M.Sc. (Biotechnology) Syllabus for the off campus PG Centres of the University of Pune (2008-09)

COURSE STRUCTURE

T/P	CODE	TITLE	MARKS	HOURS
SEMESTER I				
T	BT 11	Advanced Biological Chemistry	100	60
T	BT 12	Molecular and Cell Biology	100	60
T	BT 13	Environmental Biotechnology	100	60
P	BT 14	Advanced Biological Chemistry (Practical)	100	60
P	BT 15a	Molecular and Cell Biology (Practical)	50	30
P	BT 15b	Techniques in Environmental Biotechnology (Practical)	50	30
SEMESTER II				
T	BT 21	Genetic Engineering	100	60
T	BT 22	Bioinformatics	100	60
T	BT 23	Plant Biotechnology	100	60
P	BT 24	Genetic Engineering (Practical)	100	60
P	BT 25a	Tools in Bioinformatics (Practical)	50	30
P	BT 25b	Applied Plant Tissue Culture (Practical)	50	30
SEMESTER III				
T	BT 31	Animal Biotechnology	100	60
T	BT 32	Fermentation Technology	100	60
T	BT 33 a	Principles of Virology	50	30
T	BT 33 b	Advanced Immunology	50	30
P	BT 34	Techniques in Animal Biotechnology (Practical)	50	30
P	BT 35a	Bioprocess Engineering (Practical)	50	30
P	BT 35b	Techniques in Virology and Immunology (Practical)	100	60
SEMESTER IV				
T	BT 41	Genomics and Proteomics	75	45
T	BT 42	Legal and Ethical Aspects in Biotechnology and IPR	75	45
T+P	BT 43	Clinical Research and Database Management	75	30+15
T+P	*BT44a	Nanobiotechnology	75	45
T	*BT44b	Stem Cell Technology and Regenerative Medicines	75	45
T	*BT44c	Agricultural Biotechnology	75	45
P	BT 45	Project (Practical)	200	120

*****Any one of these can be opted

N.B. For assessment of each course, 80% will be for Semester-end examination and 20% for internal assessment. Internal assessment will be continuous throughout the semester, and the marks should be submitted to the Examination section before the commencement of Semester-end examination.

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DETAILED SYLLABUS

Semester I:

BT 11 ADVANCED BIOLOGICAL CHEMISTRY 60L

General Biochemistry: Chemical basis of life, macromolecules- monomers, polymers, synthesis and degradation, Acid Base balance and its maintenance, thermodynamics, separation techniques- centrifugation, chromatography, electrophoresis etc.; quantitative estimation and structure determination by spectroscopy-UV-Visible, fluorescence, IR, NMR 18L

Protein Biochemistry: Proteins in solutions and in membrane – physical and chemical properties of soluble proteins, flexibility of protein structure, stability of folded confirmation, mechanism of protein folding; interactions with other molecules – structure of protein-ligand complexes, energetics and dynamics of binding, Allostery; Protein engineering – isolation of genes and expressing for protein synthesis, site directed mutagenesis; Protein Microarrays, strategies and applications 20L

Phytochemistry: Plants in medicine, types of secondary metabolites, origin of pharmacognosy, pharmacological activities of natural products, methods associated with phytochemical investigations of herbal products, variation in species, herbal medicines-regulations and practices worldwide. 10L

Metabolomics: Basic concepts-overview of cellular metabolism, introduction to pathways of primary and secondary metabolites, medicinal and agricultural importance of secondary metabolites; use of analytical techniques; metabolic pathway manipulations at enzyme and whole cell level, Metabolic flux-analysis and applications 12L

BT 12 MOLECULAR AND CELL BIOLOGY 60L

Cell structure and function: Types, structure and functions of plasma membrane, cell signaling: communication between cells and their environment, cytoplasmic membrane systems – structure functions and membrane trafficking, Aerobic respiration and the mitochondria, photosynthesis and the chloroplasts 25L

Cell biology of flowering plant and animals: plant - body, transport, response to environmental challenges, nutritional regulation of development, reproduction; **animals -** Physiology, Homeostasis, and temperature regulation, Hormones, reproduction, development, nutrition, gas exchange and behavior. 15L

Information and Heredity: Chromosomes and cell division, DNA and its role in heredity, genotype to phenotype-DNA to protein, Development-differential gene expression, Molecular biology and medicine, Natural defenses against diseases. 10L

Genotype to phenotype: genome project, mutation, polymorphism, interacting genes, genes in population- genetic variability and evolution, gene-environment interactions, pharmacogenomics, X-linked immunodeficiencies. 10L

BT 13 ENVIRONMENTAL BIOTECHNOLOGY 60L

Energy and Environment: Non-Conventional energy sources -
Hydroelectric, Wind, Tidal ocean, thermal energy, geothermal, solar energy collectors, Hydrogen, Magneto hydrodynamic, Nuclear energy, Chemical energy, Bio-energy (Energy from biomass) 12L

Environmental Pollution Monitoring and control: Air - Transport and diffusing of pollutants, Thermal inversion, Gas laws governing dispersion of air pollutants, Guassian plume model for pollution dispersion, Air Quality standards, Monitoring and control of Sox, Nox, Cox, SPM, RPM, Pm10; **Soil** - Physicochemical and bacteriological analysis of soil, Problems associated with soil alkali soils, sodic soils, and solid waste, Fate of insecticides fungicides, pesticides in soil, use of genetically modified (insect-, pest- and pathogen resistant) plants. Ecotoxicology of soil pollutants, Municipal solid waste treatment strategies; **Noise** - Measurement of noise, indices, Effect of meteorological factors on noise levels, Noise control and abatement, Impact on human health, Bioremediation-Biotechnology for clean environment. Biomaterials as substitutes for non-degradable materials. Bioremediation- Biotechnology for clean environment. 20L

Wastewater engineering: Waste water constituents, Analysis and selection of flow rates and loadings, Process Selection, Physical unit operations, Chemical unit operations, Fundamentals of biological treatment, Types and kinetics of biological treatment, Advanced waste water treatment, Treatment, reuse and disposal of biosolids 10L

Environmental Impact Assessment, Ecoplanning and Sustainable Development: Indian standards Is2490, Is3360, Is3307, Is2296, Iso 14000 series, Minas for Industries and Ecomarks, Public liability Insurance Act, ElA guidelines and assessment methods, Environmental priorities in India and agenda 21, Conservation Biotechnolohy, Remote sensing and Gis (Principal and applications in ecological mapping and environmental hazard predictions), Ecological modeling. Bioindicators and biosensors for detection of pollution. 18L

BT 14 ADVANCED BIOLOGICAL CHEMISTRY (PRACTICAL) – 60H

1. Laboratory safety, Introduction to measurements: balances and pipetting Preparation of solutions of given normality and its standardisation
2. Thin layer/paper/Column chromatography : proteins, lipids, hormones, secondary metabolites, mixture of dyes
3. Spectrophotometry: Estimations-proteins, chlorophyll, hormones; Derivatives and difference spectra: Indicators, cytochromes , haemoglobin; Analysis of Standard curves, linear regression and assessment of ranges and reliability
4. Enzyme assays b –galactosidase, LDH - time, temperature, protein concentration and cofactors. Km and Vmax, Various kinetic plots
5. Polyacrylamide gel electrophoresis : Native gel, SDS-PAGE

6. Preparation of beads and column packing for cationic/anionic exchange chromatography, to find out the capacity and nature of the cationic/anionic exchange resin
7. Gel filtration chromatography: Sepharose, Sephadex
8. DEAE cellulose chromatography of proteins, Nucleic acids, secondary metabolites, hormones
9. 2-D gel electrophoresis of proteins and isoelectrofocusing
10. Isolation and separation of secondary metabolites.

BT 15a MOLECULAR AND CELL BIOLOGY (PRACTICAL) – 30H

1. Isolation of chromatin: Determination of mononucleosomal size, Chromatin gel electrophoresis.
2. Isolation of genomic DNA from animal/plant and bacteria. Estimation and analysis of DNA by restriction digestion and Gel electrophoresis.
3. Demonstration of animal handling for experimental purposes: cervical dislocation, dissection of rat: cardiac puncture, blood sample preparation and its handling.
4. Osmotic fragility of RBCs.
5. Developmental studies: chick: developmental stages and Gastrulation.
6. Programmed cell death during embryonic development.
7. Cell types of plants - maceration of various tissue explants and identification of xylem vessels, trachieds, stomata, root hair etc.

BT 15b TECHNIQUES IN ENVIRONMENTAL BIOTECHNOLOGY (PRACTICAL)- 30H

1. Estimation of biomass from planktonic organisms.
2. Physicochemical and biological analysis of soil.
3. Qualitative and quantitative changes in pesticides/fungicides/insecticides.
4. Testing of cytotoxicity (onion root tip assay/pollen germination) of polluted water.
5. Biodegradation of environ-friendly materials

Semester II:

BT 21 GENETIC ENGINEERING 60L

Tools in genetic engineering: DNA modifying enzymes and restriction enzymes for GE, Vectors in gene cloning, Transformation and Transfection, cDNA and genomic DNA cloning and characterization. 15L

Expression strategies and methods for producing industrially important molecules:
Various expression vectors in bacteria and eukaryotes including shuttle vectors. Induced expression strategies and protocols. Chimeric constructs, Expression of industrially important products. 10L

Analytical techniques: PCR – design and optimization, use to engineer DNA, amplification of specific sequences from a cDNA library, use in diagnosis of diseases; DNA sequencing- Maxam-Gilbert method, Sanger's Dideoxy chain termination method, Automated DNA sequencing method. Sequencing strategies and analysis, and applications. Human genome sequencing: Genetic and physical mapping techniques, sequencing strategies, and gene annotation. 20L

Applications: Genetic diseases-Detection and Diagnosis, Gene therapy – *ex vivo, in vivo*, gene delivery systems, viral and non viral; DNA marker technology in plants,

DNA fingerprinting, Genetically engineered biotherapeutics and vaccines and their manufacturing, Transgenic plants. 15L

BT 22 BIOINFORMATICS 60L

Bioinformatics Algorithms and Tools: Publicly available databases; Visualisation of sequence data; Sequence alignment; Homology searching - including BLAST; Gene expression informatics; Introduction to gene finding 10L

Molecular Modeling, Drug designing and Chemoinformatics: Acquisition of chemical information - including molecular structures - from databases; Visualisation of molecules; Simulation of molecular interactions; Introduction to industry-standard modeling software. Energy Optimization techniques: golden section method, parabolic interpolation, conjugate gradient, Raphson, genetic algorithm; Structure based drug designing, locating binding sites in protein structure, SMILES- Simplified Molecular Input Line Entry System. 20L

Structural Bioinformatics: Protein structures, Ramchandran plot, protein folding-structure function relationship, conformational energy calculations, protein structure predictions, secondary and tertiary, protein structure classification-SCOP, CATH, Immunoinformatics-epitope prediction 15L

Bioinformatics: The Business of Research: Research methodology (focusing on computer-based research); Case studies of areas of current bioinformatics research; Routes to research funding (academic and commercial); Bioinformatics business models 15L

BT 23 PLANT BIOTECHNOLOGY 60L

Plant Biotechnology: Overview – concept, definition and landmarks 5L
Algal biotechnology – qualitative and quantitative improvement in economically important algae 5L

Fungal biotechnology – qualitative and quantitative improvement in economically important fungi (higher fungi) 10L

Seed plant biotechnology – qualitative and quantitative improvement in economically important seed plants 5L
Micropropagation - Advantages of tissue culture techniques over conventional methods for crop improvement. Plant growth regulators/retardants in plant tissue culture., Explant preparation- regeneration by organogenesis and somatic embryogenesis from callus and cell suspension culture, direct embryogenesis. 15L

Transgenics for stress tolerance, secondary metabolites, crop improvement somaclonal variation, somatic hybridization, haploids in plant breeding, increase in productivity by manipulation of photosynthesis, nitrogen fixation, nutrient uptake efficiency, biotic and abiotic stress tolerance-insects, fungi, bacteria, viruses, weeds, drought, salt, flooding and temperature, quality improvement of protein, lipids, carbohydrates. Plantibodies, plant-derived vaccines. 10L

Applications:

- Mass multiplication of economically important plants
- Biopesticides – Insecticides, Rodenticides and fungicides
- Biofertilizers & Vermiculture
- Phytoremediation
- Pharmaceuticals, Nutraceuticals and cosmaceuticals
- Biofuels 10L

- Single Cell Proteins

BT24 GENETIC ENGINEERING (PRACTICAL) – 60H

1. Isolation of plasmid DNA- i) minipreparation ii) large scale isolation
2. *In vitro* DNA ligation, transformation of *E.coli*
3. Characterisation of transformants: DNA gel electrophoresis, Restriction map analysis
4. Southern blot analysis
5. Isolation of cytoplasmic RNA
6. Electrophoresis of RNA on denaturing gels.
7. Separation of poly A^+ RNA on oligo-dT column
8. Northern and dot blotting technique.
9. cDNA synthesis and cloning
10. PCR/ RFLP technique
11. Agrobacterium mediated genetic transformation and recombinant selection,
12. Amplification of RAPD, ISSR, SSR and AFLP markers.

BT25a TOOLS IN BIOINFORMATICS (PRACTICAL) – 30H

1. Retrieval of sequences using ENTREZ
2. Sequence analysis using BLAT, Align, Lalign
3. Multiple sequence alignment and Phylogenetic analyzing using Clustal, ClustalW
4. Studying 3D structure using RASMOL
5. Homology Modeling using Swiss PDB – Hb, Protease
6. Calculation of Phi and Psi angle - Hb, Protease
7. Docking: protein-protein; protein-small molecules
8. Potential energy calculation of regular structures
9. To mutate protein and energy minimization using Swiss PDB viewer
10. Gene prediction – Gene D'cefer
11. Adhesion protein prediction – Sea path
12. Comparative proteomics and genomics – Proteome calculator
13. Protein annotation - PLHost

BT 25b APPLIED PLANT TISSUE CULTURE (PRACTICAL) – 30H

1. Virus propagation in cells, cytopathogenic response of cells to viruses
   or
   Chlorela and Spirulina culture and biochemical analysis of products.
2. In vitro production of secondary metabolites, assay of drugs
   or
   Hairy root culture for secondary metabolite production

3. In vitro induction of somatic embryogenesis
   Or
   Anther culture for haploid production

4. Protoplast isolation and fusion

5. Effect of plant growth regulators on various explants for callus induction, cell suspension culture, growth analysis, cell plating efficiency

Semester III:

BT 31 ANIMAL BIOTECHNOLOGY **60L**

Animal biotechnology: Overview-livestock breed and their productivity, artificial breeding-methods and hazards, Gene banking, conservation and exchange in India. Cell culture – types, maintenance, and kinetics of growth, genetics and applications. Stem cells – principles for identification, purifications, assessment of proliferation heterogeneity, long-term maintenance and characterization. 30L

Transgenic animals: artificial breeding – *in vitro* fertilization and embryo transfer, artificial insemination, germ cell storage, Genetic modifications – methods, integration of microinjected sequences into embryos – case study on mice, problems after developing transgenic animals. 30L

BT 32 FERMENTATION TECHNOLOGY **60L**

Introduction to fermentation: aerobic and anaerobic fermentations; Kinetics of growth and product formation - chemically structured models; mass transfer diffusion, membrane transport; Fermenter design - operation, measurement and control in fermentation; Aeration and agitation in fermentation: Oxygen requirement, measurement of adsorption coefficients, bubble aeration, mechanical agitation, correlation between mass-transfer coefficient and operating variables, hollow fibre reactors, immobilized cell reactors. 25L

Molecular engineering: Important strains and pathways – types, development of cultivations systems for aerobes and anaerobes, mutation and genetic engineering for strain improvements, product formation and inhibition pathways and their regulations; applications in medicine, agriculture and industry. 12L

Biotransformation: types, methods and processes, analysis and isolation of products, applications in waste management, medicine and agriculture; Biogas production – pathways, regulation/modulation, advanced biomethanation systems and their applications. 10L

Bioprocess technology: Down stream processing-Methods for vitamins, amino acids, organic acids, enzymes, antibiotics, alcohols and vaccines;
Applications of cells in bioprocesses (lactic acid bacteria, yeasts, mixed cultures, plant and animal cells); microbes as biocontrol agents and chemical factories.

13L

BT 33a PRINCIPLES OF VIROLOGY **30L**

Basic virology: 15L
Classification, morphology and ultrastructure
Viral replication: VSV, Pox/SV40, Polio & HIV

Viral replication: Bacteriophages
Infectivity assays
Viral Diagnosis
Antivirals and Vaccines

Epidemiology: Principles and applications 15L

Epidemiology with reference to HIV, measles as examples
Immunopathogenesis
Acute and persistent infections
Animal and poultry viruses
Plant viruses
New emerging viral diseases
Clinical trials: viral vaccines.

BT 33b ADVANCED IMMUNOLOGY 30L

Basic immunology: Immune system: cells, organs, tissues. Innate immunity vs. acquired immunity. Evoultion of immune response in plants, insects and mammals. Complement system. Cell-cell interaction and signal transduction during immune response; Transplant immunology. Parasitic immunology. Auto immunity, molecular mimicry, therapy. Hybridoma technology (Monoclonal antibody) and other techniques in molecular immunology. 15L

Advanced immunology: Animal models and transgenic animals and their use in immunological studies. Experimental immunology - Vaccine development, Stem cell technology; Chimeric antibodies, phage display, antibody engineering; Large scale manufacture of antibodies. Manufacturing of immuno-diagnostics, Recombinant vaccines, combined vaccines, polyvalent vaccines.

15L

BT 34 TECHNIQUES IN ANIMAL BIOTECHNOLOGY (PRACTICAL) – 30H

1. Study of embryonic induction during development in frog/chick
2. Initiation of mammalian cell culture and maintenance.
3. Growth studies by viable cell count analysis
4. Effect of growth factors on cell proliferation
5. In situ localization of antigens during cell proliferation by immunofluorescence microscopy.

BT 35a BIOPROCESS ENGINEERING (PRACTICAL) – 30H

1. Working of lab bench fermentor, industrial fermentor
2. Optimization of parameters for growth and product formation
3. Monitoring and control of fermentation parameters
4. Solid state fermentation – biogas production
5. Batch and continuous fermentation
6. Biotransformation

BT 35b TECHNIQUES IN VIROLOGY AND IMMUNOLOGY (PRACTICAL) – 60H

1. Electron microscopic observations of ultrastrucutre of animal viruses
2. Propagation of viruses in animals/tissue culture/embryonated eggs and preparation of virus
3. Microtitration - Haemagglutination technique, ELISA
4. Immunodiffusion
5. Immunoelectrophoresis
6. Rocket immunoelectrophoresis

7. Western blotting
8. Cell hybridization
9. Production of polyclonal antibodies and characterization.
10. Radioimmunoassay,
11. Immunofluorescence,
12. Agglutination, rosette-formation, complement fixation

Semester IV:

BT 41 GENOMICS & PROTEOMICS **45L**

Genomics 25L

Introduction to genomics, sequencing strategies for whole genome analysis, sequence data analysis.
Comparative genomics, genome annotation.
Structural genomics.
Functional genomics.
Global analysis of gene expression.
Transcriptomics and microarray.
Toxicogenomics.
Pharmacogenomics.

Proteomics 20L

Strategies in proteomics.
Structural/functional proteomics.
Proteomics methodologies.
Computational approach for studying protein–protein interactions.
Proteomics applicatioons: drug development, screening of diagnostic markers, identification and characterization of novel proteins.

BT 42 LEGAL AND ETHICAL ASPECTES IN BIOTECHNOLOGY AND IPR 45L

Basic Concepts of Intellectual Property: Introduction to intellectual property rights; Intellectual property laws; Trade Related Aspects of Intellectual Property Rights 5L

Forms of IPR like patent, design and copyright: 20L (8L+5L+7L)

Patents: Introduction to patent law and conditions for patentability; Procedure for obtaining patents; Rights of a patentee; Patent infringements; Biotechnology patents and patents on computer programs; Patents from an international perspective.
Copyright: Registration procedure and copyright authorities; Assignment and transfer of copyright Copyright infringement and exceptions to infringement; Software copyright;
Designs: Introduction to the law on Industrial Designs; Registration and piracy; International perspective; Registration, commercial exploitation and infringement

IPR laws: Rights/protection, infringement or violation, remedies against infringement: civil and criminal; Indian Patent Act 1970 and TRIPS; Major changes in Indian Patent system as post TRIPS effects; Contents of patent specification and the procedure for patents; (a) Obtaining patents; (b) Geographical indication; (c) WTO; Detailed information on patenting biological products; Plant breeders' and farmers' rights; Biodiversity; Budapest treaty; Appropriate case studies. 20L

BT 43 CLINICAL RESEARCH AND DATABASE MANEGEMENT 30L+15H P

The Establishment of the Food and Drug Administration; The History of the Legislation and Regulations, which Govern the Clinical Research Process; which Protect the Rights, Safety, and Well-Being of Human Subjects. 8L

Drug Discovery and Pre-Clinical Research: The Clinical Research and New Drug Application Approval Process; The Biologics Research, Development, and Licensing Process; Medical Device Research, Development, and Marketing. 12L

Clinical Trial Development and Management: Protocol Design and Development; Case Report Form Design and Development; Principals of Data Management and the Query Resolution Process; The Study Types Providing Expanded Access to Investigational Products; Essentials of Source Documentation: Maintaining and Managing Essential Documents; Recording and Reporting Non-Serious and Serious Adverse Events.

10L

Methods in clinical research - 15H

Metabolic studies; isotopic methods; imaging; immunoassays; techniques for genetic analysis (RFLP, pedigree analysis, etc.); application of tools of molecular biology, including DNA and RNA analysis; physiologic studies; receptor studies; kinetic analysis (including introduction to pharmacokinetics); laboratory quality control and normative values.

Conbinatronics: introduction, structural elements, synthesis- peptides, non peptides; libraries, solid phase peptide synthesis, multiple solid phase synthesis

BT 44a NANOBIOTECHNOLOGY 30L+15H P

Theory:

Introduction to Nanoworld, Nanoscience and Nanotechnology - nanoparticles, nanowires, thin films and multilayers 5L

Applications in various fields viz. Physical and Chemical, Materials, Life Sciences 5L

Nanobiotechnology: Introduction, Biomolecules as nanostructures and their applications in nanotechnology viz. Biosensors, separation of cells and cell organelles, drug delivery, gene therapy etc.

Synthesis of nanostructures :

Natural in inorganic, Natural in organism, chemical and physical methods -Sol Process, Micelle, Chemical Precipitation, Hydrothermal Method, Pyrolysis, Bio-based Protocol, Chemical Vapor Deposition, Sputtering etc. 14L

Functionalization of nanoparticles for biological applications. 4L

Recent trends in Nanobiotechnology. 2L

Practicals : - 15H

1. Synthesis of Al_2O_3 nanoparticles using sol gel method
2. Synthesis of Fe_2O_3 nanoparticles by chemical method
3. Synthesis of semiconductor (ZnS, CdS etc.) nanoparticles by chemical method
4. Synthesis of nanoparticles using biological process – (2-3 methods)
5. Detection of nanoparticles in colloidal solutions using UV-Vis absorption technique
6. Size determination of nanoparticles using laser beam

7. Functionalization of nanoparticles for biological application – (4-5 methods)
8. XRD Data analysis – case studies
9. Biological sample preparation for SEM
10. Analysis of AFM, SEM and TEM pictures.

BT 44b STEM CELL TECHNIQUES & REPRODUCTION 45L

Cells of Reproduction and Early Development:

Gametes and fertilization
Early development: Metabolic activation, cytoplasmic rearrangement, embryonic induction, cell lineages, pattern formation.
Embryonic stem cells, cell differentiation 20L

Committed Cells and Late Development:

Stem cells, Embryonic stem cells, differentiation.

ES cell technologies, Transgenics and knock outs.

Gene therapy.

Human cloning and Bioethics. 25L

BT 44c AGRICULTURAL BIOTECHNOLOGY 45L

Homozygous plant production through ovule, anther & pollen culture and their applications.
Embryo rescue & embryo culture in rearing viable hybrid embryos
Endosperm culture & production of triploids
Apomixis & experimental polyembryony
Micropropagation for multiplication of selected elite varieties of a) cereal, b) pulse and c) oil seed crops. 20L

Use of bioreactors in plant production & Scale-up –
Marker assisted technology, diagnostic kits & virus indexing
Biofertilizers, biopesticides
Transgenic crops- herbicide resistant, pest resistant, stress tolerant
Biotic & abiotic stress, source of secondary metabolites and edible vaccines, metabolic engineering 18L

Somaclonal and gametoclonal variations and their applications in crop improvement 2L

Case studies in agro-biotechnology –one each from a) cereal, b) pulse, c) oil seed crops. 5L

BT 45 PROJECT 120H