the course opens up diverse career opportunities in research, diagnostics, and genetic counselling. Additionally, it complements studies in biotechnology, biochemistry, and environmental science, promoting interdisciplinary innovation and real-world applications.
2	Vertical:	Minor (M2)
3	Type:	Theory
4	Credit:	2 credits (1 credit = 15 Hours for Theory in a semester)
5	Hours Allotted:	30 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives: • To familiarize learners to the foundational principles of Mendelian inheritance and provide insight into the mechanisms of sex determination and sex linkage. • To acquaint learners to the genetic basis of chromosomal aberrations and genetic disorders, and acquaint the learners with advanced diagnostic techniques.	
8	Course Outcomes: Upon completion of this course, students will be able to: • Explain the foundational principles of Mendelian inheritance and gain insight into the mechanisms of sex determination and sex linkage. • Analyse the genetic basis of chromosomal aberrations and genetic disorders, along with identifying the advanced diagnostic techniques for these aberrations and disorders.	

Module 1: Genetics and heredity – I

1.1 Introduction 1.1.1 Definition, Scope and Importance of Genetics. 1.1.2 Brief explanation of the following terms: Allele, Wild type and Mutant alleles, Locus, Dominant and Recessive traits, Homozygous and Heterozygous, Genotype and Phenotype, Genome, Cistron, Muton, Recon.	01hr
1.2 Mendelism and heredity 1.2.1 Mendel's laws of inheritance (Law of segregation, Law of Dominance, Law of Independent Assortment) 1.2.2 Test cross, Back cross 1.2.3 Chromosomal basis of inheritance	4hrs
1.3 Extension of Mendelism 1.3.1 Dominance relationships: Complete Dominance, Incomplete Dominance and Co-dominance 1.2.2 Lethal Alleles (Dominant, recessive and intermediate lethal) 1.2.3 Multiple Alleles 1.2.4 Polygenic Inheritance 1.2.5 Epistasis	7hrs
1.4 Linkage: Concept and Types – Complete and Incomplete	01hr
1.5 Crossing Over: Stern's experiment, mechanism and types	01hr
1.6 Extrachromosomal / Maternal inheritance	01hr

Module 2: Genetics and heredity – II

2.1 Sex determination and sex linkages 2.1.1 Types of sex determination (XX/XO, XX/XY, ZZ/ZW and haplo-diploidy) 2.1.2 Genic balance theory 2.1.4 Environment and sex determination – <i>Bonelia</i> and crocodiles 2.1.4 Sex linked determination – Colour blindness, haemophilia, hypertrichosis of the ear 2.1.5 Sex-influenced and sex-limited traits	4hrs
2.2 Nondisjunction and its implications 2.2.1 Deletion and its types 2.2.2 Duplication and its types 2.2.3 Inversion 2.2.4 Translocation	3hrs
2.3 Genetic disorders 2.3.1 Inborn errors of metabolism (PKU, Alkaptonuria, Albinism, G6PD deficiency) 2.3.2 Single gene disorder (cystic fibrosis) 2.3.3 Multifactorial (Breast cancer) 2.3.4 Genetic imprinting / Uniparental disomy (Prader-Willi and Angelman syndrome)	4hrs
2.4 Detection of disorders/diseases and chromosomal abnormalities 2.4.1 Karyotype 2.4.2 Banding (G, C, FISH)	2hrs
2.5 Genetic counselling and Pedigree analysis (Symbols and types) 2.5.1 Genetic counselling (Introduction, process, ethical and legal issues) 2.5.2 Pedigree analysis (Symbols and types)	2hrs

10	References: • Fraser, G. R., Mayo, O. (1975). Textbook of Human Genetics. Blackwell Scientific. ISBN 9780632089901, 0632089903. • Griffiths, A. J. (2004). An Introduction to Genetic Analysis. WH Freeman and Company. ISBN 0716749394. • Hartl, D. L. (2018). Essential genetics and genomics. 7th edition. Jones & Bartlett Learning. ISBN 9781284152456, 1284152456. • Mange, E. J., Mange, A. P. (1999). Basic Human Genetics. United States: Sinauer Associates, Incorporated. ISBN 9780878934973, 0878934979. • Pierce, B. A. (2020). Genetics: a conceptual approach. 7th edition. Macmillan International Higher Education. ISBN 2019952819, 9781319297145. • Russell, P. J. (2009). Genetics. 3rd edition. San Francisco: Benjamin Cummings. ISBN 0321569768, 9780321569769. • Simmons, M. J., & Snustad, D. P. (2015). Principles of genetics. 7th edition. John Wiley & Sons. ISBN 1119142288, 9781119142287. ONLINE TOOLS AND WEB RESOURCES • https://swayam.gov.in/courses/4922-genetics-and-genomics • https://www.coursera.org/learn/genetics-evolution • https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/ • https://learn.genetics.utah.edu/
11	Internal Continuous Assessment: 40% External, Semester End Examination 60% Individual Passing in Internal and External Examination
12	Continuous Evaluation through: Quizzes, Class Tests, Presentation, Project, Role play, Creative writing, Assignment etc. (at least 3)

Syllabus
B.Sc. (Zoology)
(Semester – IV)
Title of Paper: Laboratory Exercises on
Genetics and Heredity

Sr. No.	Heading	Particulars
1	Description of the course: Including but not limited to:	This hands-on practical course in genetics and heredity provides students with essential laboratory skills to study heredity, and molecular mechanisms governing life. Covering fundamental topics such as Mendelian inheritance, chromosomal organization, and gene expression, the course progresses to advanced concepts like mutations, and genetic disorders. Students will gain experience in DNA extraction, gel electrophoresis, and karyotyping.
2	Vertical:	Minor (M2)
3	Type:	Practical
4	Credit:	2 credits (1 credit = 30 Hours for Practical work in a semester)
5	Hours Allotted:	60 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives: - To acquaint learners to genetic analysis techniques, including karyotyping, pedigree analysis, and chromosomal staining. - To develop skills in solving problems based on inheritance patterns, linkage, and genetic abnormalities.	
8	Course Outcomes: Upon completion of this course, students will be able to: - Demonstrate skills in genetic analysis through practical techniques such as chromosome staining, blood group identification, and linkage mapping. - Interpret and evaluate genetic disorders, inheritance patterns, and chromosomal abnormalities using problem-solving approaches.	
9	- Observation of Barr bodies – staining and mounting. - Mounting of Polytene chromosomes from salivary glands of Chironomus larvae. - Study of Mitotic Index. - Identification of Blood groups. - Problems based on monohybrid, dihybrid, test cross and back cross. - Determination of linkage and cross-over analysis (through two-point test cross and three-point test cross data). - Identification and preparation of idiograms – Normal male, normal female. - Identification and preparation of idiograms –Turner's Syndrome, Klinefelter's Syndrome, Down's Syndrome, Patau's Syndrome, Edwards Syndrome, Cri-du-chat Syndrome, D-G Translocation.	

	9. Pedigree analysis – identification of symbols and problems. 10. Interpretation of genetic formulae: Deletion, duplication, inversion and translocation. 11. Submission of report on inheritance of suitable genetic traits in humans. (e.g. Rolling of tongue, attached ear lobes, widow's peak, etc.)	
10	References: • Fraser, G. R., Mayo, O. (1975). Textbook of Human Genetics. Blackwell Scientific. ISBN 9780632089901, 0632089903. • Griffiths, A. J. (2004). An Introduction to Genetic Analysis. WH Freeman and Company. ISBN 0716749394. • Hartl, D. L. (2018). Essential genetics and genomics. 7th edition. Jones & Bartlett Learning. ISBN 9781284152456, 1284152456. • Mange, E. J., Mange, A. P. (1999). Basic Human Genetics. United States: Sinauer Associates, Incorporated. ISBN 9780878934973, 0878934979. • Pierce, B. A. (2020). Genetics: a conceptual approach. 7th edition. Macmillan International Higher Education. ISBN 2019952819, 9781319297145. • Russell, P. J. (2009). Genetics. 3rd edition. San Francisco: Benjamin Cummings. ISBN 0321569768, 9780321569769. • Simmons, M. J., & Snustad, D. P. (2015). Principles of genetics. 7th edition. John Wiley & Sons. ISBN 1119142288, 9781119142287. ONLINE TOOLS AND WEB RESOURCES • https://swayam.gov.in/courses/4922-genetics-and-genomics • https://www.coursera.org/learn/genetics-evolution • https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/ • https://learn.genetics.utah.edu/	
11	Internal Continuous Assessment: 40%	External, Semester End Examination 60% Individual Passing in Internal and External Examination
12	Continuous Evaluation through: Quizzes, Class Tests, Presentation, Project, Role play, Creative writing, Assignment etc. (at least 3)	

QUESTION PAPER PATTERN (External and Internal)

S. Y. B. Sc. Zoology evaluation pattern and question paper pattern for semester end theory examination of minor courses

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for Semester End Examination
Continuous Evaluation through: Quizzes, Class Tests, Presentation, Project, Role play, Creative writing, Assignment, etc. (10 Marks), Viva (5 marks) Overall performance (5 Marks) Total (20 Marks)	As per paper pattern	01.00 hour

Format of Theory Question Paper: Semester End Examination

Time 1.0 Hr

Max. Marks 30

Attempt any two out of four:

Q. 1. Answer the following:	
a. Module I	05
b. Module I	05
c. Module II	05
Q. 2. Answer the following:	
a. Module II	05
b. Module II	05
c. Module I	05
Q. 3. Answer the following:	
a. Module I	08
b. Module II	07
Q. 4. Answer the following:	
a. Module II	08
b. Module I	07

**S. Y. B. Sc. Zoology Evaluation pattern and Question paper pattern for Semester End
Practical Examination of Minor Course**

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for Semester End Examination
Continuous Evaluation through: Assignment / Objective test (10 Marks), Viva (5 marks) Overall performance (5 Marks) = 20 Marks	As per paper pattern	2 hrs

Format of Practical Question Paper: Semester End Examination

Time 2 hrs

Max. Marks 30

Q.1 One Major experiment	10
Q.2 One Minor experiment	07
Q.3 Identification (any four)	08
Q.4 Journal & Viva	05

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S. Y. B. Sc. Zoology: Semester – III
Skeleton Question Paper pattern for Practical Examination
S3MNP Laboratory Exercises on Cytology

Duration: 2 hrs

Total Marks: 30

Major (10)

Q.1 Measure the size of the given cell sample using oculometer and stage micrometer.

OR

Q.1 Stain prokaryotic cells (bacteria) by Crystal violet staining technique.

OR

Q.1 Mount the given tissue to show Mitosis / Meiosis.

Minor (07)

Q.2 Demonstrate permeability of cell through plasma membrane (osmosis in blood cells).

OR

Q.2 Stain eukaryotic cell (WBCs) from blood smear by Leishman stain.

Q.3 Identify and describe. (08)

- a) Nucleus (Euchromatic and heterochromatic) / Mitochondria (various shapes) / Golgi Bodies (various shapes)
- b) Lysosomes (Multivesicular bodies, Residual Bodies) / Vacuoles / Centrioles / Rough Endoplasmic Reticulum (RER)
- c) Prions / Viroids / Bacteriophages / Mycoplasma
- d) Simple Microscopy / Compound Microscopy / Phase contrast Microscopy / Fluorescence microscopy / Scanning Electron Microscopy / Transmission Electron Microscopy / Immuno-Electron Microscopy

Q.4 Journal and viva (05)

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S. Y. B. Sc. Zoology: Semester – IV
Skeleton Question Paper pattern for Practical Examination
S3MNP Laboratory Exercises on Genetics and Heredity

Duration: 2 hrs

Total Marks: 30

Major

- Q.1 a)** Mounting of Barr bodies. (06)
b) Calculation of mitotic index. (04)

OR

- Q.1** Mount polytene chromosomes from salivary glands of *Chironomus* larvae. (10)

Minor

- Q.2.** Interpretation of genetic formulae (2 problems). (07)

OR

- Q.2** Identification and preparation of ideogram (any one syndrome). (07)
and explain the causes and characteristics of the same.

- Q.3 a)** Problems (any one) based on monohybrid, dihybrid, test cross and back cross, epistatic interactions, linkage and cross-over analysis. (04)
b) Identification of Pedigree symbols (any 4). (04)

OR

- Q.3** Identify blood group of the given blood sample. (08)

- Q.4** Journal and submission of report on inheritance of suitable genetic trait. (05)

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 - 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sd/-
Sign of the BOS
Coordinator
Dr. Vaishali U. Somani
BOS in Zoology

Sd/-
Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology

Sd/-
Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology