University of Tehran

College of Science

School of Biology

Description of program and course syllabi

Plant Biology

Master of Science

Systematics

Table 1- Required courses

Major: Plant Biology Program: Master of Science

No.	Course name	Unit			Hours			Prerequisite/ Corequisite
		Theoretical	Practical	Total	Theoretical	Practical	Total	
1	Advanced Plant Systematics	2	0	2	32	0	32	None
2	Vegetation Ecology	2	0	2	32	0	32	None
3	Plant Developmental Biology	2	0	2	32	0	32	None
5	Advanced Plant Cytology and Anatomy	2	0	2	32	0	32	None
6	Plant Metabolism	2	0	2	32	0	32	None
7	Uptake and Transport in Plants	2	0	2	32	0	32	None
Total		12	0	12	192	0	192	-

Table 2- Elective courses

Major: Plant Biology (Systematics and Ecology) Program: Master of Science

No.	Course name	Units			Hours			Prerequisite
		Theoretical	Practical	Total	Theoretical	Practical	Total	
1	Flora of Iran	2	0	2	32	0	32	None
2	Plant Geography	2	0	2	32	0	32	None
3	Variation and Evolution in Plants	2	0	2	32	0	32	None
4	Comparative Anatomy of Vascular Plants	2	0	2	32	0	32	None
5	Biology and Classification of Bryophytes	2	0	2	32	0	32	None
6	Methods and Tools in Plant Systematics	2	0	2	32	0	32	None
7	Advanced Phycology	2	0	2	32	0	32	None
8	Flora of Iran Laboratory	1	0	1		0	32	None
9	Field Study in Botany	1	0	1		0	32	None
10	Advanced Plant Ecology	2	0	2	32	0	32	None
11	Plant Population Genetics	2	0	2	32	0	32	None
12	Plant Cytogenetics	2	0	2	32	0	32	None
13	Palynology	2	0	2	32	0	32	None
14	Biosafety	2	0	2	32	0	32	None
15	Seminar	2	0	2				None
Total								

Students must take 10 units of this table, chosen with approval of the department.

Prerequisites for Master of Science degree in Plant Biology.

Topics of required courses

Major: Plant biology

Program: Master of Science

Course title: Advanced Plant Systematics
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Understanding the basic concept of systematics and biosystematics by using different techniques of speciation.

Topics of the course:

1- Principles of plant systematics
2- Species, speciation and concepts in species biology
3- Breeding systems in plants
4- Overview of evolutionary trends of morphological characters
5- Chromosomal evidence and its importance in plant systematics
6- Embryological evidence and its importance in plant systematics
7- Secondary metabolites and their importance in plant systematics
8- Isoenzyme evidence and its importance in plant systematics
9- Molecular systematics: Introduction to techniques with high polymorphisms
10- Numerical taxonomy and principles of phylogenetic analyses
11- Seminars

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Cronqist, A. (1988) The evolution and classification of flowering plants, 2nd ed; New York Botanical Garden.
2. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P. F., Donoghue, M.J. (2007) Plant Systematics: A phylogenetic approach; Sinauer Associates Inc., Sunderland, MA.
3. Simpson, M. G. (2009) Plant Systematics, 2nd ed.; Elsevier Academic Press.
4. Soltis, D.E., Soltis, P.S., Doyle, J.J. (1998) Molecular Systematics of plants II: ;Kluwer Academic Publishers, Boston.
5. Stace, C.A. (1980) Plant taxonomy and biosystematics; University Park Press, Baltimore.
6. Stuessy, T.F. (2008) Plant Taxonomy: The Systematic Evaluation of Comparative Data; Columbia University Press.

Course title: Vegetation ecology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
The overarching goal of the vegetation ecology is to better understand interactions of plants with each other, and with the other biotic and abiotic components of different ecosystems.

Topics of the course:

1. Aims, history, concepts and nature of vegetation ecology
2. Concepts of communities – complementary perspectives
3. Climatic classification systems: humidity coefficients, aridity coefficients (de Martin), Gaussen's coefficient, Emberger coefficient, Coupon classification, Holdrige classification
4. The role of physico-chemical factors on vegetation
5. Soil classification
6. Limiting factors of vegetation in natural condition
7. Zonobiomes
8. Methods of vegetation analysis: physiognomic surveys, floristic methods, various schools (Zurich-Montpelier, Upsala, Russian, …), sampling methods, data matrix composition, correlation between species and samples, correlation and distance coefficients, methods of estimation of species richness, etc.
9. Vegetation structure (Braun-Blanquet method): the concept of releve, minimal area, coefficients (associability, fidelity, frequency), dominant species, companying species, etc., data analysis
10. Cluster analysis, correlation analysis
11. Ordination analysis: principal component analysis, correspondence analysis, canonical correspondence analysis, etc.

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Barbour, M. G., Burk, J. H., Pitts, W. D., Gilliams, F. S., Schwartz, M. W. (1999) Terrestrial Plant Ecology; Addison Wesley Longman, New York.
2. Kent, M., Coker, P. (1995) Vegetation description and analysis; John Wiley, Sons.
3. Mueller-Dombois, D., Ellenberg, H. (1974) Aims and Methods of Vegetation Ecology; Wiley
4. Van der Maarel, E. (2005) Vegetation Ecology; McGraw Hill.

Course title: Plant Developmental Biology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Familiarization with the different phases of plant development and the regulatory mechanisms
The practical objectives of the course:
Explaining different stages of plant development and differentiation and the applications of this field of study

Topics of the course:

1. Differentiation in cells and protoplasts, the biochemical reactions involved and the role of nucleoproteins
2. Protein folding, primary, secondary, tertiary and quaternary structures, post-translational modifications of proteins
3. Cell cycle and its regulation, different types of cyclin and CDK, checkpoints, Ubiquitin-proteasome system of protein degradation, etc.
4. Cytoskeleton, polymerization, motor proteins, the role of cytoskeleton in growth, polarity and its role in differentiation, proliferative and formative division, phragmoplasts, etc.
5. Cell division and differentiation, changes in the tracheids, gamma seedling formation, kinetic models of cell division and differentiation, genetics and epigenetics of cell differentiation
6. Definition of meristems, a review of the theories on the organization of meristems, meristem dimensions and functional domains, etc.
7. Apical meristem, *Arabidopsis* meristem as a model, activations the genes important in terms of the maintenance of meristem characteristics, fate determination of cells, the role of hormones in meristem maintenance, etc.
8. Leaf development: meristems function, morphological patterns along dorsi-ventral and lateral axes, regulation of the expression of genes important in terms of cell division, etc.
9. Apical meristem in the root: embryological ontogeny in *Arabidopsis*, the role of auxin in the formation of embryonic meristem, meristem organization and functional domains, regulation of gene expression, etc.
10. The formation of flower in plants, control of meristem function and the number of flower organs, maintenance of meristem function, fluctuations in the size of meristems, monoecious flowers, floret meristem, etc.
11. Control of the timing of flower formation, gibberellic pathways, abscisic acid, regulatory genes, meristem function, etc.
12. Sex in plants, genotypic determination of sex, formation of seedless fruits
13. Aging in plants: metabolism, hormones, inhibitors, hormonal antagonism, etc.
14. Molecular mechanisms of plant responses to environmental stimuli, hypersensitivity, apoptosis and necrosis
15.

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Buvat, R. (1989) Ontogeny, Cell Differentiation and structure of vascular plants; Springer-Verlag.
2. Hennig, L., Köhler, C. (2010) Plant Developmental Biology: Methods in Molecular Biology, Vol. 655; Humana Press.
3. Howell, S.H. (1998). Molecular Genetics of Plant Development. Cambridge University Press.
4. Inze, D. (2008) Cell cycle control and plant development; Springer.
5. Leyser, O., Day, S. (2003) Mechanisms in Plant Development. Blackwell Publishing.
6. Lyndon, R.F. (1990) Plant Development, the cellular basis. Unwin Hyman Ltd.
7. McManus, M.T., Veit, B.E. (2002).Meristematic Tissues in Plant Growth and Development. Sheffield Academic Press (CRC Press).
8. Pua, E-C, Davery, M.R. (2010) Plant Developmental Biology - Biotechnological Perspectives, Volume 1; Springer.
9. Sussex, I.M. (1989). Patterns in Plant Development. Cambridge University Press.
10. Timmermans, M.C.P. (2010) Plant Development (Current Topics in Developmental Biology). Academic Press.

Course title: Advanced plant cytology and anatomy
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Structure and composition of the cell wall, morphology of plastids and vacuoles, differentiation of dermal, fundamental and vascular tissues and origin and structure of secondary plant body will be studied.

Topics of the course:
1. An overview of plant structure and development
2. Structure and composition of the cell wall: cell wall expansion, cell plate and middle lamella formation, the primary wall, plasmodesmata, the secondary wall, wall pits
3. Plastids: morphology and structure of various types
4. Vacuoles
5. Genomes: nuclear, plastid and mitochondrial genomes
6. Differentiation of dermal tissue: Cuticles and epicuticle waxes, specialized epidermal cells
7. Differentiation of fundamental (ground) tissue system: parenchyma, collenchyma, sclerenchyma: sclereids and fibers
8. Differentiation of vascular tissue system: Xylem, tracheids, primary xylem treachery elements, vessel members
9. Differentiation of vascular tissue system: Phloem, sieve tube elements, companion cells and sieve cells
10. Origin and structure of secondary plant body: vascular cambium formation, structure and function of the vascular cambium, structure and function of the cork cambium and periderm, unusual secondary growth

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Beck, C.B. (2010) An Introduction to Plant Structure and Development. Plant Anatomy for the Twenty First Century. Cambridge University Press.
2. Bowes, B.G., Mauseth, J.D. (2008) Plant Structure, A Color Guide. Manson Publishing.
3. Buchanan, B. B., Gruissem W., Jones R. L. (2000) Biochemistry and Molecular Biology of Plants. John Wiley & Sons.
4. Buvat, R. (1989) Ontogeny, Cell Differentiation and Structure of Vascular Plants.Springer-Verlag.
5. Cutler, D.F., Botha, E., Stevenson, D.W. (2008) Plant Anatomy. An applied approach. Blackwell Publishing.

6. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells and Tissues of the Plant Body-Their Structure, Function and Development.Wiley Interscience.
7. Fahn, A. (1990) Plant Anatomy. Pergamon Press.
8. Harrison, M., Dashek W. V. (2006) Plant Cell Biology. Science Publishers.
9. Robinson D. (2003) The Golgi Apparatus and the Plant Secretory Pathway.Blackwell Publishing Ltd .
10. Rudall, P. (2007) Anatomy of Flowering Plants. An Introduction to Structure and Development. Cambridge University Press.

Course title: Plant Metabolism
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Understanding the mechanisms of metabolic reactions and their regulation.

The practical objectives of the course:
Explaining the mechanisms of metabolic reactions in plants and to utilize this insight in the fields of metabolic engineering and genetic manipulations in order to increase the yield of plant products valuable in industry, medicine and nutrition.

Topics of the course:

1. Free energy, enthalpy, entropy and activation energy
2. Redox potential, pH, oxygen and hydrogen electrode, fluctuations of free energy in a redox reaction
3. Different types of biological catalysts, kinetics of enzymatic reactions, reaction rates
4. Michaelis-Menten equation, bisubstrate reactions (ordered, random and ping-pong mechanisms), definition of catalysis, enzyme specificity, the lock-and-key and induced fit models
5. Inhibition of enzyme activity, irreversible inhibition, reversible inhibition (competitive, uncompetitive and mixed)
6. Hill equation, cooperation, allosteric regulation of enzymatic activity
7. Mechanisms of enzymatic catalysis including substrate channeling, acid-base catalysis and covalent catalysis
8. Regulation mechanisms including reversible and irreversible inhibition, the role of substrate concentration, temperature and pH on the reactions, feedback inhibition, association and dissociation of enzyme subunits, metobolon (enzymatic aggregates), covalent modification of enzymes (adenylylation, bi-adenylylation, phosphorylation, bi-phosphorylation, disulfide bonds, etc.) and enzyme categorization
9. Regulation of enzyme transcription, catabolic inhibition, inducible and constitutive enzymes
10. The central role of calcium in plant metabolism, the role of GABA pathway in the regulation of plant metabolism
11. Mechanisms of metabolic regulation in different metabolic pathways including glycolysis, respiration, Kelvin cycle and photorespiration
12. Mechanisms of the regulation of key nitrogen metabolism enzymes including nitrate reductase enzymes, glutamine synthase, asparagine synthase and other enzymes of amino acid biosynthesis

Table of assessment

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-	-	**80%- written**	**20%**

References:

1. Ashihara, H. Crozier, A. and Komami A. (2011). Plant Metabolism and Biotechnology, John Wiley and Sons, Ltd., Publication, 404 Pages.
2. Buchanan, B.B., Gruissem, W., Jones, R.L. (2000) Biochemistry and Molecular Biology of Plants. American society of plant physiologists.

3. Dennis, D.T. (1997) Plant Metabolism; Longman.
4. Plaxton W. C. and Mcmanus M.T. (2006). Control of Primary Metabolism in Plants. Black Well Publishing, 373 Pages.
5. Storey K.B. (2004) Functional metabolism: regulation and adaptation; John Wiley & Sons, Inc., 594 Pages.

Course title: Uptake and Transport in Plants
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Learning mechanisms of the uptake and transport of minerals and the transport of organic material in plants.

The practical objectives of the course:
Explaining the mechanisms of uptake and transport in plants and to utilize this insight in creating methods to increase the overall yield of agricultural products.

Topics of the course:

1. Mechanisms of ionic mobility in soil, ionic absorption hypotheses, regions of ionic absorption in roots, the role of mycorrhizae in absorption and the definition of depletion zone
2. The driving force of different ions, electrochemical potential, Goldman equation, Kinetic absorption, high affinity transport system (HATS), low affinity transport system (LATS), Michaelis-Menten equation, regulation of ionic absorption, regulation of ionic absorption by remote regions (the relationship between cells and organs)
3. The structure of plasma and tonoplast membranes, proteins responsible for the absorption and transport of ions including channels, transporters and pumps, primary and secondary active transport, uniporters, symporters, antiporters, the structure and function of the carriers of various cations and heavy metals in plants and aquaporins
4. The structure and function of plasma membrane and tonoplastic H^+-ATPases and their regulation, ionic transport across vacuole membranes, different types of pyrophosphotases, the structure and function of vacuole H^+ pyrophosphotase
5. Energetics of potassium ions in tonoplast, control of pyrophosphotase by calcium ions, calcium channels in tonoplast, plant potassium channels and their structure and function
6. Metabolite transport among organelles, transport of molecules across the membranes of chloroplasts, mitochondria and other organelles as well as the structure and function of phosphate translocator
7. Pathways of water and mineral transport across roots, apoplastic and symplastic transport, ion release into xylems and the involved theories, transport to branches, perspiration, translocation of ions
8. Transport of molecules in sap and the regulation of long-distance transport and the circulation of material between branches and roots
9. The role of plant hormones and regulator molecules in the absorption and transport of material
10. Absorption and transport of plant hormones: absorption and aggregation, translocation of hormones, polar transport of oxygen

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	**-**	**80%- written**	**20%**

References:

1. Buchanan, B.B., Gruissem, W., Jones, R.L. (2000) Biochemistry and molecular biology of plants. American society of plant physiologists.

2. Glass, A.D.M. (1989) Plant nutrition. Jones and Bartlett Publishers.
3. Holbrook, N., M., Zwieniecki, M.A. (2005) Vascular transport in plants; Elsevier Academic Press.
4. Jaiwal, P.K., Singh, R.P., Dhankher, O.P. (2007) Plant membrane and vacuolar transporters; www.cabi.org
5. Marschner, H. (1986). Mineral nutrition in higher plants. Academic press.
6. Rengel, Z. (1999) Mineral nutrition of crops. Food products press.
7. Srivastava, L.M. (2002) Plant Growth and Development; Academic press.
8. Tobin, K.A. (1992) Plant orgenelles, compartmentation of metabolism in photosynthesis cells. Cambridge University Press.
9. Yeo, A. and Flowers, T. (2007) Plant solute transport; Blackwell Publishing.

Plant Biology Curriculum

Post-graduate Program Syllabuses (M.Sc. degree)

Systematics

Elected Courses

Course title: Flora of Iran
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Understanding the main habitat of Iranian plants and their indicator species
Topics of the course:

1. Principle and history of flora of Iran
2. Statistical evaluation of Iranian plant including the Number of orders, families, genera and species, endemics, comparing the flora of Iran with neighbor countries.
3. Classification of Iran vegetations
4. Iranian north forests, indicator species and endemics
5. Iranian conifer forests (*Juniperus* and *Cupressus*) and their indicator species
6. Zagros *Quercus* forests
7. *Pistacia* and *Amygdalus* communities
8. Mountain steppe habitats (*Astragalus*, *Stipa*, *Acantholimon*,…)
9. Desert steppe habitats (*Artemisia*, …) and indicator species
10. Aquatic plants (families and genera)

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	**10%**	**80%- written**	**10%**

References:

1. Davis, S. D., Heywood, V. H., Hamilton, A. C. (eds.). (1994) Centers of plant diversity, a guide and strategy for their conservation. Vol. 1: Europe, Africa, South West Asia and the Middle East. – WWF & IUCN. Oxford.
2. Freitag, H. (1986) Notes on the distribution, climate, and flora of the sand deserts of Iran and Afghanistan. – Proc. Roy. Soc. Edinburgh 89 B: 135–146.
3. Frey, W., Probst, W. (1986) A synopsis of the vegetation of Iran. – In: Kürschner, H. (ed.) Contributions to the Vegetation of Southwest Asia. Beih. Tübinger Atlas Vorderen Orients, A, 6. Nr. 24: 9-24. Dr. Ludwig Reichert.Wiesbaden.
4. Ghahreman, A., Attar, F. (1999) Biodiversity of Plant Species, vol. 1. Tehran University press.
5. Klein, J. C. (1994) La végétation altitudinale de L'Alborz Central (Iran): entre les régions irano-touranienne et euro-sibérienne. – Biblioth. Iran. 40. Institut Français de Recherche en Iran. Téhéran.
6. Léonard, J., 1981-1992: Contribution a l'étude de la flore et de la végétation des deserts d'Iran: Etude des aires de distribution les phytochories, les chorotype. Fasc. 1-2. – Jardin botanique national de Belgique. Meise.
7. Rechinger, K.H., 1963-2005: Flora Iranica, vols: 1-175. Akademische Druck-u. Verlagsanstalt. Graz.
8. Zohary, M. (1973) Geobotanic foundation of the Middle East. 2 vols - Stuttgart, Amsterdam.

Course title: Plant Geography
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Understanding the concept of plant geography, vicariance, endemism, climatic zone of the world and main biomes.

Topics of the course:

1. Principle and concept of plant geography (ecology, phytososiology, methods in plant geography and its history)
2. Chorology (definition, goals, restriction factors, type of distribution maps, niches,…)
3. Vicariance, speciation, relict species and center of diversity
4. Endemism: subcategories of endemism, endemic types or species
5. Floristic regions: six regions of the world recognized by plant geographers
6. Climatic zones of the world (Coriolis effect, El Niño,…)
7. Biomes: Tropical rain forest
8. Biomes: Savana
9. Biomes: Desert
10. Biomes: Mediterranean
11. Biomes: Temperate rain forest
12. Biomes: Tundra and Taiga (also called boreal forest)

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	**-**	**80%- written**	**20%**

References:

1. Cox, C. B., Moore, P.D. (2000) Biogeography: an ecological and evolutionary approach. 6th ed.: Blackwell Scientific Publications, Oxford.
2. Freitag, H. (1986) Notes on the distribution, climate, and flora of the sand deserts of Iran and Afghanistan. – Proc. Roy. Soc. Edinburgh 89 B: 135–146.
3. Goodall, D. W. (ed.) (1977). Ecosystems of the world. Elsevier. New York.
4. Léonard, J., 1991/1992: Contribution a l'étude de la flore et de la végétation des deserts d'Iran. Etude de la végétation: Analyse phytosociologique et phytochorologique des groupments végétaux. Fasc. 10 (1 & 2). – Jardin Botanique National de Belgique. Meise.
5. Takhtajan, A. (1986) Floristic Regions of the World. – University of California Press, California. (English translation from Russian).
6. Zohary, M. (1973) Geobotanic foundation of the Middle East. 2 vols. – Stuttgart, Amsterdam.

Course title: Variation and Evolution in Plants
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The objectives of the course:
Understanding the main trends in evolution and originating of plants and the causes as well as factors leading to the current variation of modern plants

Topics of the course:

1. Ecological conditions of geological era and its impact on origin and evolution of plants
2. Origin of life, the increase of oxygen in the atmosphere, and its impact on plant evolution, eukaryotic life and its following changes, autotrophy, etc.
3. Appearance and diversity of algae and fungi
4. Origin of land plants and their relationship with algae
5. Evolution of life cycle (sporophytic and gametophytic)
6. Evolutionary relationships between mosses and vascular plants
7. Evolution of vascular system and stele
8. The impact of some biological events (e.g. breeding system, hybridization, genetic drift, polyploidy etc.) on diversity and speciation

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Stewart, N. W., Rothwell, G. W. (1999) Paleobotany and the Evolution of Plants. Cambridge University Press.
2. Cronquist, A. (1988) The Evolution and Classification of Flowering Plants. The New York Botanical Garden.
3. Wilis, K. J., McElwain, J. C. (2002) The Evolution of Plants. Oxford University Press.
4. Judd, W. S., Campbell, C. S., Kellog, E. A. Stevens, P. F. and Donoghue, M. J. (2002) Plant Systematics: A Phylogenetic Approach (3rd Ed.). Sinauer Associates.

Course title: Comparative Anatomy of Vascular Plants
No. of units: 2
No. of hours: 32
Unit type: theoretical- practical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Understanding the main tissues of plant body (epidermal, ground and vascular tissues) and comparing the root, stem and leaves in different plant groups
Topics of the course:

1. Overview on plants tissue and organs focusing on three tissue systems
2. Epidermal tissue: stomata, cuticle, trichome and epidermal cells
3. Ground tissues: Cortex, supportive tissues
4. Vascular tissues: protostele, siphonostele, Eustele, etc.
5. Root (comparing root variation among different main groups of vascular plants): Primary root structure (apex, cap), epidermis and hypodermis, cortex and endodermis, pericycle and vascular cylinder, lateral and adventitious roots, secondary growth in roots
6. Stem (comparing stem variation among different main groups of vascular plants): Primary stem structure, primary vascular system, nodal vasculature, vascular cambium, secondary xylem, secondary phloem, primary and secondary thickening meristems, periderm
7. Comparative analysis of wood: Gymnosperms to flowering plants
8. Leaf: microphyll and megaphyll, internal structure, ecological factors and leaf adaptation
9. Flower organs: internal structures, primitive and advanced flower structures
10. Seed and fruit: structures and dispersal

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Evert, R.F., Eichhorn, S.E. (2013) Raven Biology of Plants. Eight edition. W.H. Freeman and Company Publishers.
2. Fahn, A. (1984). Plant Anatomy. Pergamon Press, Oxford.
3. Mauseth, J.D. (1988) Plant Anatomy. The Benjamin/Cummings Publishing Company, Inc., Menlo Park, Calif.
4. Peterson, R.L., Peterson, C.A., Melville, L.H. (2009) Teaching Plant Anatomy through Creative Laboratory Exercises. NRC Press, Canada.

Course title: Biology and Classification of Bryophytes
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Morphology, physiology and ecophysiology of main groups of Bryophytes will be studied.

Topics of the course:

1. Morphology and classification of Hepatics
2. Morphology and classification of Bryophytes
3. Chemical and biochemical components of Bryophytes
4. Physiology and ecophysiology of Bryophytes
5. Ecology of Bryophytes and their role on study of environmental pollution
6. Geography of Bryophytes
7. Principle and concept of plant geography (ecology, phytosociology, methods in plant geography and its history)
8. Systematics and Evolution of Anthocerotopsida and Marchantiopsida (Anthocerotaceae, Aytoniaceae, Conocephalaceae, Lunulariaceae, Marchantiaceae, Ricciaceae)
9. Systematics and Evolution of Jungermaniopsida (Frullaniaceae, Jungermanniaceae, Metzgeriaceae, Pellaiceae, Porellaceae, Radulaceae)
10. Systematics and Evolution of Bryopsida I: Polytrichaceae, Timmiaceae, Encalyptaceae, Funariaceae
11. Systematics and Evolution of Bryopsida II: Grimmiaceae, Fissidentaceae, Dicranaceae, Orthotrichaceae
12. Systematics and Evolution of Bryopsida III: Pottiaceae
13. Systematics and Evolution of Bryopsida IV: Amblystegiaceae, Leskeaceae, Brachytheciacea
14. Systematics and Evolution of Bryopsida V: Bryaceae, Mniaceae Plagiotheciaceae
15. Systematics and Evolution of Bryopsida VI: Hypnaceae, Leucodontaceae, Neckeraceae

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Frey, W., Kürschner, H. (1991) Conspectus Bryophytorum Orientalium et Arabicorum. Bryophtorum Bibliotheca 39: 1-181.
2. Kürschner, H. (2001) Towards a bryophyte flora of the Near and Middle East. 3. An artificial key to the Anthocerotopsida and Hepaticophytina of the Near and Middle East. Nova Hedwigia 72: 161-200.
3. Puri, P. (1981) Bryophytes: Morphology, Growth and Differentiation. Atma Ram & Sons, Dehli, Lucknow.
4. Shaw, A. J., Goffinet, B. (2000) Bryophyte Biology. Cambridge.
5. Smith, G. M. (1983) Cryptogamic Botany (Bryophytes and Pteridophytes) vol II. 2nd. Mc Graw-Hill, London.
6. Smith, A.J.E., (1990) The Mosses Flora of Britain & Ireland.

Course title: Methods and Tools in Plant Systematics
No. of units: 2
No. of hours: 32
Unit type: theoretical-practical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Preparing pollens for LM and SEM studies, extractions of secondary metabolites, isoenzyme and DNA, PCR, electrophoresis and data analyses are the main objectives of this course.

Topics of the course:
1. Taxon sampling in systematics
2. Preparing samples for palynology
3. Palynology laboratory (Preparing pollens for SEM)
4. Palynology laboratory (Preparing pollens for LM)
5. Extraction and study of selected secondary metabolites
6. Secondary metabolites laboratory
7. Extraction and study of isoenzymes
8. Isoenzyme laboratory (extraction, electrophoresis, staining and data analyses)
9. DNA extraction and study of microsatellites
10. DNA extraction laboratory, Polymerase Chain Reaction (PCR) and gel electrophoresis

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
50%	**-**	**50%- written**	**-**

References:

1. Cronqist, A. (1988) The evolution and classification of flowering plants, 2nd ed. New York Botanical Garden.
2. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P. F., Donoghue, M.J. (2007) Plant Systematics: A phylogenetic approach. Sinauer Associates Inc., Sunderland, MA.
3. Simpson, M. G., (2009) Plant systematics, 2nd ed., Elsevier Academic Press.
4. Soltis, D.E., Soltis, P.S., Doyle, J.J. (1998) Molecular Systematics of plants II: Kluwer Academic Publishers, Boston.
5. Stace, C.A. (1980) Plant taxonomy and biosystematics. University Park Press, Baltimore.
6. Stuessy, T. F. (2008) Plant Taxonomy: The Systematic Evaluation of Comparative Data. Columbia University Press.

Course title: Advanced Phycology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Taxonomy, classification and molecular systematics of diatoms, haptophytes, dinophytes, chrysophytes and major branches of algae will be studied.

Topics of the course:
1. Algae in the warp and weave of life: bound by plastids
2. Evolution and relationships of algae: major branches
3. Classification and diatom systematics: the past, the present, and the future
4. The taxonomy of Cyanobacteria: molecular insights into a difficult problem
5. Molecular systematics of red algae: conflict of classical and modern approach
6. Molecular systematics of the green algae: conflict of classical and modern approach
7. Systematics of the Charophytes green algae
8. Molecular systematics of Haptophytes, Dinophytes, Chrysophytes, etc.
9. Classification of the Phaeophyceae from past to present
10. Molecular systematics of algae: a review of the past findings and the perspectives

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Brodie, J., Lewis, J. (2007) Unravelling the Algae*:* The Past, Present, and Future of Algae Systematics. Systematics Association Special Vol.75.CRC Press.
2. Barsanti, L., Gualtieri, P. (2005) Algae: Anatomy, Biochemistry, and Biotechnolog*;* CRC Press.
3. Bhattacharya, D. (1998) Origins of Algae and Their Plastids; Springer-Verlag.
4. Lee, R. E. (2008) Phycology (4th Ed.) Cambridge University Press.

Course title: Flora of Iran Laboratory
No. of units: 1
No. of hours: 32
Unit type: practical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students will learn how to identify different groups of Iranian plants.

Topics of the course:

1. An introduction to botanical Latin
2. Identification of Iranian Pteridophytes: morphological characters and terminology
3. Identification of Iranian gymnosperms: morphological characters and terminology
4. Identification of Iranian basal angiosperms: focusing on Iranian taxa
5. Identification of aquatic monocots: morphological characters and terminology
6. Identification of taxa of Asparagales and Liliales: Diagnostic key and morphological terminology
7. Identification of taxa of Poales, Cyperales, Juncales: Diagnostic key and morphological terminology
8. An overview on orders of Dicots in the flora of Iran
9. Identification of taxa of Ranunculaceae, Brassicaceae: Diagnostic key and morphological terminology
10. Identification of taxa of Rosaceae, Fabaceae and Malvaceae: Diagnostic key and morphological terminology
11. Identification of taxa of Boraginaceae, Lamiaceae and Scrophulariaceae: Diagnostic key and morphological terminology
12. Identification of taxa of Apiaceae, Asteraceae: Diagnostic key and morphological terminology

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
50%	**-**	**50%- written**	**-**

References:

1. Rechinger, K.H., (1963-2016) Flora Iranica, vols: 1-182. Akademische Druck-u. Verlagsanstalt, Graz.
2. Stern, W.T. (1983) Botanical Latin. 3rd ed. David & Charles, London.

Course title: Field Study in Botany
No. of units: 1
No. of hours: 32
Unit type: practical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Understanding the main habitat of flowering plants with their indicator species.

Topics of the course:
1- Different methods of plant collections for various plant groups
2- Preparation and preservation of plant samples for cytology, molecular phylogenetics, plant anatomy
3- Plot sampling for phytosociological studies
4- Sampling in ecology
5- The characteristics of plants in fields
6- Various plant groups in Iran observed in nature
7- Desert, mountainous and Hyrcanian vegetation in Iran

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

1. Mueller-Dombois, D., Ellenberg, H. (1974) Aims and Methods of Vegetation Ecology. Wiley, New York.
2. van der Maarel, E. (2005) Vegetation Ecology. McGraw Hill, London.

Course title: Advanced Plant Ecology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Understanding the concept of autoecology including thermal balance of plants, water relations of plants and carbon balance as well as the ecosystem concept are the overall objectives of this course.

Topics of the course:
1. Introduction and concepts in plant ecology
2. Autoecology: Thermal balance of plants
3. Autoecology: Water relations in plants, nutritional relation in plants
4. Autoecology: Carbon balance
5. The ecosystem concept: Processes in ecosystems sustainability, the biogeochemical cycles, biodiversity and ecosystems
6. Syndynamics, synchorology, synecology
7. Global cycle of materials, human impacts on carbon balance, the impact of human activities on biodiversity, socio-economic interactions

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Schulze, E.D., Beck, E., Müller-Hoheinstein, K. (2005) Plant Ecology. Springer, Stuttgart.
2. Gurevitch, J., Scheiner, S.M.., Fox, G.A. (2006) The ecology of plants, 2nd ed. Sinauer Associates Inc., Sunderland, MA.

Course title: Plant Population Genetics
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Principle of classic genetics, fundamentals of natural selection, population structure and gene flow as well as molecular population genetics are the main objectives of this course.

Topics of the course:

1. Principle and concept of classical genetics: theory and assumptions
2. Genotype frequency: Mendel's model of genetics, Hardy-Weinberg expected genotype frequencies, the fixation index and heterozygosity, mating among relatives
3. Fundamentals of natural selection: natural selection on a di-allelic locus, further models of natural selection
4. Genetic drift and effective population size: the effect of sampling lead to genetic drift, model of genetic drift, bottle neck effect, founder effect, parallelism between drift and inbreeding
5. Population structure and gene flow: genetic populations, direct measures of gene flow, fixation indices to measure the pattern of population subdivision, population subdivision and the Wahlund effect, models of population structure
6. Mutation: the source of all genetic variation, the fate of new mutation, mutation models, Muller's Ratchet, mutation models, the influence of mutation on allele frequency and autozygosity
7. Molecular population genetic: the neutral theory, measures of divergence and polymorphism, DNA sequence divergence and the molecular clock, testing the molecular clock hypothesis and explanation for rate variation in molecular evolution
8. Quantitative trait variation and evolution: quantitative traits components of phenotypic variation, evolutionary change in quantitative traits, quantitative trait loci (QTL)

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	**-**	**80%- written**	**20%**

References:

1. Hamilton, M.B. (2009) Population genetics Wiley, John & Sons.
2. Halliburton, R. (2004) Introduction to Population Genetics Pearson/Prentice Hall, Upper Saddle River, N.J.
3. Hedrick, P.W. (2011) Genetics of Populations, Fourth Edition. Jones & Bartlett Publishers, MA.

Course title: Plant Cytogenetics
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Chromosome and their structure, Polymorphisms and deficiencies and Molecular cytogenetics will be studied.

Topics of the course:

1. Chromosomes and cytogenetics: An introduction
2. Chromosome and their structure
3. Telomere, centromere, chromatin and heterochromatin
4. Polymorphisms and deficiencies (origin and occurrence of deficiencies)
5. Polyploidy in higher plants: allopolyploids, autopolyploids, aneupolyploids
6. Deletion, insertion, inversion, crossing over, duplication
7. Cell cycle
8. Staining: Q-banding, G-banding, C-banding, immunostaining, CGH, ISH, GISH and FISH
9. Molecular cytogenetics: future perspectives
10. Cytogenetics and plant systematics

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	**-**	**80%- written**	**20%**

References:

1. Gupta, P. K. (2013) Cytogenetics: An Advanced Study, 1st ed.
2. Stace, C.A. (1989) Plant Taxonomy and Biosystematics, 2nd ed. Edward Arnold. London.

Course title: Palynology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Understanding the advanced aspects of palynology considering the development and formation of pollen grains and spores and learning the pollen types in certain plant groups.

Topics of the course:

1. History, branches and aims of palynology and applications
2. Palynomorphs (spores and pollen grains) in various plant groups and their structural differences, fossil palynomorphs
3. Application of palynology, survival potential and pollen age duration, collection and preservation of pollen grains, pollen grains preparations (acetolysis, Woodhouse methods, electron microscopy, etc.)
4. Development and evolution of pollen grains: spore and pollen grain formation considering different reproductive structures, development of exine and its chemical composition
5. Pollen grain shedding: Monad, diad, tetrad, etc., pollen grain maturation and anther dehiscence
6. Morphological diversity of pollen grains, cellular conditions of pollen grains
7. Development of anther and pollen grains, pollination and fertilization
8. Self-incompatibility and its factors, types of self-incompatibility
9. Pollen allergy, the effect of environmental conditions and pollutants on pollen allergy
10. Terminology in palynology: Aperture types, microsculpturing, classification of pollen grains

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

1. Dafni, A., Hesse, M., Pacini, E. (2000) Pollen and Pollination. Springer.
2. Evert, R.F., Eichhom, S.E. (2013). Raven Biology of Plants. Freeman and Company Publishers.
3. Jansonius, J., McGregor, D. C. (1996) Palynology: Principles and Application; American Association of Stratigraphic Palynologists Foundation.
4. Hesse, M. (2009). Palynology. Springer.
5. Hesse, M., Halbritter, H., Weber, M., Buchner, R., Frosch-Radivo, A., Ulrich, S. (2007): Pollen Terminology: An illustrated handbook.
6. Horowitz, A. (1992) Palynology of Arid Lands; Elsevier.
7. Moore, P. D., Webb, J. A., Collinson, M. E. (1991) Pollen Analysis; Blackwell Scientific Publications.
8. Traverse, A. (2007) Paleopalynology (2nd Ed.); Springer.
9. Saxena, M. R. (1993) Palynology; International Science Publisher.

Course title: Biosafety
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** no
The overall objectives of the course:
Familiarization with the chemical and biological hazards in biology laboratories.

The practical objectives of the course:
Explaining the physical, chemical and biological hazards in biology laboratories and methods of confronting them.

Topics of the course:

1. Introduction to biosafety and work in biology laboratories, principles of safety, working with chemicals: powdered chemicals, chemicals storage, working with pressurized gases, etc.
2. Labeling of chemicals, solvents, oxidants, MSDS, flammable compounds, etc.
3. Familiarization with cryogenic gases and liquids, explosives, working with acids and bases, corrosive and irritant compounds
4. Working with UV radiation and radioactive compounds ,effects of UV radiation on human skin and eyes, disposal of radioactive wastes
5. Biosafety levels introduction
6. Work with biological compound, personal protective equipment, type one and two laboratories, human and animal samples
7. Categorization of pathogenic microorganisms, infections and epidemics
8. Methods of biological hazard control in diagnosis, treatment and research, personal protection, waste disposal and isolation
9. Microbial sampling, identification and counting, technical and statistical issues in sampling, etc.
10. Release of genetically modified microorganisms into the environment, ethics and rules, production and storage of microbial products
11. Ethics and issues associated with biotechnological products
12. Biosafety of recombinant DNA technology, expression systems and genetically manipulated organisms
13. Biosafety of work with compounds commonly used in molecular biology laboratories
14. Biosafety of the transportation of biological material
15. Safety and protection in chemistry laboratories
16. First aid in Biology laboratories
17. Safety data sheets

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
-	-	**80%- written**	**20%**

References:

1. Laboratory Biosafety Manual. 2004; 3rded; World Health Organization (WHO); Geneva; Switzerland.
2. Biological Safety Manual. 2007; University of Pennsylvania; Pennsylvania; USA.
3. The Laboratory Biosafety Guidelines. 2004; 3rded; Public Health Agency of Canada; Canada.

4. Biosafety in Microbiological and Biomedical Laboratories; 2007; 5th ed, US Government Printing Office; USA.
5. Guidance on Regulations for the Transport of Infectious Substances; 2007–2008; World Health Organization; USA.