UNIVERSITY OF MUMBAI

SYLLABUS
For the
PET EXAMINATION
In

LIFE SCIENCES
(with effect from March 2020 onwards)

Cover Page

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Item No. _____

UNIVERSITY OF MUMBAI

Sr. No.	Heading	Particulars
1	Title of the Course	Pre-entrance test (PET) for Ph. D.
2	Eligibility for admission	-
3	Passing Marks	-
4	Ordinances / Regulations (if any)	-
5	No. of Years / Semesters	-
6	Level	P.G. ~~/ U.G./ Diploma / Certificate~~ **(Strike out which is not applicable)**
7	Pattern	Yearly / Semester **(Strike out which is not applicable)**
8	Status	~~New~~ / Revised **(Strike out which is not applicable)**
9	To be implemented from Academic Year	From March 2020 onwards.

Date: 20th April 2020 Signature : Indu Anna George

Name of BOS Chairman / Dean: Dr. Indu Anna George. (BOS Chairperson).

Preamble:

The syllabus for the Pre-Entrance Test for Ph. D. (PET) in Life Sciences has been designed in accordance with the Minimum Standards and Procedure for the award of M. Phil. and Ph. D. degrees as described in the VCD of 2018 (No. Exam./Thesis/Univ./VCD/947 of 2018).

This syllabus has been drafted for encouraging the candidates to infer, associate and be prepared with the skills and methodology that would be required for research in Life Sciences. The test itself would be a conscious endeavour to assess the candidates' knowledge of the subject and acumen for research.

This syllabus has been presented in two parts. Part I expands the fundamentals of Research Methodology whereas Part II is devoted to the essence of the wide range of disciplines that is embraced in Life Sciences.

The test itself would be conducted online at locations specified by the University of Mumbai. It would consist of a 100 multiple choice questions (MCQs) where each question would be of 1 mark. The maximum marks that could be thus obtained in the test would be 100.

The candidate would have to attempt two papers of 50 marks each. The first paper (Paper I) would be on Research Methodology, research aptitude, comprehension, logic, reasoning, communication and general knowledge. The second paper (Paper II) would have questions related to Life Sciences. The candidate would be required to obtain an aggregate of 50% or above (Paper I and II taken together) to qualify the test.

A relaxation of 5% would be allowed (i.e. 50% to 45%) to those candidates who belong to the reserved category or are differently abled or belong to other categories as prescribed by the Government of Maharashtra.

The PET certificate would be issued by the University of Mumbai online.

Requests for revaluation or photocopies of the test would not be entertained.

PART I

RESEARCH METHODOLOGY

A. Introduction to research, Definition, Objectives of research

B. Types of research: Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical.

C. Research approach: Quantitative and qualitative approach.

D. Literature review

E. Formulation of hypothesis

F. Research designs:

1. Defining the research problem: Selecting and defining the problem.
2. Need for a research design, features of a good design.
3. Types of research designs- Explorative/ descriptive/ experimental/ Survey/ Case Study.

G. Sampling techniques for research:

1. Sample design-Criteria of selecting a sampling procedure.
2. Characteristics of a good sampling design.
3. Different types of sample designs and size of sample.

H. Methods and tools of data collection:

1. Collection of primary data: Observation method, Interview method, Questionnaire method, case study method.
2. Collection of secondary data.
3. Selection of appropriate method of data collection.

I. Data processing and management:

1. Processing operations: Editing, coding, classification, tabulation.
2. Use of data entry software (MS Excel & SPSS).
3. Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in research.

4. Basic Approaches to Ethics; Post humanism and Anti-Post humanism.
5. Applying for ethical approval/ clearance.
6. Need for peer-review, publication of research findings (Impact factor, Citation index).

J. Role of statistics in research:

1. Measures of central tendency.
2. Measures of dispersion.
3. Normal distribution and normal curve.
4. Testing of Statistical Hypothesis.
5. Type I and Type II errors.
6. Guidelines for selecting an appropriate test.

K. Presentation of data and report writing:

1. Graphical representation of data in various ways.
2. Preparation of research report/Publication of scientific research articles.
3. Research Proposal Writing and proposal writing for Funding and Academic Purposes.

L. Ethics in research:

1. Bioethics: Definition – moral, values, ethics and ethics in biology
2. Role and importance of ethics in research.
3. Basic Approaches to Ethics; Post humanism and Anti-Post humanism.
4. Applying for ethical approval/ clearance.
5. Need for peer-review, publication of research findings (Impact factor, Citation index).

M. Information search and data retrieval

1. Use of the internet to extract evidence.
2. Tools for web search/ web search engines (PubMed, Cochrane Databases, Google Scholar, ResearchGate).
3. Data mining of biological databases.

PART II

SUBJECT SPECIFIC TOPICS

- Environmental Sciences:
- Evolution
- Animal Sciences
- Plant Sciences:
- Microbiology
- Genetics
- Biochemistry
- Cell Biology
- Cell communication and Signalling.
- Molecular Biology and Recombinant Technology.
- Analytical Techniques.

Environmental Sciences:

A. **Ecosystems:** structure, function and dynamics of ecosystem, components, Habitat and niche, Food web and energy flow, productivity and biogeochemical cycles, ecological succession.
B. **Types of ecosystems**: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine), ecosystem modelling and resource management and conservation.
C. **Community ecology**: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
D. **Biodiversity**: Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, biodiversity management approaches.
E. **Species interactions**: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
F. **Population ecology**: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal.
G. **Environmental health**: Environmental stress and adaptation, effects of pollution on living systems, environmental pollutants related human disorders, biomonitoring indicators, bioremediation and phytoremediation of pollutants.
H. **Toxicology**: Basic principles of toxicology including LD50 and ED50, management of acute intoxication, Biochemical and Genetic mechanism of natural detoxification.
I. **Renewable energy** and biofuels

J. **Conservation biology**: Principles of conservation, major approaches to management, conservation strategies and cryopreservation.

Evolution:

A. **Emergence of evolutionary thoughts**: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; speciation; Mendelism; spontaneity of mutations; the evolutionary synthesis.
B. **Origin of cells and unicellular evolution**: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.
C. **Molecular Evolution** using suitable examples.

Animal Sciences:

A. Animal diversity and Taxonomy: Five kingdom system of Classification, General classification of Invertebrates and Vertebrates.

B. Animal Physiology - maintenance of homeostasis:

1. **Haematology and Cardiovascular system**: Blood cell types, functions and haematopoiesis.
2. **Comparative anatomy of heart structure** and circulatory system, cardiac cycle and blood pressure.
3. **Respiratory system** : Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination
4. **Digestive system :** Digestion, absorption, energy balance, BMR
5. **Excretory system :** Comparative physiology of excretion, kidney, urine formation

C. Animal Physiology - Control and Coordination:

1. **Nervous System :** Neurons and glial cells, resting membrane and action potential, neurotransmission of impulses; gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system,
2. **Sensory systems :** Vision, Olfactory, Auditory, Taste and Somatosensory
3. **Endocrine System :** Endocrine glands, basic mechanism of hormone action,

4. **Immune System :** Innate and adaptive immune response, cells and organs involved in immunity, antigens, structure and function of antibody molecules, generation of antibody diversity, monoclonal antibodies, MHC molecules, antigen processing and presentation, B and T cell receptors, activation and differentiation of B and T cells, humoral and cell- mediated immune responses, the complement system, hypersensitivity, immune response during infections, Vaccines

D. Animal Physiology - Reproduction and Developmental Biology

1. **Reproduction:** Asexual and Sexual reproduction, Parthenogenesis and Hermaphroditism, Male and female Reproductive physiology, gametogenesis and ovulation

   Hormonal regulation of reproduction.

2. **Concepts of development**: Potency, commitment, specification, induction, competence, determination and differentiation
3. **Early development:** Fertilization and zygote formation, cleavage, blastula formation, gastrulation, neurulation

Plant Sciences:

A. Plant Taxonomy:

B. The plant cell wall: Architecture and composition.

C. Transportation: Loading, unloading and transport through xylem, phloem and plasmodesmata.

D. Photosynthesis - Light harvesting complexes, photoprotective mechanisms, chloroplast electron transport chain, ATP synthesis; Carbon fixation by the C3, C4 and CAM pathways, photorespiratory pathway.

E. Nitrogen assimilation, metabolism and symbiotic nitrogen fixation.

F. Plant Hormones: Biosynthesis and biological activity of auxins, cytokinins, gibberellins, Ethylene, Abscissic acid, Salicylates, Jasmonates and Brassinosteroids.

G. Plant Reproduction: Self incompatibility, Double fertilization and seed formation.

H. Sensory Photobiology and its role in plant development: Phytochromes, Cryptochromes, phototropins; photoperiodism and biological clocks.

I. Plant Development: Factors affecting seed germination, apical meristems and the development of the root, shoot, leaf and flowers.

J. Stress response: Plant response to abiotic (water, salt and temperature)

K. **Plant defence methods**: Anatomy, secondary metabolites, hypersensitive reactions, hormonal signals. Host recognition and establishment of disease, biotic (viral, fungal and insects) stress, R - avr system.
L. **Secondary metabolites of plants**: Terpenes, Phenolics, Alkaloids, biosynthesis and their roles in plants.
M. **Programmed Cell Death and Senescence** in plants: Concept and factors that affect programmed cell death.

Genetics:

A. **Mendelian Genetics and its Modifications:** Dominant and recessive, alleles, multiple alleles, pseudoalleles, Codominance, incomplete dominance, Lethal and Essential Genes, Pleiotropy and Epistasis,
B. **Cytoplasmic inheritance:** organelle genetics, maternal inheritance.
C. **Microbial genetics:** transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating.
D. **Quantitative genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping, linkage and crossing over.
E. **Population Genetics:** gene pool, gene frequency, Hardy Weinberg Law and its role in evolution and speciation, Pedigree analysis.
F. **Gene mapping methods:** Linkage maps for linkage testing, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
G. **Human pedigree analysis:** Pedigree symbols, construction and analysis of pedigrees.

Biochemistry:

A. **Structure of molecules and bonds**: Atoms, molecules, chemical bonds and other interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction).
B. **Composition, structure, function and metabolism:** Carbohydrates, Lipids, Amino acids and Proteins; Nucleotides and Nucleic acids; vitamins.
C. **Biophysical chemistry:** pH, buffer, reaction kinetics, thermodynamics, colligative properties
D. **Bioenergetics:** Glycolysis, oxidative phosphorylation, coupled reactions, group transfer, biological energy transducers.
E. **Catalysis**: Enzymes and enzyme kinetics, enzyme regulation, enzyme extraction and purification, mechanism of enzyme catalysis, isozymes
F. **Conformation of proteins:** Primary, secondary, supersecondary, tertiary and quaternary structure; Ramachandran plots.
G. **Conformation of nucleic acids**: DNA (helix; A, B, Z), types of RNA

Cell Biology:

A. **Importance, structure and function at molecular level of the following in the cell:** Plasma membrane, Nucleus, Rough and Smooth Endoplasmic reticulum, cytoskeleton, lysosomes, peroxisomes, mitochondria, chloroplasts, vacuoles and oil bodies, protein bodies in plants.
B. **Molecular details of the Cell Cycle and its regulation:** Stages of the cell cycle, cyclins, CDKs and the activation of the cyclin-CDK complexes. G1 cyclins, start/ restriction point, S phase cyclin, DNA replication, molecular details of mitosis: Prophase, Metaphase, anaphase, telophase, exit from mitosis and meiosis. Cell cycle regulation.

Cell communication and signalling

A. **Concept of cell surface receptors, second messengers and regulation of the signalling pathway**.
B. **Signalling pathways:** (a). Receptor tyrosine kinases (RTK): EGF signalling (b). JAK-STAT pathway. (c). G protein coupled receptors. (d). Bacteriorhodopsin signalling. (e). Toll-like receptors (in immunology) (f). Two component signalling: (i) Bacterial – chemotaxis, quorum sensing. (ii). Plant two component signalling.
C. **Components and functions of extracellular matrix**: Fibres, cell adhesion molecules and gap junctions.
D. **Cancer**: cell cycle anomaly; oncogenes, virus induced cell transformation, metastasis and treatment.
E. **Apoptosis**: Concept, signalling pathways, role in development and maintenance and effects of aberrant apoptosis

Molecular Biology and Recombinant DNA Technology:

A. **Structure of Gene:** Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene.
   Other elements of Eukaryotic Genome: Satellite DNA, Tandem repeat array, Transposons: LINE and SINE.

B. **DNA replication:** Unit of replication and enzymes involved (Prokaryotes and Eukaryotes) replication origin and replication fork, fidelity and processivity of replication, extrachromosomal replicons (plasmid).

C. **DNA repair:** Direct repair, Excision of base pair, Post replicative, SOS.

D. **Recombination:** Homologous and Non Homologous.

E. Transcription:

i)Transcription in prokaryotes: *E.coli* RNA polymerase, transcription activators and repressors, initiation, elongation and termination, processing of tRNA and rRNA in *E. coli*.

ii) Transcription in Eukaryotes - RNA Polymerases of eukaryotes and their promoters. Formation of initiation complex, capping, elongation & termination, RNA processing, RNA editing, major and minor splicing systems, polyadenylation. Eukaryotic rRNA genes, formation of eukaryotic tRNA molecules,

F. Translation: Outline of Translation.

The Genetic Code: The Decoding System, Codon-Anticodon interaction.

Ribosomes: the special properties of the prokaryotic and eukaryotic ribosomes, ribosome biogenesis.

Translation process: initiation, elongation and termination factors of prokaryotes and eukaryotes mechanisms to overcome premature translation termination, role of suppressor tRNAs.

Inhibitors of protein synthesis: Prokaryotic and eukaryotic protein synthesis inhibitors and their significance.

G. Genomic Mutations: Mutagenic agents and types of mutations (Addition, deletion, frame shift, Insertion, Inversions and Translocations).

H. Regulation of Gene expression in Prokaryotes: Transcriptional regulation - inducible and repressible system, positive regulation and negative regulation; Operon concept – lac, trp, Ara operons, the galactose operon, relative positions of Promoters and Operators, Regulons, Master switches, Regulation of Translation, Regulation of the synthesis of Ribosomes, Unregulated changes in gene expression, Feedback Inhibition, RNA interference, mRNA half-life, riboswitches, ribozymes.

I. Gene expression in Eukaryotes: Regulatory strategies in Eukaryotes, Transcriptional Control by hormones, signalling factors and environmental factors, Role of transcription factors, enhancers, silencers, chromatin remodelling in regulation of gene expression, role of post-translational modifications in transcription initiation, Regulation of processing, Regulation through RNA splicing, RNA degradation and RNA interference, Translational control, Regulation of gene expression in plant cells by light. Diseases associated with defects in regulation.

Recombinant DNA Technology:

A. Introduction to Genetic Engineering

B. **Restriction Endonucleases**: Restriction Endonuclease: Type I, Type II, Type III, Restriction mapping.
C. **DNA Joining Strategies**, DNA ligase, Homopolymer tailing, Adaptors.
D. **Cloning Vectors**: Basic properties of plasmids, pBR322 as vector, pUC as vector,
E. **Expression vectors**, Cosmid vectors, P element as a vector, Mammalian vectors, Ti Plasmid.
F. **Cloning strategies**: Shotgun Cloning: Genomic DNA libraries, cDNA cloning.
G. **Screening and selection strategies**: Direct Selection e.g. antibiotic resistance, GFP, LacZ, Immunochemical screening, Nucleic acid hybridization method.
H. **Sequencing Genes and Genomes**: Chain termination method of DNA sequencing, Next generation sequencing.
I. **Polymerase Chain Reaction** - Principle and application
J. **Applications of Genetic Engineering** in agriculture, Medicine, Animal husbandry, Forensics and Archaeology.
K. **Human Genome Project** and Genome wide association studies.

Microbiology:

A. **Microbial diversity:** Bacteria, Archaea and their outline of classification; Eukaryotic microbes: Yeasts, molds and protozoa (General characteristics)
B. **Viruses** - Structure and life cycle
C. **Prokaryotic Cell Structure**: Cell wall, cell membrane and nucleoid; Flagella and motility; cell inclusions like endospores, gas vesicles.
D. **Microbial Growth:** Growth curve; Mathematical expression of exponential growth phase; Synchronous growth; Effect of environmental factors on growth; diauxic growth.
E. **Chemotherapy/Antibiotics:** General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.
F. **Host Parasite Interaction:** Recognition, mechanism of microbial pathogenicity and establishment of disease by different pathogens like viruses, bacteria and parasites into animal hosts (one example each). Nosocomial infection and Emerging infectious diseases.
G. **Industrial Microbiology:** Batch, Fed - Batch and Continuous culture, Types of fermenters, Products of Industrial importance (primary and secondary metabolites)

Analytical Techniques

A. **pH and buffers:** Principles and theory, pH meters.
B. **Colorimetry and spectroscopy**: Beer- Lambert laws, types of spectra- absorbance, emission, fluorescence and action spectra, single and double beam spectrophotometers, and their applications.
C. **Microscopy**: Basic principles and instrumentation for optical, phase contrast, interference, fluorescence, confocal and electron microscopes and their applications.
D. **Microtomy**: Principles and types, sample preparation and sectioning parameters.
E. **Centrifugation**: Principles and types, simple and differential, ultracentrifugation – preparative and analytical.
F. **Chromatography**: Principle, methodology and applications of chromatography using (paper, thin layer and columns (gel filtration, ion exchange, affinity, gas, HPLC and FPLC).
G. **Electrophoresis**: Principles and types of electrophoresis and their applications for proteins, nucleic acids, pulse-field gel electrophoresis
H. **X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MRI – fMRI)**
I. **Radioisotope methods and tracer techniques in biology**: Basic principles of radioactivity, Geiger- Muller and scintillation counters, autoradiography, radionuclide imaging, CT Scan and PET scan
J. **Immunological Techniques**: Immunoprecipitation - single and double, ELISA and RIA
K. **Molecular Biology Techniques** : Primers, PCR and its types, RFLP, RAPD, AFLP, Blotting techniques: Southern, Western
L. **Biosensors:** Concept, structure, amperometric and potentiometric biosensors.