There will be two papers in the subject:
Paper I: Theory: 3 hours ... 70 marks
Paper II: Practical: 3 hours ... 15 marks
Project Work ... 10 marks
Practical File ... 5 marks

PAPER I- THEORY: 70 Marks

S. No.	UNIT	TOTAL WEIGHTAGE
1.	Reproduction	16 Marks
2.	Genetics and Evolution	15 Marks
3.	Biology and Human Welfare	14 Marks
4.	Biotechnology and its Applications	10 Marks
5.	Ecology and Environment	15 Marks
TOTAL		**70 Marks**

PAPER I –THEORY – 70 Marks

All structures (internal and external) are required to be taught along with diagrams.

1. Reproduction

i. Reproduction in Organisms

Reproduction, a characteristic feature of all organisms for continuation of species; modes of reproduction - asexual and sexual reproduction; asexual reproduction - binary fission, sporulation, budding, gemmule formation, fragmentation; vegetative propagation in plants.

Definition of life span; life span of a few organisms (banana, rice, rose, banyan, butterfly, fruit fly, tortoise, crocodile, parrot, crow, elephant, dog, horse, and cow).

Asexual reproduction – definition, types (binary fission in Amoeba and Paramoecium, budding in yeast and Hydra, conidia in Penicillium, zoospores in Chlamydomonas, gemmules in sponges), definition of clone.

Vegetative propagation – definition, vegetative propagules (tuber of potato, rhizome of ginger, bulbil of Agave, leaf buds of Bryophyllum, offset of water hyacinth, runner of grass, sucker of pineapple, bulb of onion).

Sexual reproduction: Plants – definition, phases of life cycle (juvenile/vegetative, reproductive and senescence), unusual flowering phenomenon (bamboo and Strobilanthes kunthiana). Animals – continuous and seasonal breeders (definition, differences and examples).

Events in sexual reproduction – prefertilisation (gametogenesis and gamete transfer in plants and animals), chromosome number in the cells of house fly, fruit fly, butterfly, human beings, rat, dog, maize, apple, onion, cat, rice, Ophioglossum; fertilization

(definition, types - external and internal), post-fertilisation (embryogenesis), definition and example of parthenogenesis, differences between asexual and sexual reproduction.

ii. Sexual reproduction in flowering plants

Flower structure; development of male and female gametophytes; pollination - types, agencies and examples; outbreeding devices; pollen-pistil interaction; double fertilization; post fertilization events - development of endosperm and embryo, development of seed and formation of fruit; special modes - apomixis, parthenocarpy, polyembryony; Significance of seed dispersal and fruit formation.

Pre-fertilisation structures and events.

Structure of microsporangium, T.S. of anther microsporogenesis, structure and development of pollen grain, viability of pollen grain, economic importance of pollen grain. Pistil – structure of megasporangium (L.S. of anatropous ovule), megasporogenesis, structure and development of female gametophyte.

Types of pollination (autogamy, chasmogamy, cleistogamy, geitonogamy, xenogamy), adaptations in flowers pollinated by wind, water and insects. Advantages of self and cross-pollination. Contrivances for prevention of self-pollination. Pollen-pistil interaction in terms of incompatibility/compatibility, events leading to fertilisation, definition of triple fusion and double fertilization, changes in the ovary and ovule for seed and fruit formation. Significance of double fertilization. Apomixis, polyembryony, parthenocarpy to be explained briefly. Fruits to be classified into true and false, structure (L.S) of a typical fruit (mango and coconut); Internal structure of dicot (bean) and monocot (maize) seeds; definition, differences and examples of albuminous and non-albuminous seeds. Significance of seed and fruit formation. Significance of dispersal of seeds.

Post-fertilisation events - embryo formation (monocot and dicot); types of endosperm (cellular, nuclear and helobial); definition of perisperm.

iii. Human Reproduction

Male and female reproductive systems; microscopic anatomy of testis and ovary; gametogenesis - spermatogenesis and oogenesis; menstrual cycle; fertilisation, embryo development upto blastocyst formation, implantation; pregnancy and placenta formation (elementary idea); parturition (elementary idea); lactation (elementaryidea).

Organs of male and female reproductive system and their functions; internal structure of testis and ovary to be taught with the help of diagrams; gametogenesis spermatogenesis (including spermiogenesis and spermiation) oogenesis; hormonal control of gametogenesis, structure of sperm and mature ovum, menstrual cycle - different phases and hormone action, differences between oestrous and menstrual cycle, menarche and menopause, physico-chemical events during fertilisation, implantation, embryonic development up to blastocyst formation, important features of human embryonic development (formation of heart, limbs, digits, appearance of hair on head, eyelashes, separation of eye lids, external genital organs and first movement of foetus with reference to time period) placenta and its functions. Parturition; lactation – hormonal control and importance.

iv. Reproductive Health

Need for reproductive health and prevention of Sexually Transmitted Diseases (STDs); birth control - need and methods, contraception and medical termination of pregnancy (MTP); amniocentesis; infertility and assisted reproductive technologies - IVF, ZIFT, GIFT (elementary idea for general awareness).

Definition of reproductive health, programs of reproductive health (family planning, RCH), population explosion - role of government in controlling the population, contraceptives methods and their methods of action (natural-periodic abstinence, withdrawal or coitus interruptus, lactational amenorrhea; artificial – barriers, IUDs, oral pills, implants and surgical methods, definition of medical termination of pregnancy (MTP) and reasons for it; causes of infertility. Amniocentesis and its role in detecting genetic defects. Assisted reproductive technologies: IVF, IUT, ZIFT, ICSI, GIFT, AI, IUI. - definition and application only. Causes, symptoms and methods of prevention of sexually transmitted diseases (gonorrhoea, syphilis, genital herpes, chlamydiasis, genital warts, trichomoniasis, hepatitis- B, AIDS).

2. Genetics and Evolution

i. Principles of inheritance and variation

Heredity and variation: Mendelian inheritance; deviations from Mendelism - incomplete dominance, co-dominance, multiple alleles and inheritance of blood groups, pleiotropy; elementary idea of polygenic inheritance; chromosomal theory of inheritance; chromosomes and genes; sex determination - in humans, fruit fly, birds and honey bee; linkage and crossing over; mutation; sex linked inheritance - haemophilia, colour blindness; Mendelian disorders in humans; chromosomal disorders in humans.

Explanation of the terms heredity and variation; Mendel's Principles of inheritance; reasons for Mendel's success; definition of homologous chromosomes, autosomes and sex chromosomes; alleles – dominant and recessive; phenotype; genotype; homozygous; heterozygous, monohybrid and dihybrid crosses; back cross and test cross, definitions to be taught with simple examples using Punnett square. Incomplete dominance with examples from plants (snapdragon - Antirrhinum) and co-dominance in human blood group, multiple alleles – e.g. blood groups, polygenic inheritance with one example of inheritance of skin colour in humans (students should be taught examples from human genetics through pedigree charts. They should be able to interpret the patterns of inheritance by analysis of pedigree chart). Biological importance of Mendelism. Pleiotropy with reference to the example of Phenylketonuria (PKU) in human beings and starch synthesis in pea seeds. Chromosomal theory of inheritance; autosomes and sex chromosomes (sex determination in humans, fruit fly, birds, honey bees and grasshopper), sex-linked inheritance - with reference to Drosophila (colour of body-yellow and brown; and colour of eyes-red and white), and man (haemophilia and colour blindness), definition and significance of linkage and crossing over. Mutation: spontaneous, induced, gene (point – transition, transversion and frame-shift); chromosomal aberration: euploidy and aneuploidy; human genetic disorders: phenylketonuria, thalassaemia, colour blindness, sickle cell anaemia; chromosomal disorders: Down's syndrome, Klinefelter's syndrome, Turner's syndrome.

ii. Molecular basis of Inheritance

Search for genetic material and DNA as genetic material; structure of DNA and RNA; DNA packaging; DNA replication; central dogma; transcription, genetic code, translation; gene expression and regulation - lac operon; human and rice genome projects; DNA fingerprinting.

Structure of eukaryotic chromosomes with reference to nucleosome; properties of genes such as ability to replicate, chemical stability, mutability and inheritability. Search for DNA as genetic material - Griffith's experiment, Hershey and Chase's experiment, Avery, McLeod and McCarty's experiment; double helical model of DNA (contributions of Meischer, Watson and Crick, Wilkins, Franklin and Chargaff); Differences between DNA and RNA; types of RNA (tRNA, mRNA and rRNA, snRNA, hnRNA); central dogma – concept only; reverse transcription (basic idea only), Meselson and Stahl's experiment, replication of DNA (role of enzymes, namely DNA polymerase and ligase), transcription, posttranscriptional processing in eukaryotes (splicing, capping and tailing). Intron, exon, cistron, (definitions only). Discovery and essential features of genetic code. Definition of codon. Protein synthesis - translation in prokaryotes. Gene expression in prokaryotes; lac operon in E. coli.

Human Genome Project: goal; methodologies [Expressed Sequence Tags (EST), Sequence Annotation], salient features and applications. DNA finger printing – technique, application and ethical issues to be discussed briefly. Rice Genome Project (salient features and applications).

iii. Evolution

Origin of life; biological evolution and evidences for biological evolution (palaeontology, comparative anatomy, embryology and molecular evidences); Darwin's contribution, modern synthetic theory of evolution; mechanism of evolution - variation (mutation and recombination) and natural selection with examples, types of natural selection; gene flow and genetic drift; Hardy - Weinberg's principle; adaptive radiation; human evolution.

Origin of life - abiogenesis and biogenesis, effect of oxygen on evolution to show that reducing atmosphere is essential for abiotic synthesis. Important views on the origin of life, modern concept of origin of life, Oparin Haldane theory, definition of protobionts, coacervates), vestigial organs; Miller and Urey experiment. Evidences of evolution: morphological evidences, definition and differences between homologous and analogous organs (two examples each from plants and animals). Embryological evidences – theory of recapitulation, definition and differences between ontogeny and phylogeny. Palaeontological evidence – definition of fossils. Geological time scale (with reference to dominant flora and fauna) Biogeographical evidence – definition of biogeography, molecular (genetic) evidences -for example genome similarity, universal genetic code; Darwin's finches (adaptive radiation).

Lamarckism: brief idea of Lamarck's theory, evidences in favour of Lamarckism such as evolution of long neck of giraffe to be discussed. Darwinism: salient features of Darwinism, contribution of Malthus, criticism of Darwinism. Examples of natural selection – Long neck of giraffe, industrial melanism, resistance of mosquitoes to DDT and resistance of bacteria to antibiotics, Lederberg's replica plating experiment, Neo-

Darwinism (Modern Synthetic Theory); Variation - causes of variation, Hugo de Vries theory of mutation - role of mutation in evolution; Hardy Weinberg's principle, factors affecting Hardy Weinberg equilibrium: gene migration or gene flow, genetic drift (Founder's effect, bottle-neck effect), mutation, genetic recombination and natural selection, types of natural selection (directional, disruptive and stabilizing). Evolution of man - three features of each of the ancestors Dryopithecus, Ramapithecus, Australopithecus, Homo habilis, Homo erectus, Homo neanderthalensis, Cro-magnon man and Homo sapiens leading to man of today.

3. Biology and Human Welfare

i. Human Health and Diseases

Pathogens; parasites causing human diseases (common cold, dengue, chikungunya, typhoid, pneumonia, amoebiasis, malaria, filariasis, ascariasis, ring worm) and their control; Basic concepts of immunology - vaccines; cancer, HIV and AIDS; Adolescence - drug and alcohol abuse.

Communicable and non-communicable diseases; modes of transmission, causative agents, symptoms and prevention; viral diseases (common cold, chikungunya and dengue), bacterial diseases (typhoid, pneumonia, diphtheria and plague), protozoal diseases (amoebiasis, and malaria, graphic outline of life cycle of Plasmodium), helmintic diseases (ascariasis, and filariasis); fungal (ringworm); cancer - types of tumour (benign, malignant), causes, diagnosis and treatment, characteristics of cancer cells (loss of contact inhibition and metastasis).

Immunity (definition and types – innate and acquired, active and passive, humoral and cell-mediated), Interferons – definition, source and function; structure of a typical antibody molecule, types of antibodies - IgG, IgA, IgM, IgD and IgE (function and occurrence, e,g. in serum, saliva, colostrum); vaccination and immunisation, allergies and allergens – definition and general symptoms of allergies; autoimmunity, primary and secondary lymphoid organs and tissues, brief idea of AIDS – causative agent (HIV), modes of transmission, diagnosis (ELISA), symptoms, replication of retrovirus in the infected human cell (including diagram) and prevention.

Alcoholism and smoking - effects on health.

Drugs: effects and sources of opioids, cannabinoids, cocaine and barbiturates.

Reasons for addiction; prevention and control of alcohol and drug abuse.

ii. Strategies for enhancement in food production

Improvement in food production: green revolution, plant breeding, tissue culture, single cell protein, bio fortification, apiculture and animal husbandry.

Measures for proper maintenance of dairy farms and poultry farms; apiculture and pisciculture – definition, brief idea and advantages of each.

Animal breeding - brief idea of inbreeding, out-breeding, cross-breeding and artificial insemination, Multiple Ovulation Embryo Transfer Technology (MOET). Advantages of artificial insemination.

Plant breeding – a brief reference to green revolution. Steps in plant breeding (germplasm collection, evaluation, selection, cross hybridisation or artificial hybridisation (concept of emasculation and bagging), selection and testing of superior recombinants, testing, release and commercialisation of new cultivars), advantages of mutation breeding, examples of some Indian hybrid crops like wheat, rice, maize, sugarcane, millet. Definition of heterosis and inbreeding depression.

Application of plant breeding for (i) disease resistantance [examples of some disease resistant varieties of crops for example wheat (Himgiri), Brassica (Pusa swarnim), cauliflower (Pusa shubhra, Pusa snowball K– 1), Cow pea (Pusa komal), chilli (Pusa sadabahar)],(ii) insect resistance [examples of some insect resistant varieties of crops – Brassica (Pusa Gaurav), flat bean (Pusa sem 2, Pusa sem 3), okra (Pusa sawani, Pusa A–4)], (iii) improved food quality (bio fortification, e.g., wheat – Atlas 66, maize hybrids, iron fortified rice). Tissue culture (technique and application – micro propagation, somaclones, disease free plants and somatic hybridisation), single cell protein – source and significance.

iii. Microbes in Human Welfare

In household food processing, industrial production, sewage treatment, energy generation and microbes as biocontrol agents and bio fertilisers. Antibiotics.

Use of microbes in: (i) Household products: Lactobacillus (curd), Saccharomyces (bread), Propionibacterium (Swiss cheese); (ii) Industrial products: beverages (with and without distillation), antibiotics (Penicillin – discovery and use); sources (microbes) and uses of organic acids, alcohols and enzymes (lipase, pectinase, protease, streptokinase) in industry, source (microbes) and applications of Cyclosporin-A, Statins. (iii) Sewage treatment – primary and secondary treatment; (iv) Production of biogas (methanogens, biogas plant, composition of biogas and process of production); (v) Microbes as biocontrol agents (ladybird, dragonfly, Bacillus thuringiensis Trichoderma, Nucleopolyhedrovirus (Baculovirus), and (vi) Microbes as biofertilisers (Rhizobium, Azospirillum, Azotobacter, Mycorrhiza, Cyanobacteria), IPM, harmful effects of chemical pesticides.

4. Biotechnology and its Applications

i. Biotechnology - Principles and processes

Genetic Engineering (recombinant DNA technology).

Definition and principles of biotechnology; isolation of genomic (chromosomal) DNA (from bacteria/plant cell/animal cell, by cell lysis), isolation of gene of interest (by electrophoresis), steps of formation of recombinant DNA, discovery, nomenclature, features and role of restriction enzymes (EcoRI, HindII) and role of ligase; cloning vectors (features of a good cloning vector, examples of cloning vectors like pBR322, Agrobacterium, retroviruses, bacterial artificial chromosome (BAC), yeast artificial chromosome (YAC)), methods of transfer of rDNA into a competent host, e.g. by direct method (temperature shock), microinjection, gene gun, methods of selection of recombinants (antibiotic resistance, insertional inactivation/blue-white selection), cloning of recombinants, i.e., gene amplification (by in vivo or in vitro method -using

PCR technique), bioreactor (basic features and uses of stirred tank and sparged tank bioreactors), downstream processing.

ii. Biotechnology and its applications

Applications of biotechnology in health and agriculture: human insulin and vaccine production, stem cell technology, gene therapy; genetically modified organisms - Bt crops; transgenic animals; biosafety issues, biopiracy and biopatents.

In agriculture: for production of crops tolerant to abiotic stresses (cold, drought, salt, heat); pest-resistant crops (Bt-crops, RNAi with reference to Meloidogyne incognita); crops with enhanced nutritional value (golden rice).

In medicine: insulin, gene therapy - with reference to treatment of SCID, molecular diagnosis by PCR, ELISA and use of DNA/RNA probe.

Transgenic animals for bioactive products like alpha-1-antitrypsin for emphysema, alpha-lactalbumin; vaccine safety testing, chemical safety testing; study of diseases.

Role of GEAC, definition and two examples of biopiracy, biopatent; ethical issues.

5. Ecology and Environment

i. Organisms and Populations

Organisms and environment: habitat and niche, population and ecological adaptations; population interactions -mutualism, competition, predation, parasitism; population attributes - growth, birth rate and death rate, age distribution.

Definition of ecology; major biomes of India – Tropical rain forests, deciduous forests, deserts and sea coasts (their annual temperatures and precipitation). Definition of habitat and niche.

Definition of population; population attributes: sex ratio, types of age distribution pyramids for human population; definition of population density, natality, mortality, emigration, immigration, carrying capacity. Ways to measure population density. Calculation of natality and mortality.

Population growth: factors affecting population growth and population growth equation; growth models: exponential growth and logistic growth along with equations, graph and examples of the same; life history variations: definition of reproductive fitness and examples.

Population interactions – definition of mutualism, competition (interspecific, interference, competitive release and Gause's Principle of Competitive Exclusion), predation (adaptations in organisms to avoid predation), parasitism (ecto-, endo-, and brood parasites), commensalism, amensalism.

ii. Ecosystem

Ecosystems: patterns, components; productivity and decomposition; energy flow; pyramids of number, biomass, energy; nutrient cycles (carbon and phosphorous);

ecological succession; ecological services - carbon fixation, pollination, seed dispersal, oxygen release (in brief).

Definition and types of ecosystems; structure of ecosystem (brief idea about biotic and abiotic components).

Effects of abiotic factors (temperature, water, light, soil) on living organisms, definition of stenothermal, eurythermal, stenohaline and euryhaline), responses to abiotic factors (regulate, conform, migrate, suspend); ecological adaptations: morphological, physiological and behavioural in response to loss of water and extremes of temperature in plants and animals including humans. Allen's rule.

Structure and function of pond ecosystem; ecosystem functions: (i) Productivity – gross primary productivity (GPP), net primary productivity (NPP) and secondary productivity (ii) Decomposition (fragmentation, leaching, catabolism, humification and mineralization), factors affecting rate of decomposition (iii) Energy flow. Various types of food chains – grazing and detritus, food webs, trophic levels, ecological pyramids – energy, number and biomass (iv) Nutrient cycle – definition of biogeochemical cycles – gaseous cycle (Carbon) and sedimentary cycle (Phosphorous).

Definition of PAR, 10% Law, standing crop and standing state.

Succession: definition to explain the meaning, kinds of succession (hydrarch, xerarch; primary and secondary succession with examples), definition of pioneer community, climax community and sere; significance of ecological succession.

Ecological services and their cost.

iii. Biodiversity and its Conservation

Concept of biodiversity; patterns of biodiversity; importance of biodiversity; loss of biodiversity; biodiversity conservation; hotspots, endangered organisms, extinction, Red Data Book, biosphere reserves, national parks, sanctuaries and Ramsar sites.

Definition of biodiversity, few examples of each type of biodiversity - species, ecosystem and genetic. Global biodiversity and proportionate number of species of major taxa of plants, invertebrates and vertebrates; patterns of biodiversity (latitudinal gradients, species-area relationship – graph and equation), "rivet popper hypothesis", importance of species diversity to the ecosystem (narrowly utilitarian, broadly utilitarian, ethical terms).

Examples of some recently extinct organisms, causes of loss of biodiversity (habitat loss and fragmentation, over-exploitation, alien species invasion, co-extinction).

Biodiversity conservation: In-situ methods - protected areas: biosphere reserves, national parks, wildlife sanctuaries, sacred groves; ex-situ methods - captive breeding, zoo, botanical gardens, cryopreservation, wild life safari, seed banks, tissue culture. Definitions and examples of each of the above. Hotspots, Ramsar sites and Red Data Book.

The place, year and main agenda of historic conventions on biological diversity (the Earth Summit and the World Summit).

iv. Environmental Issues

Air pollution and its control; water pollution and its control; agrochemicals and their effects; solid waste management; radioactive waste management; greenhouse effect and climate change; ozone layer depletion; deforestation; any one case study as success story addressing environmental issue(s).

Definition of pollution and pollutant; environmental issues: air pollution and its control, major sources of gaseous and particulate pollutants, control devices for air pollution such as: scrubbers and electrostatic precipitators, catalytic converter, CNG, Bharat stages, noise pollution: harmful effects and control; Water pollution, major sources and its control, composition of waste water, thermal pollution, eutrophication - cultural or accelerated, BOD, effect of sewage discharge on BOD and dissolved oxygen content in river; case studies of waste water treatment (FOAM and EcoSan); Soil pollution – sources, effects and control, agrochemicals and their harmful effects, integrated organic farming, contribution of Ramesh Chandra Dagar, bio magnification and bio concentration; solid waste management, Radioactive waste management, e-waste.

A brief understanding of the concept of deforestation (slash and burn agriculture or jhum cultivation's contribution), greenhouse effect. Impact of global warming in terms of climatic changes, rise in sea levels, melting of ice caps, El Nino effect; impact on animals and plants due to climate changes. Ozone depletion – causes, ozone hole, Dobson unit, effects on plants and animals, methods to control ozone depletion, Montreal protocol. The following case studies as success stories addressing environmental issues: Chipko Movement, Joint Forest Management, contribution of Ahmed Khan of Bangalore.

Main provisions of Environmental Acts — Environmental Protection Act, Water (prevention and control of pollution), Air (prevention and control of pollution act).

PAPER II

PRACTICAL WORK – 15 Marks

PROJECT WORK AND PRACTICAL FILE – 15 Marks