According to ICAR BSMA COMMITTEE 2021, restructuring of Mastersand Ph.D. (Biotechnology) Programme is proposed as:

Degree Nomenclature M.Sc/ M.Tech/ MVSc Biotechnology

Course Curriculum:

Major: 20 credits (12 credits of core + 8 credits of optional)

Course Code	Course Title	Credit hours
BT 501	Principles of Biotechnology	3+0
BT 502	Fundamentals of Molecular Biology*	3+0
BT 503	Molecular Cell Biology*	3+0
BT 504	Techniques in Molecular Biology I*	0+3
BT 505	Omics and Systems Biology*	2+1
BT 506	Genetic Engineering	3+0
BT 507	Techniques in Molecular Biology II	0+3
BT 508	Introduction to Bioinformatics	2+1
BT 509	Plant & Animal Tissue culture	2+1
BT 510	Microbial and Industrial Biotechnology	2+1
BT 511	Molecular Plant Breeding	2+1
BT 512	IPR, Bio-safety and Bioethics	2+0
BT 513	Immunology and Molecular Diagnostics	3+0
BT 514	Nano Biotechnology	2+1
BT 515	Environmental Biotechnology	3+0
BT 516	Bio-entrepreneurship	1+0
BT 517	Stress Biology and Genomics	2+0
BT 518	Gene Regulation	2+0

*Core course

Minor (8 credits) - From one of the related disciplines

Biochemistry

Microbiology

Physiology

Genetics and Breeding

Plant Genetic Resources

Plant Pathology

Bioinformatics

Note: As per the availability of faculties new disciplines can be introduced.

Student can take PG courses as minor from the related departmentsof the university.

Biochemistry

Microbiology

Genetics and Breeding

Statistics

Bioinformatics

Computer Application

Common courses (5 credits)

Course Code	**Course Title**	**Credit hours**
BT 519	Library and Information Services	(0+1)
BT 520	Technical Writing and Communications Skills	(0+1)
BT 521	Intellectual Property and its Management	(1+0)
BT 522	Basic Concepts in Laboratory Techniques	(0+1)
BT 523	Research Ethics and Rural Development Programmes	(1+0)

BT 591	Seminar 1

BT 599	Research 30
Total	**70**

DegreeNomenclature:Ph.D in Biotechnology

Course Curriculum:

Major: 12 credits (6 credits of core + 6 credits of optional)

BT 601	Advances in Molecular Biology*	**3+0**
BT602	Advances in Genetic Engineering*	**3+0**
BT 603	Omics and Molecular Breeding*	**3+0**
BT 604	Commercial Plant Tissue Culture	**2+0**
BT605	Plant Microbe interaction#	**2+0**
BT 606	RNA Biology	**1+0**
BT 607	Plant Hormones and Signaling#	**2+0**
BT 608	Computational and Statistical tools in Biotechnology#	**2+1**
BT 609	Advances in Animal Cell Culture	**2+1**
BT 610	Trends in Vaccinology	**2+1**
BT 611	Advances in Reproductive Biotechnology	**2+1**

*Core courses

Minor (6 credits) from (any one) of the following disciplines:

- Biochemistry
- Genetics and Breeding
- Microbiology
- Physiology

- Plant Pathology
- Bioinformatics

Note: As per availability of faculties new disciplines can be introduced

Students can take PG and PhD courses as minor from related departments of the university.

Supporting (5 credits) from the (any one) following disciplines:

- Biochemistry
- Genetics
- Microbiology
- Bioinformatics
- Computer Applications Statistics

Common Courses –

BT 691	Seminars I	**0+1**	
BT 692	Seminars II		**0+1**
BT 699	Researches		**0+75**
Total			**100**

Post Graduate (PG) – Ph.D. Academic Regulation

1. **Description:** A degree course of Master's and PhD shall comprise of the courses of study consisting for the curriculum and syllabus provided in these regulations and spread over a minimum of two and three academic years, respectively.

2. **Academic Year and Semester Calendar:** The academic year shall ordinarily be from first week of August to June. It shall be divided into two semesters of 105 days each. The semester calendar of each academic year shall be issued by the Dean Post Graduate Studies (Dean, PGS) before the start of the Academic session.

3. Admission to Master's/PhD Course

Admission to Master's/PhD programme shall be done on the basis of selection on merit basis.

No candidate shall be admitted to the Master/PhD course unless he/she has –

i. Passed Bachelor Degree in Veterinary Science / Biotechnology/ Fishery Science / Life Science / Pharmacy for MSc / MVSc and B.Tech courses in Biotechnology.
ii. Obtained a CGPA of not less than 6.0 on a ten point scale in case of candidates belonging to Unreserved (UR) and Other Backward Classes (OBCs) and a CGPA of not less than 5.5 on a ten point scale in case of candidates belonging to Scheduled Castes (SCs) and Scheduled Tribes (STs) categories in his/her Bachelor or Master's Degree. The respective formula will be converted in 4.0 scales for traditional system.

4. Selection of Students

i. To be eligible for seeking admission in any discipline, the candidate must have passed the concerned subject without any supplementary examination.

ii. One seat in each discipline in M.Sc, M.Tech and MVSc programme is reserved for the candidates to be nominated by Indian Council of Agricultural Research (ICAR), New Delhi based on the All India Joint Entrance test conducted by ICAR, New Delhi.

iii. In case of PhD admissions, one additional seat will be created and reserved for the candidates who qualify SRF examination by ICAR / in-service candidates of SAU'sThis seat will be for internal in-service candidate of DUVASU. In case it remains vacant will be given to in-service candidates of SAU/ICAR institutes on the basis of merit.

5. Reservation of Seats for Admission

The reservation policy of the Government of Uttar Pradesh will be followed for admissions to Master's and PhD programme(s), however, in the event of any seat falling vacant due to non-availability of applicants/candidates of a particular category from the reservation quota or UR or that reserved for ICAR, then such vacant seats shall be filled up with the students belonging to any other categories provided they have secured the minimum qualifying marks. The roster will be applicable on the total number of seats in Master's and PhD degree programme.

6. Time of Admission

Admission to Master's and PhD degree programmes shall be made at the commencement of the first semester of each academic year, unless, specified by the University Authority.

7. Counselling

Counselling for admission to the post graduate courses shall be held on the specified date as mentioned in the prospectus of the year or as notified by the Registrar.

ENROLLMENT, REGISTRATION AND CONTINUANCE

1. Enrolment

i. Students admitted to Master's or PhD programmes and the continuing students shall present themselves in the respective department in the College of Veterinary Science and Animal Husbandry/Office of the Dean, College of Biotechnology at the beginning of each semester on dates notified by the Registrar/Dean, PGS for advisement and registration, respectively.

2. Registration

Following advisement as prescribed above, registration and enrollment of candidatesselected for admission and registration of the continuing students shall be completed onscheduled date(s) notified earlier by Registrar/ Dean, PGS for each semester.

3. Mode of Registration

Registration shall consist of the following steps:

i. After getting the five registration cards signed from the concerned Instructor(s) and Headof Department, the students shall deposit the university fees and other dues.

ii. After depositing the fee, the student shall submit the duly completed and signedregistration cards in the office of the Dean, PGS.

iii. No registration will be allowed in absentia.

4. Registration of Fresh Students

Registration for the first semester of the year for Master's or PhD degree programme isa part of admission procedure and shall be governed by the admission rules. Admission ofnew students failing to register in the prescribed manner on the assigned date is liable to becancelled.

5. Registration of Continuing Students

Registration of the continuing students in the subsequent semester(s) shall be held in asimilar way on the date and time notified by the Registrar/ Dean, PGS.

6. Late Registration

A continuing student, who does not register on the day of registration, shall be requiredto pay a late registration fee at the rate of Rs. 100/- per day for next six days excludingholidays. Student failing to register within next 6 working days shall not be allowedregistration in that particular semester.

7. Suspension of Registration

The registration of any student may be suspended by the Vice-Chancellor on therecommendation of the disciplinary committee. A student whose registration has

beensuspended as above will have to vacate the hostel and leave the campus if such a measureis deemed necessary by the University authorities in the interest of academic discipline andpeace of the campus.

8. Cancellation of Registration

The Vice-Chancellor may cancel the registration of any student or group/ batch/ classesof students who indulge in acts of indiscipline, misconduct, violation of the rules andregulations of the University, strikes, absence from class(es) without permission or withoutany valid reason or in cases the Vice-Chancellor has reasons to believe that theircontinuance in the institution would not be in the interest of the University.

9. Dropping from the University

Discontinuation of studies by any Master's or PhD student will be permissible only onjustified grounds after the completion of first semester examination. The student may beallowed by Dean, PGS to seek re-admission in the subsequent year(s) subject to thecondition that the total period of withdrawal shall not exceed four semesters in case of

Master's and six semesters in case of PhD students including the semester in which he /shehad withdrawn. In case the student leaves the university without prior permission fordropping from the competent authority, his/her admission will be cancelled by the Registraron the recommendations of Dean PGS.

ATTENDANCE REQUIREMENT

1. Record of Class Attendance

Each teacher shall maintain a record of the student's attendance in each course taughtby him/her in each semester. It would be responsibility of course teacher to convey shortageof attendance to the student and in case of highly irregular students a letter should be sentto their parents conveying that student's registration is liable to be cancelled. Soon after thecompletion of the semester i.e. the next day of completion of semester the HOD shouldsend the complete attendance statement to the Dean PGS with specific remarks andrecommendations, who would in turn forward it to the office of the COE as well as toRegistrar office with recommendations. The notification of the

attendance to the studentshould be displayed on the notice board and University website and be announced in theclassroom by the concerned teacher.

2. Minimum Class Attendance

Each student shall be regular in attending classes and shall be required to have aminimum of 75 per cent attendance (including attendance benefit; if any), both in theory andpractical separately in each course in each semester at Master's and PhD level failing whichhe/ she will not be allowed to appear in the semester examination and he/ she shall bedeclared as failed.

1. Allotment of Advisor

Major Advisor of the Master's/PhD student should be allotted with in three months ofadmission in first semester by the concerned Head of Department, keeping in view therecommendation of the Departmental Academic Committee and approved by the Dean,

PGS. The Major advisor should be allotted on seniority and rotational basis provided thefaculty member(s) fulfill the minimum eligibility conditions for becoming an Advisor.

2. Accreditation for Postgraduate Teaching and Research in College of Veterinary Science and Animal Husbandry and College of Biotechnology:

- All teachers of the University in the rank of Professors/Principal Scientist from ICARinstitutions shall be automatically accredited for postgraduate teaching and research upto PhD level in the concerned subject or the Allied subjects.
- All teachers of the University in the rank of Associate Professors/Senior Scientist fromICAR institutions shall be automatically accredited for postgraduate teaching and Masterresearch including in Allied Subject. For guiding research up to PhD level, he/she willhave to follow procedure of accreditation.
- All teachers of the University in the rank of Assistant Professors/ Scientist from ICARinstitutions will be eligible for teaching postgraduate courses as per their qualification.The teachers (Assistant Professors or equivalent) having PhD degree will be eligible forM.Sc/ M.Tech/ M.V.Sc. teaching and will undertake PhD

teaching after acquiring experience of twoyears of M.Sc/ M.Tech/ M.V.Sc. teaching. The Teachers (Assistant Professors or equivalent) havingM.Sc/ M.Tech / M.V.Sc. degree will be eligible for M.Sc/ M.Tech/ M.V.Sc. teaching after acquiring two years of teachingexperience.

2.1 For postgraduate teaching and research, faculty members (Assistant Professors) will beaccredited by the Accreditation Committee consisting of Dean of concerned college(Chairman), Director of Research, Head of concerned department and Dean, PGS(Convener). For accreditation to guide research at Master or PhD level, the number andquality of research publications shall be taken in to consideration. For accreditation, ateacher will have to make an application to Dean, PGS through proper channel bysubmitting their bio-data along-with willingness.

The recommendation of Accreditation Committee will be considered by the Academic Council for final approval.

2.2. M.Sc./ M.Tech / MVSc: An Assistant Professor/Scientist having PhD degree (relaxable to Master'sdegree in the faculty (discipline) where PhD's are not available) shall be accredited toguide research at the Master's level provided that staff member has -

I. A minimum experience of teaching/research/extension for a period of 2 years in case ofPhD and 5 years in case of M.Sc./ M.Tech/ MVSc and

II. Has at least three research papers published in the journal of repute having NAASrating not less than 4.0. However, an Assistant Professor possessing PhD degree in theallied subject shall be considered for accreditation to guide research at Master's levelprovided that he/she has

i. A minimum experience of teaching/research/extension in the concerneddiscipline for a period of 5 years in case of PhD and 8 years in case of M.Sc/ M.Tech/ MVScand

ii. Has at least 8 research papers in the concerned discipline published in thejournal of repute (NAAS rating ≥ 4.0).

2.3. PhD: A faculty members having PhD degree shall be considered for accreditation toguide research at PhD level provided he/she has guided research at Master level fora period of at least two years and successfully guided at least two Master degreestudents.

2.4. Co-Major Advisor: Co-Major Advisor from same or other department/disciplinemay be appointed by Dean, PGS on recommendation of Major Advisor/ Head of

Department under the following conditions.

i. Where there is inter-institutional collaboration with other outsideInstitute/University/Agency.

ii. Where Major advisor has gone on leave for a period exceeding six months.

iii. Where Major Advisor of other institution/University, Co-Major Advisor will be of theparent University and vice versa.

3. Accreditation for Postgraduate Teaching and Research in College of Biotechnology:

- All the teachers of the University in the rank of Professor/Principal Scientist from ICARinstitutions possessing PhD degree in the Veterinary Science and AnimalHusbandry/allied subject shall be automatically accredited for postgraduate teaching andResearch up-to PhD level.
- All the teachers of the University in the rank of Associate Professor/Senior Scientist fromICAR institutions possessing PhD degree in the Veterinary Science and AnimalHusbandry /allied subject will be eligible for teaching postgraduate courses in the collegeof biotechnology and shall be considered for accreditation to guide research atMaster/PhD level provided-
- All the teachers of the University in the rank of Assistant Professor/Scientist from ICAR institutions possessing Master's/PhD degree in the Veterinary Science and Animal Husbandry/allied subject will be eligible for teaching postgraduate courses and shall be considered for accreditation to guide research at Master's/PhD level in the college of biotechnology provided-

3.1 For Guiding Research at Master's Level- The teacher has taught at least 2 years at thecollege of biotechnology as core or resource faculty and has published

3researcharticles in the NAAS rated journals (rating not less than 4) in the biotechnology relatefield.

3.2 For Guiding Research at PhD Level- That the teacher has taught at least 3 years at thecollege of biotechnology as core or resource faculty and published 5 research articles inthe NAAS rated journals (rating not less than 4) in the biotechnology related field.

3.3 For Guiding Research at Master's Level- A teacher possessing Master's/PhD degreein the allied subject shall be considered for accreditation to guide research at Master's level provided the teacher has taught at least 3 years at college of biotechnology as core or resource faculty and published 5 research articles in the NAAS rated journals (rating not less than 4) in the biotechnology related field.

3.4 For Guiding Research at PhD Level- A teacher possessing PhD degree in theVeterinary Science and Animal Husbandry/allied subject shall be considered foraccreditation to guide research at PhD level provided the teacher has taught at least 5years at college of biotechnology as core or resource faculty and published 8 researcharticles

4. Allotment of Students to the Retiring Persons

A teacher likely to retire in two years will not be eligible for allotment of student for Masters/PhD degree programme.

5. Allotment of Student to Teacher on Extra Ordinary Leave or Study Leave

Teachers of the University on extra ordinary leave or on study leave or who leave the University service will cease to continue to act as Advisors of the postgraduate students ofthe University.

6. Change of Major Advisor

An advisor once assigned to Master's /PhD student will normally be not changed.

Where the need for the change of Advisor becomes necessary, either because the Advisorhas retired or resigned and left or is on long leave or refuses to act as an advisor, or in anyother circumstance where the Dean of the College on recommendations of the concernedHOD of the department is convinced or has reasons to believe that the change of Advisorhas become imminent and inevitable, the Dean, PGS will change the Major Advisor,however, rest of the members of the Advisory Committee will remain the same.

In all suchcases, the circumstances under which such a change became unavoidable shall berecorded on file and intimated to the Dean, PGS.

1. Advisory System

Head of the Departments shall be responsible for maintenance of academicstandard in the Departments. Head of the Department will ensure that a major advisorshall be assigned to each postgraduate student within 3 months after admission inconsultation with the Academic Committee of the Department. Besides there shall also be an Advisory Committee for each student which shall be approved by the Dean, PGSon the recommendations of Advisor through HOD and Dean of the in the first semesterof admission.

The Advisory Committee, in case of candidates pursuing Master's degree shallconsist of minimum of four members. Two members of the faculty shall represent themajor subject and one of them will be the major advisor who will also be the chairmanof the committee. However, in exceptional cases if there is only one faculty member inthe department, one member from the allied subject can be opted. Third member shallrepresent the minor subject and the fourth member shall represent nominee of the Dean, PGS.

For Doctorate degree, the Advisory Committee shall consist of minimum of four members.

i. Two members from major subject, one of them will be the Major Advisor, who willalso be the chairman of the committee.

ii. One member from the minor field.

iii. One member as nominee of Dean, PGS.

Moreover, the Dean, PGS may give approval to add one more members to thecommittee on the request of the Advisory Committee based on proper justifications.

The Advisory Committee shall guide the students in the choice of courses inmajor, minor and supporting field, with a view to enhance quality, usefulness and toavoid repetition of research. To monitor the progress of research work of studentperiodical meetings of the Advisory Committee must be held during the course ofresearch work

and proceedings of the meetings of the Advisory Committee becompulsorily be sent to the office of the Dean PGS.

AWARD OF DEGREE AND THE RESIDENTIAL REQUIREMENTS

For the award of Master's and PhD degree(s), the minimum residential requirement andthe maximum permissible time limit for the completion of degree(s) including submission ofthesis shall be as under

Residential Requirement

Degree	Minimum Semesters	Maximum Semesters
Master's	04	08
PhD	06	12

The semester(s) washed out on account of withdrawal, dropping by the student of his/her own, failure to register in time, medical grounds, use of unfair means or dropped for any other reason whatsoever described above, shall be counted towards the maximum permissible time limit of semesters.

Note:

1. The residential requirement in the University shall include the stay at University and /or such other institutions/research stations with which the University has MOU.
2. If the student fails to complete his/her programme successfully within the maximum time limit prescribed for the programme as above, his/her enrollment in the university will automatically be cancelled.

Programme of Study

1. Programme of Study

a) Head of the Department shall convene a meeting of all the faculty members of thedepartment for allotment of courses during the ensuing semester. Details about thecourses along with the names of teachers being offered during that semester will

becommunicated by Head of the Department to the Dean of the concerned college andDean, PGS at least 15 days prior to the date of registration.

b) A detailed programme of study giving the course requirement(s) of the students admittedto the Master's or PhD degree programme shall be prepared by the respective Advisorand the advisory committee and submitted by the advisors through the Head of Department and Dean of the concerned college to the Dean, PGS for approval at leasttwo months before the commencement of second semester. The Dean, PGS shallapprove the programme of studies within one month of the receipt of the programme ofstudies from the Advisor after suggesting such changes as he/she may deemnecessary.

c) The programme of study shall be prepared out of the approved courses and shall bedevised so as to ensure the inclusion of the required core and other major, minor andbasic supporting courses as prescribed by the department and approved by theAcademic Council.

1.1 Requirement of Credit Hours	**Master's**	**PhD***
Teaching credit hours	40	25
Research	30	75
Total	70	100

Courses: There shall be the following types of courses in postgraduate studies.

	Masters' Programme	Doctoral Programme
Course work		
Major courses	20	12
Minor courses	08	06
Supporting courses	06	05
Common courses	05	--
Seminar	01	02
Thesis Research	30	75
Total	**70**	**100**

1.2 Common Courses: Five courses are of general in are mandatory for Master's programme. In case of PhD student are exempted for these courses.

The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management
4. Basic Concepts in Laboratory Techniques
5. Research Ethics and Rural Development Programmes

1.3Minor Subject Courses

To be selected for both the Master's and PhD degree programmes from any one ofthe allied subjects as per ICAR PG curricula and syllabi of the University.

(a) If a student has studied the equivalent course(s) in Master's degree programme fromthe same or any other University, then the matter may be discussed and some otheralternate courses should be advised from the major/minor subjects by the AdvisoryCommittee and the recommendations should be submitted to the Dean, PGS forexemption from studying such course(s) and approval of the programme of study.

(b) For each postgraduate programme, the minor and supporting courses shall be identifiedby the department concerned and will be selected from the list as of minor subjects.

2. Change/Withdrawal of Courses

The course once registered can be changed or withdrawn within ten days from thelast day of registration. However, withdrawal without addition shall not be allowed if studentsare taking minimum credit load.

The Dean, PGS may permit a student to drop all courses on exceptional emergentconditions like ill health up to the last date for dropping courses on the recommendation ofAdvisor, Head of the Department and Dean of the College. In such

cases, the students willwithdraw from all courses and grade **"W"** will be recorded against each course.

3. Change in the Programme of Study

No change in the programme of studies shall normally be permitted. However, underspecial circumstances, Dean, PGS may on the recommendation of the Advisory Committeeand Head of the Department, for reasons to be specified, permit a change in the programmeof study including synopsis.

MAXIMUM AND MINIMUM PERMISSIBLE CREDIT LOAD IN A SEMESTER

a. Master's: A student is permitted to register for a maximum course/research load equivalent of 20 hours which will include 18 credit courses and 2 non-credit courses and minimum of 9 credit hours. No student is allowed to take more than 2 non-credit courses in one semester. If the residential requirement has been satisfactorily completed along with the requisite credit hours of course and research work and final viva voce examination has not been conducted, the Master's student will have to register for next semester(s) by paying only the registration fee Rs. 500/- and hostel charges, if he/she is a hosteller.

b. PhD: A student is permitted to register for a maximum course/research load of 18 credit hours and minimum of 9 credit hours. If the residential requirement has been satisfactorily completed along with the requisite credit hours of course and research work and final viva voce examination has not been conducted, the student will have to register for next semester(s) by paying only registration fee Rs. 500/- and hostel charges, if he/she is a hosteller.

EXAMINATION AND PREPARATION OF RESULTS

1. The examination shall be to assess whether the student has been able to achieve alevel of competence. For academic assessment, evaluation of practical aspects of thecurriculum should receive much greater emphasis leading to separate examinations.

2. Internal Evaluation: At the end of semester, there will be an internal examination. Thetheory examination will be conducted by the Controller of Examinations (COE) andquestion papers for each course will be submitted by the Course In-charge through

Head of the Department.

3. The theory question paper in internal examinations should be of 50% objective and

50% subjective and of three hours duration. The evaluation will be made on 10 pointscale.

4. The practical examinations will be conducted in the concerned department examinationby the Course In-charge and one more teacher to be nominated by Head of theDepartment.

Note: There shall be no make-up examination in lieu of any missed semesterexamination (theory or practical).

5. Comprehensive Examination: There shall be a comprehensive (Preliminary) examination for Master and PhD students to be held on successful completion of at least 75 percent of the course work in major and minor subjects. The procedure of comprehensive examination is as under:

Attributes	Master's Programme	PhD Programme
Major Subjects	One paper	Two papers
Minor Subjects	One paper	One paper
Paper Setting	External	External
Evaluation	External	External
Qualifying Marks	60%	60%
Oral Examination	No	External
Grading	Satisfactory/Unsatisfactory	

(a) Written Comprehensive Examination: The written examination will be external and shallconsist of theory papers from the major field and minor fields. The Head of the

Departmentwill submit a common panel of 7 examiners, not less than the rank of AssociateProfessors/Senior Scientist in each field through Dean of the concerned college and DeanPGS before the end of second semester for all the registered students (Major and Minor)Dean PGS may amend the panel as deemed appropriate. If no panel is received withinstipulated time, Examination Committee can appoint the examiner on its own. There will beone paper in major field and one paper in minor field for Master's and two paperscomprising of half of the course in each paper in major field and one paper in minor fieldfor PhD programme. The question paper of written comprehensive examination should beof 50% objective and 50% subjective and of three hours duration for major and minorsubject. The question papers shall be so designed that these tests judge the overallcomprehension of the student in the major/minor field. The process of written examinationof both major and minor fields shall be completed by COE within two months after the startof second year of postgraduate programme. The answer books of major field and minorfield of subjects will be sent to the respective appointed examiners for evaluation to bedone within 15 days of the receipt. In case of unsatisfactory performance both in Major andMinor subject, the student will have to appear in repeat written exam conducted only aftertwo months of the declaration of the result and a new examiner will be appointed for therepeat exam from the panel submitted earlier.

(b) Oral Comprehensive Examination: After satisfactory completion of the writtencomprehensive examination, oral examination of the student will be conducted by theExternal Examiner along with other members of the Advisory Committee for PhD. Theresult of the external oral examination will be submitted through Head of the Department tothe COE and it will be marked as satisfactory/ unsatisfactory. In case of unsatisfactoryperformance, the student will have to appear in the repeat oral examination conducted onlyafter a lapse of at least two months and a new examiner will be appointed for Re-oralexamination from the panel submitted earlier. No oral comprehensive examination will beconducted for Master's programme and minor subject of PhD.

6. The grades/marks obtained in theory and practical examinations will be enteredseparately in the transcript of the students against each course.

7. Evaluation of Answer sheets/Books of Semester Examination: The answer sheets/books shall be evaluated by the internal examiners. The internal examiner(s) willevaluate the answer books and the marked answer books will be shown to the concernstudent. The marks obtained in the theory and practical will be entered in the prescribedmark-sheets and it will be ensured that the result reaches to the COE within seven daysfrom the date of examination through Head of the Department.

8. Pass Percentage

i. Minimum marks to get through in a course is 60% separately, in theory and practical,failing which a student has to repeat the course in subsequent semester(s).

ii. There will be no provision of any grace marks even if a student fails by any marks.

9. Remuneration for Examination

As per university rules (For external examiners only)

10. Grading

After adding the marks obtained in the theory and practical examinations, gradepoint for the course will be calculated on "Ten Point Scale". The aggregate ofpercentage of marks earned in theory and practical in courses is divided by 10 and isexpressed as grade point.

i. Calculation of Overall Grade Point Average (OGPA): For calculation of OGPA, thefollowing shall be the formula / procedure)

a) The points earned will be zero if the marks obtained in a course (theory andpractical separately) are less than 60 **%.**

b) The credit point in a course shall be equal to the marks obtained in theory andpractical separately multiplied by number of credit hours in theory and

practicalcomponents, respectively and divided by 10. The **total credit point** earned invarious courses shall be summed up and divided by total number of credit hours forcalculation of **GPA (Grade Point Average)**. The **OGPA** will be equal to the totalcredit points divided by **total number of credit hours** in all the semesters.

11. Division and Honours

Division	CGPA / OGPA
Second division	6.000 - 6.999
First division	7.000 - 7.999
First division with distinction	8.000 and above

12. Preparation of Results

a. Tabulation of the results shall be done from the award list of the examiners by theoffice of the COE.

b. Tabulation work should be completed within five days from last date of the receipt oflast award list from the examiners.

13. Declaration of Results

The office of COE will do the collation of the results and declare the semesterresults before the commencement of next semester.

14. Transcript / Mark Sheet

All the marks/grades obtained in theory and practical examination(s) will beentered in the computer and hard copy will be maintained in the office of the COEseparately and the Grade sheets/ Transcripts of the students will be prepared by theoffice of COE.

At the end of each semester, the COE will issue the semester report card to allthe students with a copy of the same to the advisor of the student(s) while theComposite Academic Transcript will be issued on the completion of degree programmeof the student.

15. Re-totaling/ Scrutiny/ Re-evaluation

(a) No re-totaling or scrutiny of marked answer books is allowed in any of the PGexaminations

(b) No re-evaluation of marked answer books is allowed in any of the PG examinations.

INITIATION OF RESEARCH WORK

(a) A postgraduate student shall submit his/her proposed synopsis to Dean, PGS throughMajor Advisor/ Head of the Department in the second semester after presenting a synopsisseminar before advisory committee. Major advisor will ensure that it should be gotapproved from Dean, PGS preferably before the start of examination of 2nd semester of theadmission. The time between synopsis and thesis submission shall be two semesters forMaster Programme and four semesters for PhD programme.

While preparing the synopsis of the student, the department should fix priorities inadvance in tune with overall research priorities/ mandates decided for the department atuniversity level. Within these, the research problems of individual student be finalized by acommittee consisting of major advisor and Head of the Department along with Advisorycommittee of the student. Head of the Department will ensure that the research ofpostgraduate students is a part of ongoing research/ priority area, if any and there is noduplication in the proposed research work. The student should also be associated in thisexercise and shall deliver synopsis seminar.

(b) The Advisor and HOD should also certify that approval of IAEC/CPCSEA has been takenfor conducting the experiment.

(c) Thesis Writing

Before a student can be permitted to start writing thesis, following requirements mustbe fulfilled.

i. The student shall deliver a Pre-thesis submission seminar presenting all the datacollected by him/her and analysis of such data.

ii. The reliability and authenticity of experimental results of thesis project shall beexclusive responsibility of the student and the Major Advisor.

iii. The advisory committee should approve quantum and quality of the research workdone by the student.

The Head of the Department shall in no case withhold the draft of thesis but cansend his/her comments, if any, while forwarding the thesis to the Dean, PGS.

(d) Approval of the Thesis Draft

The draft of the thesis shall be submitted to the members of the advisorycommittee for their approval at least two weeks before the last date for the submissionof the thesis to the Dean, PGS. The Dean, PGS will accept the thesis only when it isaccompanied by a certificate of approval in prescribed forms signed by all the membersof the advisory committee and a "No Objection Certificate" from the concerned Head ofthe Department.

(e) Submission of the Thesis

i) M.Sc/ MTech/ MVSc and PhD students can submit the thesis only after 75 days of registration inthe last semester of residential requirement (IV semester for MSc / M.Tech/ MVScand VIsemester for PhD).

ii) The time gap between the submission of synopsis and thesis to the office of Dean,PGS should be 2 and 4 semesters, respectively for M.Sc/ M.Tech/ MVSc and PhD students.

iii) The comprehensive examination should have been passed at least six monthsbefore the submission of thesis in case of PhD students and three months forMaster's Degree programme.

iv) There should be minimum gap of 7 and 15 days for M.Sc. / M.Tech/ M.V.Sc. and PhD, respectivelybetween Pre-thesis seminar and the thesis submission.

The student shall be required to submit 4 copies of the Thesis, one each for theUniversity Library, Departmental Library, Major Advisor and the student along with asoft copy for the Library. In case of fellowship holders, one additional copy for thefinancing agency concerned, should also be submitted.

If candidate fails to submit the thesis before the commencement of thesubsequent semester he/she will be required to register himself/herself for the semesterby paying registration fee of Rs. 500/- and hostel dues if he/she is a hosteller.

Master's students will write and submit one research paper on their researchwork in Journal having minimum NAAS rating of 4 out of thesis work before their finalviva-voce examination.

In case of PhD students, two research papers should have been submitted inJournal having minimum NAAS rating of 4 out of thesis work before their final viva-voceexamination.

Major advisor through Head of the Department shall have to give a certificate tothis effect along with a copy of research paper(s) submitted to Dean, PGS/ COE.

1. Appointment of External Examiners for Thesis Evaluation and Viva- Voce Examination

After the receipt of the thesis, the Examination Committee shall appoint anexaminer as per the University Act in the following manner:

a) The Advisor/HOD shall submit a panel of at least five examiners not below the rank ofAssociate Professor / Senior Scientist or equivalent for Master's thesis while a panel ofseven examiners for PhD thesis is required to be submitted for being appointed asexaminer(s) for evaluation of thesis through Head of the Department and Dean, PGS toCOE. The examiner must have teaching/ research experience as per the regulation ofPG/PhD advisorship. A maximum of two submitted thesis of a subject can be sent to one Examiner.

b) Where the number of students to be examined in any field of specialization is more thantwo, an additional panel of examiners may be submitted.

c) Panel of examiners for the thesis should be submitted by the Advisor through HOD andDean, PGS to the COE preferably one month before the submission of thesis for seekingconcurrence from the examiner before sending thesis.

d) No person should be appointed as examiner for more than one year consecutively. Aftera break of a year or more the same person shall, however, be eligible for re-appointment.

e) The Advisor will act as the internal examiner and chairman of advisory committee.

f) While asking the consent of the examiners for evaluating the thesis, it shall also beindicated to them that the thesis for a Master's degree has to be evaluated within 15 daysand the thesis for a PhD degree has to be evaluated within 30 days and in case theevaluation of the thesis is provided earlier then final viva-voce examination shall not beconducted before 15 days have elapsed from the date of the dispatch of the thesis by theoffice of the COE.

g) Master's thesis shall be sent to one external examiner for evaluation and PhD thesis shallbe sent to two external examiners for evaluation.

2. Evaluation of Thesis

a) Thesis should be dispatched to the external examiner(s) by registered post within oneweek of its submission to COE.

b) (i) The external examiner(s) will submit a report in the prescribed performacommentingon the thesis and indicating whether examiner recommends its acceptance or rejection. Ifthe examiner recommends acceptance, then the final viva-voce examination of Master'sor PhD students shall be conducted only after a minimum period of 15 days after dispatchof thesis to external examiner(s).

(ii) If the external examiner rejects the thesis, the evaluation report shall be placedbefore the advisory committee and Head of the Department for a decision. If the advisorycommittee along with the Head of the Department accepts the recommendations, thenthe thesis will be rejected. If the advisory committee along with the Head of theDepartment does not agree with the report of the external examiner(s), then the thesisshall be re-examined by another external examiner whose decision will be final.

c) (i) Final viva-voce examination shall be conducted by the advisory committee along withHead of the Department concerned and the external examiner for Master's student.

(ii) In case, the major advisor/ member is absent due to some unavoidable circumstanceswith valid reasons on the day of viva-voce examination, the Dean, PGS may appointinternal examiner/ chairman or the member from the subject/ allied field to conduct vivavoceexamination.

(iii) In case of PhD students, after receiving the thesis evaluation reports from both theexternal examiners, the final viva-voce examination shall be conducted by the one of thetwo external examiners appointed by examination committee and advisory committeealong with the Head of the Department.

d) If the two examiners appointed for evaluation of PhD thesis submit contradictory reportsthen the thesis will be sent to third examiner for evaluation whose report will be final.

3. Declaration of Result

Final result of the Master's/PhD students will be declared by the COE within sevendays of the conduct of viva-voce Examination after obtaining the "No Dues Certificate" dulysigned by all concern, including Head of the Department, Dean Student Welfare (DSW) andLibrarian etc.

4. Character Certificate

After the completion of postgraduate degree programme, Dean, PGS will issue theCharacter Certificate to the concerned student on the recommendation of the Advisor andthe Head of the Department.

Detailed Syllabus of PG and Ph.D. programs

I. Course Title : Principles of Biotechnology

II. Course Code :BT 501

III. Credit Hours : 3+0

IV. Aim of the course

- To understand the basics of Molecular biology, plant and microbial Biotechnology
- Importance and applications in agriculture, case studies and success stories
- Public education, perception, IPR and related issues

V. Theory

Unit I (12 Lectures)

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

Unit II (16 Lectures)

Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

Unit III (8 Lectures)

Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications. Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics. Plant cell and tissue culture techniques and their applications.

Unit IV (12 Lectures)

Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions, Success stories in Biotechnology, Careers and employment in

biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

I. Course Title: Fundamentals of Molecular Biology

II. Course Code: BT 502

III. Credit Hours: 3+0

IV. Aim of the course

• To understand the basics of DNA, RNA, structure, types and chromatin assembly.

• To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.

• To understand different levels of gene regulation and the pathways involved.

V. Theory

Unit I (8 Lectures)

Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function; Structure and Types of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

Unit II (10 Lectures)

Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

Unit III (8 Lectures)

Prokaryotic transcription, initiation, elongation and termination, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription –

RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors,Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.

Unit IV (10 Lectures)

Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, transpeptidation and termination of translation; Co- and Post-translational modifications of proteins;
Translational control; Protein stability -Protein turnover and degradation.

Unit V (12 Lectures)

Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: *lac* and *trp*operons, attenuation, anti-termination, stringent control. Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helixturn- helix, helix-loop-helix etc. Epigenetic regulations

I. Course Title: Molecular Cell Biology

II. Course Code: BT 503

III. Credit Hours: 3+0

IV. Aim of the course

• To understand the basics structure and function of plant and animal cell

• To get insights into the basic cellular processes, transport, signalling, cell movement, cell division and general regulation mechanisms.

V. Theory

Unit I (8 Lectures)

Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory,treeof life, General structure and differences between prokaryotic and eukaryoticcell; Similarities and distinction between plant and animal cells; different kinds ofcellsinplant and animal tissues.

Unit II (8 Lectures)

Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus,Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles,Nucleus, Cyto-skeletal elements.

I. Course Title: Techniques in Molecular Biology I

II. Course Code:BT 504

III. Credit Hours: 0+3

IV. Aim of the course

• To get a basic overview of molecular biology techniques, good lab practices andrecombinant DNA technology

• To get a hands on training in chromatography, protein analysis, nucleic acidanalysis, bacterial and phage genetics

V. Practicals

• Good lab practices, preparation of buffers and reagents.

• Principle of centrifugation and spectrophotometry.

• Growth of bacterial culture and preparation of growth curve, Isolation of GenomicDNA from bacteria.

• Isolation of plasmid DNA from bacteria.

• Growth of lambda phage and isolation of phage DNA.

• Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Merigold).

• Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry

• PCR using isolated DNA.

• PAGEGel electrophoresis.

• Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNAconstruction.

• Transformation of *E. coli* and selection of transformants

• Chromatographic techniques

a. TLC

b. Gel Filtration Chromatography,

c. Ion exchange Chromatography,

d. Affinity Chromatography

• Dot blot analysis, Southern hybridization,Northern hybridization.

• Western blotting and ELISA.

• Radiation safety and non-radio isotopic procedure.

I. Course Title: Omics and Systems Biology

II. Course Code: BT 505

III. Credit Hours: 2+1

IV. Aim of the course

• To get a basic overview of genomics, proteomics, ionomics and metabolomics

• To get a primary information on the application of omics science across the industry

V. Theory

Unit I (8 Lectures)

Different methods of genome sequencing, principles of various sequencingchemistries, physical and genetic maps, Comparative and evolutionary genomics,Organelle genomics, applications in phylogenetics, case studies of completedgenomes, preliminary genome data analysis, basics of ionomics analysis, differentmethods

Unit II (6 Lectures)

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry,Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT,PD-Quest, etc., Study of protein interactions, Prokaryotic and yeast-based expressionsystem and purification

Unit III (6 Lectures)

Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolomeanalysis, Multivariate analysis and identification of metabolite as biomarkers, Studyofionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-RayFluorescence (XRF), Neutron activation analysis (NAA), Data integration usinggenome, transcriptome, proteome, metabolome and ionome with phenome.

Unit IV (6 Lectures)

Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Equilibrium binding and cooperatively – Michaelis-Menten Kinetics, Biological oscillators, Genetic oscillators,Quorum Sensing, Cellcellcommunication, *Drosophila* Development, Pathways to Network, Gene regulationat a single cell level, transcription network, REGULATORY CIRCUITS, Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Networkbuilding and analysis

VI. Practical (12)

- Isolation of HMW DNA and brief overview of sequencing, Primary information ongenome data analysis.
- BSA Standard curve preparation, Extraction of protein and estimation methods.
- Quantification of proteins from different plant tissues using spectrophotometry.
- 2-D Gel Electrophoresis, 2-D Image analysis.
- Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitinsystem).
- Demonstration on MALDI-TOF.

• Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

I. Course Title : Plant Genetic Engineering

II. Course Code :BT 506

III. Credit Hours : 3+0

IV. Aim of the course

• To get a basic overview of molecular cloning, vectors and genomic library construction.

• To get anoverview of PCR and its applications, sequencing, gene knockouts, transgenics etc.

V. Theory

Unit I (10 Lectures)

Historical background, Restriction Enzymes; DNA Modifying enzymes, ligase, T4 DNA polymerase, Polynucleotide kinaseetc, Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein
Interactions: Electromobility shift assay.

Unit II (14 Lectures)

Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal,pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag, etc.; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologous

expression. Introduction of DNA into mammalian cells; Transfection techniques

Unit III (12 Lectures)

Principles of PCR, Primer design, DNApolymerases, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

Unit IV (12 Lectures)

Genetic transformation of plants: DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment. Vectors and transgene design - Promoters and Marker genes. Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of gene integration site - Advance methods – *cis* genesis, intragenesis and targeted genome modification – ZFN, TALENS and CRISPR. Application of transgenic technology.

I. Course Title : Techniques in Molecular Biology II

II. Course Code :BT 507

III. Credit Hours : 0+3

IV. Aim of the course

• To get a basic overview of molecular biology techniques, good lab practices andmolecular markers.

• To get a hands on training in RNAi, microarrays, yeast2 hybrid and immunologicaltechniques.

V. Practicals

Construction of gene libraries (cDNA and Genomics).

• Synthesis and cloning of cDNA.

• Real time PCR and interpretation of data.

• Molecular markers

i. RAPD.

ii. SSR.

iii. AFLP / ISSR and their analysis.

• Case study of SSR markers - construction of linkage map.

• QTL analysis using genotypic data based on SSR.

• SNP identification and analysis.

• Microarray studies and use of relevant software.

• Proteomics

i. 2D gels,

ii. Mass spectrometry

• RNAi - designing of construct, phenotyping of the plant.

• Yeast 1 and 2-hybrid interaction.

• Generation and screening of mutants.

• Transposon mediated mutagenesis.

• Immunology and molecular diagnostics: Ouchterlony double diffusion,Immunoprecipitation, Radiation Immunodiffusion, Immunoelectrophoretic, RocketImmunoelectrophoretic, Counter Current Immunoelectrophoretic,ELISA, LatexAgglutination, Immunohistochemistry.

I. Course Title : Introduction to Bioinformatics

II. Course Code :BT 508

III. Credit Hours : 2+1

IV. Aim of the course

• To get a basic overview of computational techniques related to DNA, RNA andprotein analysis.

• To get a hands on training in software's and programs used to analyse, assembleor annotate genomes, phylogenetics, proteomics etc.

V. Theory

Unit I (8 Lectures)

Bioinformatics basics, scope and importance of bioinformatics; Biological databasesfor DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondarydatabase, structural databases –PDB,SCOP and CATH, Specialized genomicresources, Microarray database.

Unit II (10 Lectures)

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-CodingGenes, Sequence analysis, Sequence submission and retrieval system-SEQUIN,BANKit, SAKURA, Webin, Sequence alignment, pair wise alignment techniques,multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants;Phylogenetic analysis-CLUSTAL X, CLUSTAL W, Phylip, Tcoffee

Unit III (10 Lectures)

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GORMethod, Protein 3DStructure Prediction: Evaluation of models- Structure validationand refinement - Ramachandran plot, Force field calculations, SAVES. Proteinfunction prediction- sequence and domain based, Primer designing- principles andmethods.Drug discovery**,** Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, QSAR.

VI. Practical (12 Lectures)

- Usage of NCBI resources
- Retrieval of sequence/structure from databases and submission
- Different Databases, BLAST exercises.
- Assembly of DNA and RNA Seq data
- Annotation of assembled sequences,Phylogenetics and alignment
- Visualization of structures, Docking of ligand receptors

• Protein structure analysis and modelling

I. Course Title : Plant Tissue Culture

II. Course Code :BT 509

III. Credit Hours : 2+1

IV. Aim of the course

• To provide insight into principles of plant cell culture and genetic transformation.

• To get a hands on training in basic plant tissue culture techniques, callusing,micropropagation and analysis.

V. Theory

Unit I (12 Lectures)

History of plant tissue culture, principle of Totipotency; Tissue culture media; Planthormones and morphogenesis; Direct and indirect organogenesis; Direct and indirectsomatic embryogenesis; Applications of planttissueculture; National certificationand Quality management of TC plants; Genetic Fidelity testing and Virus indexingmethods – PCR, ELISA

Unit II (12 Lectures)

Micropropagation of field and ornamental crops; Virus elimination by meristemculture, meristemtip culture and micrografting; Androgenesis and gynogenesis -production of androgenic and gynogenic haploids - diploidization; Protoplast culture- isolation and purification; Protoplast culture; Protoplast fusion; Somatichybridization - Production of Somatic hybrids and Cybrids;, Wide hybridization -embryo culture and embryo rescuetechniques; Ovule, ovary culture and endospermculture.

Unit III (12 Lectures)

Large-scalecell suspension culture - Production of alkaloids and other secondarymetabolites- techniques to enhance secondary metabolite production, Somaclonalandgametoclonal variations – causes and applications; Callus culture and *in vitro*screening for stress tolerance; Artificial seeds*, In vitro* germplasm storage andcryo-preservation. Commercial Tissue Culture: Case studies and success stories,Market assessment; project planning and preparation, economics, governmentpolicies

VI. Practical (12)

• Preparation of stocks - macronutrients, micronutrients, vitamins and hormones,filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoogmedium.

• Micro-propagation of plants by nodal and shoot tip culture.

• Embryo culture to overcome incompatibility, Anther culture for haploid production.

• Callus induction in tobacco leaf discs, regeneration of shoots, root induction, roleof hormones in morphogenesis.

• Acclimatization of tissue culture plants and establishment in greenhouse.

• Virus indexing in tissue culture plants. (Using PCR and ELISA).

• Plan of a commercial tissue culture unit.

I. Course Title : Microbial/ Industrial Biotechnology

II. Course Code :BT 510

III. Credit Hours : 2+1

IV. Aim of the course

To familiarize about the various microbialprocesses/systems/activities, which havebeen used for the development of industrially important products/processes.

V. Theory

Unit (8 Lectures)

Introduction, scope and historical developments; Isolation, screening and geneticimprovement (involving classical approaches) of industrially important organisms.

Unit II (8 Lectures)

Primary metabolites, production of industrial ethanol as a case study; Secondarymetabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as casestudy; Recombinant DNA technologies for microbial processes; Strategies fordevelopment of industrial microbial strains with scale up production capacities;Metabolic pathway engineering of microbes for production of novel product forindustry.

Unit III (8 Lectures)

Microbial enzymes, role in various industrial processes, production of fine chemicalsfor pharmaceutical industries; Bio-transformations, Bio- augmentation withproduction of vitamin C as a case study; Bioreactors, their design and types;Immobilized enzymes-based bioreactors; Microencapsulation technologies forimmobilization of microbial enzymes.

Unit IV (8 Lectures)

Environmental Biotechnology, biotreatment for pollution control, treatment ofindustrial and other wastes, biomass production involving single cell protein; Bioremediationof soil; Production of eco-friendly agricultural chemicals, bio-pesticides,bio-herbicides, bio-fertilizers, bio-fuels, etc.

VI. Practical

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acidand their recovery.
- Study of bio-reactors and their operations.
- Production of bio-fertilizers.

• Experiments on microbial fermentation processofantibiotics, bio-pigments, dairy products, harvesting purification and recovery of end products.

• Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis andbiomassestimation.

• Determination of mass transfer coefficient.

I. Course Title : Molecular Plant Breeding

II. Course Code :BT 511

III. Credit Hours : 2-+1

IV. Aim of the course

• To familiarize the students about the use of molecular biology tools in plantbreeding.

• To provide a hands on training in data analysis, diversity analysis and mapping ofgenes and QTLs.

V. Theory

Unit I (8 Lectures)

Inheritance of qualitative and quantitative traits. Heritability – its estimation,Population structure of self- and cross-pollinated species, Factors affecting selectionefficiency. Development of different kinds of segregating populations – F2, F3,BC1F1, BC1F2, BC4F2, RIL (Recombinant Inbred Lines), AIL (Advanced IntercrossedLines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (NestedAssociation Mapping), MAGIC (Multi-parent Advanced Generation Intercrosspopulation).

Unit II (8 Lectures)

Causes of sequence variation and its types, Types of molecular markers anddevelopment of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS,SSRs, STMS, SNPsInDel and DARTseq; Inheritance of markers, Linkage analysisusing test cross, F2, F3, BC1F1, RIL. Construction of genetic map, Mapping genesfor qualitative traits; Genotyping by sequencing and high-density chip arrays.

Unit III (8 Lectures)

QTL mapping using structured populations; Association mapping using unstructuredpopulations; Genome Wide Association Studies (GWAS),Principle of Associationmapping– GWAS-SNP genotyping methods, DART array sequencing, Illumina'sGolden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS,Illumina Hi seq- Nano pore sequencing, Principles and methods of Genomic Selection,

Fine mapping of genes/QTL; Development of gene based markers; Allele mining byTILLING and Eco-TILLING.

Unit IV (8 Lectures)

Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers.Foreground and background selection; MAS for gene introgression and pyramiding:MAS for specific traits with examples. Haplotype concept and Haplotype-basedbreeding; Genetic variability and DNA fingerprinting. Molecular markers in Plantvariety protection, IPR issues, hybrid purity testing, clonal fidelity testing andtransgenic testing.

VI. Practical

- Construction of linkage map.
- QTL analysis using the QTL cartographer and other software.
- SNP data analysis using TASEEL.
- Detection of haplotype block using SNP data –pLinksoftware.
- Genotyping by sequencing methods –Illumina genotyping platform.
- Marker assisted breeding – MABB case studies quality traits in rice/maize.
- Genome Assisted Breeding in model crops, Genomic Selection models usingthemorphological and SNP data

I. Course Title : IPR, Bio-safety & Bioethics

II. Course Code :BT 512

III. Credit Hours : 2+0

IV. Aim of the course

• To familiarize the students about ethical and biosafety issues in plant biotechnology.

• To provide a hands-on training in data analysis, diversity analysis and mappingof genes and QTLs.

V. Theory

Unit I (10 Lectures)

IPR: historical background in India; trade secret; patent, trademark, design&licensing; procedure for patent application in India; Patent Cooperation Treaty(PCT); Examples of patents in biotechnology-Case studies in India and abroad;copyright and PVP; Implications of IPR on the commercialization of biotechnologyproducts, ecological implications; Trade agreements- The WTO and otherinternational agreements, and Cross border movement of germplasms.

Unit II (8 Lectures)

Biosafety and bio-hazards; General principles for the laboratory and environmentalbio-safety; Biosafety and risk assessment issues; handling and disposal of biohazards;Approved regulatory laboratory practice and principles,The Cartagena Protocol on biosafety; Biosafety regulations in India; national Biosafety Policy andLaw; Regulations and Guidelines related to Biosafety in other countries

Unit III (8 Lectures)

Potential concerns of transgenic plants – Environmental safety and food and feedsafety. Principles of safety assessment of Transgenic plants – sequential steps inrisk assessment. Concepts of familiarity and substantial equivalence. Risk -Environmental risk assessment – invasiveness, weediness, gene flow, horizontalgene transfer, impact on non-target organisms; food and feed safety assessment –toxicity and allergenicity.Monitoring strategies and methods for detectingtransgenics.

Unit IV (6 Lectures)

Field trails – Biosafety research trials – standard operating procedures, labelling of GM food and crop,Bio-ethics- Mankind and religion, social, spiritual &environmental ethics; Ethics in Biotechnology, labeling of GM food and crop;Biopiracy

I. Course Title : Immunology and Molecular Diagnostics

II. Course Code :BT 513

III. Credit Hours : 3+0

IV. Theory

Unit I (6 Lectures)

Immunity and its classification; Components of innate and acquired immunity;Lymphatic system; Hematopoiesis; Organs and cells of the immune system-primary,secondary and tertiary lymphoid organs Descriptions of Antigens - immunogens,hapten and adjuvants.

Unit II (12 Lectures)

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenicdeterminants; Multigene organization of immunoglobulin genes; B-cell receptor;Immunoglobulin superfamily; Principles of cell signaling; Basis of self and nonselfdiscrimination;Kinetics of immune response, memory; B cell maturation,activation and differentiation; Generation of antibody diversity; T-cell maturation,activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cellmediatedimmune responses, ADCC; Cluster of Differentiations (CDs), Cytokinesproperties,receptors and therapeutic uses.

Unit III (8 Lectures)

Phagocytosis; Complement and Inflammatory responses; Major HistocompatibilityComplex - MHC genes, MHC and immune responsiveness and disease susceptibility,HLA typing; Antigen processing and presentation- endogenous antigens, exogenousantigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation,Hapten-carrier system

Unit IV (10 Lectures)

Precipitation, agglutination and complement mediated immune reactions; Advancedimmunological techniques – RIA, ELISA, Western blotting, ELISPOT assay,immunofluorescence, flow cytometry and immunoelectron microscopy; Surfaceplasmon resonance, Biosenor assays for assessing ligand –receptor interaction,CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, CellCytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs

Unit V (12 Lectures)

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccinetechnology- Role and properties of adjuvants, recombinant DNA and protein basedvaccines, plant-based vaccines, Antibody genes and antibody engineering-chimericand hybrid monoclonal antibodies, Immunity to Infection,Bacteria, viral, fungaland parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types ofautoimmune diseases, MHC and TCR in autoimmunity; Transplantation,Immunological basis of graft rejection, immunosuppressive therapy; Tumorimmunology – Tumor antigens.

I. Course Title : Nano Biotechnology

II. Course Code :BT 514

III. Credit Hours : 2+1

IV. Aim of the course

Understanding the molecular techniques involved in structure and functions ofnano-biomolecules in cells such as DNA, RNA and proteins.

V. Theory

Unit I (8 Lectures)

Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assemblyfor creation of useful nanostructures – Bottoms up and Top down approach (Nanorods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-basednanostructures) – Preparation and Characterization of nanoparticles (particle sizeanalyzer, microscopy, viz. electron microscopy, atomic force microscopy, etc).

Unit (8 Lectures)

Cell structure – Bio macromolecules: Types, Structure, Dynamics and interactionwith water – Cellular nano machines – cellular transducers, membrane channels,membrane transporters, Membrane motors – Creation of bio-nanostructures (Nanoliposomes, Nano micelles, Nanomotors, etc).

Unit III (8 Lectures)

Chemical, physical and biological properties of biomaterials and bio response:biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials(synthetic polymers and structural proteins); Aerosol properties, application anddynamics; Statistical Mechanics in Biological Systems,

Unit (8 Lectures)

Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene deliverysystem; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolicengineering and Gene therapy.

VI. Practical

• Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials

• Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micellesand inverse micelles

• Synthesis of Carbon Nano-materials by Chemical Vapor Deposition and Sputteringtechnique

• Preparation ofthiolate silver nanoparticles, Purification and measurement of carbonnano materials

• Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticle

• Thin film preparation by spin coating technique, Synthesis of Nickel metalnanoparticle by urea decomposition method

• Synthesis of Zinc Oxide nanoparticle

I. Course Title : Environmental Biotechnology

II. Course Code :BT 515

III. Credit Hours : 3+0

IV. Aim of the course

To apprise the students about the role of biotechnology in environment managementfor sustainable eco-system and human welfare.

V. Theory

Unit I (8 Lectures)

Basic concepts and environmental issues; types of environmental pollution; problemsarising from high-input agriculture; methodology of environmental management;air and water pollution and its control; waste water treatment - physical, chemicaland biological processes; need for water and natural resource management.

Unit II (8 Lectures)

Microbiology and use of micro-organisms in waste treatment; biodegradation;degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminatedwith oils, pesticides and toxic chemicals,detergentsetc; aerobic processes (activatedsludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes:digestion, filtration, etc.

Unit III (8 Lectures)

Renewable and non-Renewable resources of energy; energy from solid waste;conventional fuels and their environmental impact; biogas; microbial hydrogenproduction; conversion of sugar to alcohol; gasohol; biodegradation of lignin andcellulose; biopesticides; biofertilizers; composting; vermiculture etc.

Unit IV (8 Lectures)

Treatment schemes of domestic waste and industrial effluents; food, feed and energyfrom solid waste; bioleaching; enrichment of ores by microorganisms; globalenvironmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain;biodiversity and its conservation; biotechnological approaches for the managementenvironmental problems.

I. Course Title : Bio-entrepreneurship

II. Course Code :BT 516

III. Credit Hours : 1+0

IV. Aim of the course

The objective of this course is to teach students about fundamentals ofentrepreneurship, launching a venture or a start up in biotechnology-based theme.

V. Theory

Unit I (4 Lectures)

Scope in biotechnology; types of bio-industries – bio-pharma, bio-agri, bio-servicesand bio-industrial; Importance of entrepreneurship; introduction tobioentrepreneurship – biotechnology in a global scale; –skills for successfulentrepreneur–creativity, leadership, managerial, team building, decision making;opportunities for bio-entrepreneurship- entrepreneurship development programs ofpublic and private agencies (MSME, DBT, BIRAC, Startup& Make in India)

Unit II (4 Lectures)

Business plan preparation; business feasibility analysis by SWOT, socio-economiccosts benefit analysis; funds/ support from various agencies; statutory and legalrequirements for starting a company/ venture.

Unit III (4 Lectures)

Entry and exit strategy; identifying needs of customers; Market linkages, brandingissues; developing distribution channels - franchising; policies, promotion,advertising; branding and market linkages for 'virtual startup company'. Pricingstrategy.

Unit IV (4 Lectures)

Knowledge centers e.g., in universities, innovation centres, research institutions(public & private) and business incubators; R&D for technology development andupgradation; assessment of technology development; managing technology transfer;

I. Course Title : Stress Biology and Genomics

II. Course Code :BT 517

III. Credit Hours : 2+0

IV. Aim of the course

To provide advanced knowledge on genomics with reference to abiotic stress toleranceand biotic stress resistance in plants tolerance.

V. Theory

Unit I (10 Lectures)

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cellas a sensor of environmental changes; role of cell membranes in signal perception;Ways of signal transduction in cells and whole plants as a response to externalfactors.Abioticstresses affecting plant productivity – Drought, salinity, water logging,temperature stresses, light stress and nutrient stress; Drought stress – Effects on

plant growth and development; Components of drought resistance; Physiological,biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect andpathogen) resistance mechanism.

Unit II (12 Lectures)

Strategies to manipulate drought tolerance – Osmotic adjustment andOsmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars;ROS and antioxidants; hormonal metabolism - ABA signaling; signaling components– transcription factors. Water logging stress – effects on plant growth andmetabolism; adaptation to water logging,tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress– effects on physiology and metabolism of plants, SOS pathways and ionhomeostasis,Strategies to improve salinity tolerance in plants. Water logging stress– effects on plant growth and metabolism; tolerance mechanisms. Physiologicaland biochemical changes – High & Low temperature tolerance mechanisms -molecular basis of thermo tolerance. Morphological and physiological changes inplants due to high and low light stresses - photo oxidation -plastid development.Characters of heliophytes and sciophytes – solar tracking – sieve effect and lightchanneling. Heavy metal stress – Al and Cd stress - effects on plant growth anddevelopment, biotech Strategies to overcome heavy metal stress Nutrient stresseffectson plant growth and development. Genetic manipulation strategies toovercome the stress effects.

Unit III (10 Lectures)

Genomics; transcriptomes, small RNAs and epigenomes; functional genomics;transfer of tolerance/resistant genes to model plants and validation of gene function.Different techniques for the functional validation of genes.Signaling pathway related to defense gene expression, R proteins, RNAi approachand genes from pathogens and other sources, coat protein genes, detoxificationgenes, transgenic and disease management. Bt proteins, resistance managementstrategies in transgenic crops, ecological impact of field release of transgenic crops.Bioinformatics approaches to determine gene function and network in model plantsunder stress.

I. Course Title : Gene Regulation

II. Course Code :BT 518

III. Credit Hours : 2+0

IV. Aim of the course

To understand the basics of gene regulation including a wide range of mechanismsthat are used by organisms to increase or decrease the production of specific geneproducts in terms of time, space, conditions or their combinations.

V. Theory

Unit I (8 Lectures)

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Bindingof RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Antitermination,Combinatorial control – Regulation of *lac, trp*and*ara*Operons. Generegulation in Lambda phage – lytic or lysogenic establishment.

Unit II (10 Lectures)

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus ControlRegion. Activator proteins and their binding sites, DNA binding domain – Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix,HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomesand their modifiers. Signal integration. Signal transduction and transcriptionalregulation. Gene Silencing. Epigenetic gene regulation.

Unit III (10 Lectures)

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Riboswitches.Gene Silencing by RNA - siRNA & miRNA – synthesis and function. NoncodingRNAs their impact, categories and role in gene regulation, chromatinassembly etc.

Unit IV (4 Lectures)

Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch,Oscillating pattern of gene expression.

Common courses (5 credits)

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from referencesources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc.
To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

• Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;

• Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
• Writing of abstracts, summaries, précis, citations, etc.;
• Commonly used abbreviations in the theses and research communications;
• Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
• Writing of numbers and dates in scientific write-ups;
• Editing and proof-reading;
• Writing of a review article;
• Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
• Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
• Accentual pattern: Weak forms in connected speech;
• Participation in group discussion;
• Facing an interview;
• Presentation of scientific papers.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT(1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledgebased economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the

protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;

• Seed viability testing, testing of pollen viability;
• Tissue culture of crop plants;
• Description of flowering plants in botanical terms in relation to taxonomy.

RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of

rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Detailed syllabus for Ph.D Biotechnology

I. Course Title : Advances in Molecular Biology

II. Course Codein :BT 601

III. Credit Hours : 3+0

IV. Aim of the course

• To provide in depth knowledge of recent developments of plant molecular biology and applications

• To discuss case studies and success stories in agriculture and industry

V. Theory

Unit I (10 Lectures)

Model Systems in Plant Biology (Arabidopsis, Rice, etc.) Forward and Reverse Genetic Approaches. Organization expression and interaction of nuclear, Mitochondrial and Chloroplast Genomes. Cytoplasmic male sterility.

Unit II (12 Lectures)

Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Transcriptional Gene Silencing, Transcript and Protein Analysis.

Unit III (12 Lectures)

Plant Developmental Processes, ABC Model of Floral Development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development. Regulation of Flowering, Plant photoreceptors and light signal transduction, vernalization, Circadian Rhythms.

Unit IV (14 Lectures)

Abiotic Stress Responses: Salt, Cold, Heat and Drought.Biotic Stress Responses. Molecular Biology of Plant-pathogen Interactions, Molecular Biology of *Rhizobium* and*Agrobacterium*-Plant interaction. Role of programmed Cell Death in Development and Defense.

I. Course Title : Advances in Genetic Engineering

II. Course Code :BT 602

III. Credit Hours : 3+0

IV. Aim of the course

To discuss the specialized topics and advances in field of genetic engineering and application of molecular tools in breeding of specific crops.

V. Theory

Unit I (14 Lectures)

Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement.Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc.); edible vaccines, etc.

Unit II (12 Lectures)

Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement;

Unit III (12 Lectures)

Gene stacking; Pathway engineering; Marker-free transgenic development strategies; Genome editing: principles and methods, Development of genome edited plants; High throughput phenotyping of transgenic plants.

Unit IV (10 Lectures)

Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

I. Course Code :BT603

II. Course Title : Omics and Molecular Breeding

III. Credit Hours : 3+0

IV. Aim of the course

To discuss the specialized topics and advances in field of genomics and genomics assisted molecular breeding.

V. Theory

Unit I (12 Lectures)

Complex traits and genetic architecture, Mapping genes and QTLs, statistical concepts in QTL mapping, high-throughput genotyping using automated platforms, genetic and physical mapping of genomes, study of population structure and kinship, association genetic analysis of QTL, case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies.

Unit II (12 Lectures)

Marker Assisted Breeding (MAB): Principles and methods, marker assisted foreground and background selection, marker assisted recurrent selection, whole genome selection, case studies in MAS, requirement for successful marker assisted breeding, cost of MAB.

Unit III (12 Lectures)

Concepts and methods of next generation sequencing (NGS), assembly and

annotation of NGS data, genome resequencing, DNA sequence comparison, annotation and gene prediction. Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing, study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein- protein interactions.

Unit IV (12 Lectures)

Study of themetabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers, study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome.

I. Course Title : Commercial Plant Tissue Culture

II. Course Code :BT 604

III. Credit Hours : 2+0

IV. Aim of the course

• To provide awareness into development of commercial scale plant tissue culture units.

• To provide an insight into the commercial applications of plant tissue culture in agriculture, medicine and industry.

• To educate about biosafety, regulatory as well as entrepreneurship opportunities.

V. Theory

Unit I (8 Lectures)

Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

Unit II (8 Lectures)

Production of useful compounds via, biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being

produced for use in pharmacy, medicine and industry.

Unit III (9 Lectures)

Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethical issues; management and commercialization.

Unit IV (7 Lectures)

Project planning and preparation, economics (entrepreneurship, cost profit ratio), government policies (incubators, different facilitation projects, loan opportunities). Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

I. Course Title : Plant Microbe Interaction

II. Course Code :BT 605

III. Credit Hours : 2+0

IV. Aim of the course

To discuss the specialized topics and advances in field of plantmicrobe interaction for understanding their potential in enhancing crop growth and development.

V. Theory

Unit I (8 Lectures)

Microbial communities in the soil and atmosphere, Community dynamics and population interactions with particular reference to plant–microbe and microbemicrobe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, effects of microorganisms on plants, effects of plants on microorganisms. Recognition processes and signal exchange, Molecular aspects of Plant Growth Promoting Rhizobacteria (PGPR), Symbiotic diazotrophs: Rhizobia and association with legumes. Mycorrhizal associations: Ectomycorrhizae, Endomycorrhizae with particular emphasis to AM fungi, Ectendomycorrhizae. Biocontrol agents and their action, endophytes associations

Unit II (8 Lectures)

Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responses in

plants: pamp-triggered immunity,effector-triggered susceptibility,qualitative resistance, r genes, structure and function, effector-triggered immunity, regulation of plant cell death, plant hormones in immunity, Plant parasite interactions and its molecular basis and impact on plant functions including photosynthesis, respiration, nitrogen metabolism and translocation

Unit III (8 Lectures)

Quorum sensing in bacteria, understanding microbiome,phytobiomes,dynamics, Applied and ecological aspects of symbioses and pathogen defense, techniques to study plant microbe interaction including microbe tagging, metagenomics and use of organismal databases to identify genes involved in interactions. Industrial application of agriculturally important microbes.

Unit III (8 Lectures)

Resistance mechanisms against attack by plant pathogens, gene-for-gene interactions; induced resistance; non-host resistance. Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Plant and microbial gene expression and signal exchange, specific regulators for different interactions including transgenic plants. Recognition mechanism and signal transduction during plant - pathogen interaction

I. Course Title : RNA Biology

II. Course Code :BT 606

III. Credit Hours : 1+0

IV. Aim of the course

To discuss the specialized topics and advances in the field of Plant RNAs, their structure and role in cellular regulation and scope for crop improvement.

V. Theory

Unit I (4 Lectures)

RNA structure, functional evolution: RNA structure, types of RNA and function; Genome evolution- RNA as genetic material to regulatory molecule, Non-Coding RNAs, structure, function and regulation

Unit II (4 Lectures)

RNA synthesis, processing and regulation: transcription and its regulation in prokaryotes and eukaryotes; RNA splicing and editing; Translation and its regulation in prokaryotes and eukaryotes

Unit III (4 Lectures)

Genome regulation: Prokaryotic- attenuation, ribozymes, aptamers, riboswitches, CRISPER-Cas; eukaryotic-Exon skipping, nonsense-mediated decay, RNAi, Long non-coding RNA.

Unit IV (4 Lectures)

Epigenetic regulation. RNA-based gene silencing technologies and their applications for crop improvement

I. Course Title : Plant Hormones and Signaling

II. Course Code :BT 607

III. Credit Hours : 2+0

IV. Aim of the course

To provide in-depth knowledge of plant hormone and their role in plant growth and development.

V. Theory

Unit I (12 Lectures)

Hormone Biosynthesis, Metabolism and its Regulation: Auxin biosynthesis and metabolism, Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis, Abscisic acid biosynthesis and metabolism, Brassinosteroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism.

Unit II (12 Lectures)

Functioning of hormones in plant growth and development: Transport of

Auxins, Induction of vascular tissues by Auxin, Hormones and the regulation of water balance, seed development and germination, Hormonal control of day length and senescence.

Unit III (12 Lectures)

Action of Hormones: Hormones in defense against insects and disease; Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction; Methods of plant hormone analysis. NPR 1 dependent Salicylic acidsignaling, PAMP and effector triggered immunity, systemic acquired resistance and SA signaling.

Unit IV (12 Lectures)

Hormone Signal Transduction: Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin biosynthesis, transport, signal transduction in stem elongation& Leaf Growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassinosteroid biosynthesis, catabolism and signal transduction. Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of Plant Hormone Analysis**:** Quantitative analysis of plant hormones based on LC/MS.

I. Course Title : Computational and Statistical tools in Biotechnology

II. Course Code :BT 608

III. Credit Hours : 2+1

IV. Aim of the course

To provide information on basic principles of computational biology and statistical tools used for data analysis

V. Theory

Unit I (8 Lectures)

Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification

of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes, etc.)

Unit II (8 Lectures)

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack- knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling

Unit III (8 Lectures)

DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools,

Unit IV (8 Lectures)

Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics

I. Course Title : Advances in Animal Cell Culture

II. Course Code : BT 609

III. Credit Hours : 2+1

IV. Aim of the course

Understanding the latest development in animal cell culture

V. Theory

Unit I

Development of cell lines using various methods, Characterization of cell lines by morphology, Chromosome analysis, DNA content, Isoenzyme analysis and antigenic markers, DNA fingerprinting.

Unit II

Setting of new cell culture lab, Detection methods for cell culture contaminants, Three dimensional culture- classification of 3D culture methods and microfluidics, Tissue engineering- types of cells, Scaffold materials, Bioprinting, Bioartificial

organs, Flow Cytometry and its applications in cell culture.

Unit III

DNA transfer by viral and non viral methods, Expression of recombinant proteins in mammalian and avian cell lines.

Unit IV

Monoclonal antibody production and characterization, Up-stream and downstream processing of cell culture based vaccines, Diagnostic antigens and other pharmaceutical agents, Cell culture fermentors.

VI. Practicals

- Primary and secondary mammalian cell culture
- Development of transformed cells
- Characterization of cell lines by karyotyping
- Transfection of cells with recombinant DNA
- Expression of recombinant proteins
- Scaling-up of cultures
- Flow Cytometry
- Immunization of mice
- Maintenance of myeloma cell lines
- Fusion
- Characterization of mAbs

I. Course Title : Trends in Vaccinology

II. Course Code :BT610

III. Credit Hours : 2+1

IV. Aim of the course

Understanding the current trends in vaccine production technologies.

V. Theory

Unit I

Immunity against veterinary infectious agents: Bacteria, Virus, fungi and parasites; Immunoinformatics and its application to epitope mapping of pathogens, etc.;

Advancement in vaccinology: Vaccinomics, Adversomics, Systems Vaccinology, reverse vaccinology, Structural Vaccinology and computational vaccinology and its applications.

Unit II

Current trends in vaccine development against animal pathogens; Molecular approaches for vaccine development including: recombinant peptide vaccines, vectored vaccines, Marker vaccines, DNA vaccines, genetically manipulated live vaccines, etc.; Plant expression system based vaccines, idiotype and synthetic peptide based vaccines.

Unit III

Vaccines and Immunotherapeutic for Treating Non-Infectious Diseases: Cancer; obesity, neurodegenerative diseases, addictions, atherosclerosis, etc.; DIVA Vaccines for animal disease; Vaccines for emerging human and animal diseases; Novel immunomodulators and vaccine delivery systems: Immunomodulators including cytokines and new adjuvants; delivery of immunogens through liposomes, microspheres, ISCOMS, nanotechnology based vaccine delivery, etc.

Unit IV

Vaccine formulation: pharmacopeia requirements; Vaccine qualities and its control; Large scale vaccine production technology: cost effectiveness of preventive immunization programmes; Stages of development of vaccine; Clinical trials of vaccine and its regulation; Commercial vaccines available against animal pathogens, its characteristics and immunization schedule; Vaccine stability, Preservation and vaccination failure; Environmental concerns with the use of recombinant vaccines.

VI. Practicals

- Purification of immunoglobulins: gel filtration and ion exchange chromatography
- Hybridoma technique for monoclonal antibody production
- Preparation of gene construct for recombinant and nucleic acid vaccine
- Expression of gene encoding immunogenic protein in prokaryotic/ yeast/ animal cell culture system
- Study of immune response against recombinant vaccine

• Use of modern adjuvants in vaccines
• Isolation and characterization of antigens from viruses, bacteria
• Immunoassays: ELISA, FAT, RIA

I. Course Title : Advances in Reproductive Biotechnology

II. Course Code :BT611

III. Credit Hours : 2+1

IV. Aim of the course

Understanding the reproductive techniques in farm animals

V. Theory

Unit I

Micromanipulation of embryos and gametes, Somatic Cell Nuclear Transfer(SCNT), nuclear reprogramming, Transgenic animal production, Combining Transgenic and SCNT, Gene targeting, Genome editing and disease modeling.

Unit II

In vivo Vs *in-vitro* production of embryos, Embryos quality, Transcriptomics, Metabolomic approach, Sperm sexing technologies and their application, Preimplantation genetic diagnosis and screening, Epigenetic reprogramming, Large offspring syndrome.

Unit III

Sources of stem cells, Embryonic stem cells, Spermatogonial stem cells, Induced pluripotent stem cells, Stem cells application in regenerative medicine and disease therapeutics.

Unit IV

Social, Ethical, Religious and regulatory issues related to assisted reproductive technology, Transgenic and stem cells therapy.

VI. Practicals

• Micro assisted fertilization- ICSI
• Embryo biopsy for PGD and sexing

- Sperm quality analysis by flow cytometry
- Embryo quality analysis
- SCNT protocol
- Isolation and characterization of embryonic stem cells
- Gene expression in sperm and embryos