University of Tehran

College of Science

School of Biology

Description of program and course syllabi

Plant Biology

Master of Science

Physiology

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 (Physiology) Program: Master of Science

No.	Course name	Units			Hours			Prerequisite
		Theoretical	Practical	Total	Theoretical	Practical	Total	
1	Molecular Mechanisms of Photosynthesis	2	0	2	32	0	32	None
2	Molecular Biology of Evolution	2	0	2	32	0	32	None
3	Halophytes Physiology	2	0	2	32	0	32	None
4	Metalophytes Physiology	2	0	2	32	0	32	None
5	Advanced Plant Ecophysiology	2	0	2	32	0	32	None
6	Plant Biochemistry	2	0	2	32	0	32	None
7	Application of Biotechnology in Plants	2	0	2	32	0	32	None
8	Advanced Plant Growth and Development	2	0	2	32	0	32	None
9	Research Methodology and Experimental Design	2	0	2	32	0	32	None
10	Methods and Tools in Plant Physiology	2	0	2	32	0	32	None
11	Mineral Nutrition of Plants	2	0	2	32	0	32	None
12	Water Relations of Plant and Soil	2	0	2	32	0	32	None
13	Systems Biology	2	0	2	32	0	32	None
14	Biosafety	2	0	2	32	0	32	None
15	Seminar	2	0	2				
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

Continuous evaluation	Midterm	Final exam	Project
-	-	**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)

Physiology

Elected Courses

Course title: Molecular Mechanisms of Photosynthesis
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:
Learning the molecular mechanism of photosynthesis.

The practical objectives of the course:
Explaining the light and darkness reactions and utilize these insight in increasing the yield of plant and to confront the organic and inorganic tensions in plants.

Topics of the course:

1. Light and energy
2. The organization and structure of photosynthetic systems
3. The history and advances in the field of photosynthesis
4. The structure and biosynthesis of photosynthetic pigments and spectroscopy
5. Antenna complexes and mechanisms of energy transport
6. Center of reaction complexes
7. Components of electron transport chains
8. Chemo-osmotic coupling and ATP synthesis
9. Carbon metabolism
10. Genetic, aggregation and regulation of photosynthetic systems
11. Origin and evolution of photosynthesis

Table of assessment

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

References:

1. Blankenship, R.E. (2002) Molecular Mechanisms of Photosynthesis; Blackwell.
2. Buchanan, B.B., Gruissem, W., Jones, R.L. (2000) Biochemistry and Molecular Biology of Plants. American society of plant physiologists.
3. Leegood, R.C., Sharkey, T.D.Caemmerer, S. (2000) Photosynthesis: Physiology and Metabolism. Kluwer Academic Publisher.
4. Lowlor, D. (2001) Photosynthesis. BIOS Scientific publishers Ltd.

Course title: Molecular Biology of Evolution
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:
Learning the molecular processes involved in evolution in general and the molecular evolution of plants in particular.

The practical objectives of the course:
Explaining the molecular processes involved in evolution.
Topics of the course:

1. Genetic polymorphism, Darwinian evolution, inheritance versus evolution, evolutionary rate concept
2. Genetic diversity and evolution, a methodological error, protein diversity versus genetic diversity
3. Genetic diversity in natural populations, the genetic basis of individualism
4. The origin of species, geographical isolation, the concept of race, human races
5. Definition of species, reproductive isolation, origin of species and the mechanisms of speciation in plants
6. Geographical speciation, quantum speciation, genetic diversification during speciation, species concept in asexually reproducing organisms
7. Molecular evolution and macro-evolution, DNA hybridization, ortholog and paralog genes
8. From amino acid sequences to phylogeny, immunological techniques and electrophoretic phylogeny
9. Evolution of genome size , neutral theory of molecular evolution, molecular clock
10. The role of genetic regulation in evolution, molecular evolution and the evolution of organisms
11. Physiological basis of resistance to alcohol, genetic basis of adaptation to alcohol
12. Molecular foundations of the differences in alcohol dehydrogenase activity, regulating genes in the natural population, regulatory genes and adaptation
13. The origin and the evolution of plant tissues, evolution of organs, evolution of vegetative and reproductive organs
14. Evolution of plants in geological era

Table of assessment

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

References:

1. Ayala, F.J. (1982) Population and Evolutionary Genetics: A Primer Benjamin-Cummings Publishing Company
2. Niklas, K, J. (1997) The Evolutionary Biology of Plants. University of Chicago Press.
3. Willis, K. J, McElwain, J. C. (2014) The Evolution of Plants. Oxford University Press.
4. Pontarotti, P. (2011) Evolutionary Biology-Concepts, Biodiversity, Macroevolution and Genome Evolution. Springer
5. Russell, R.J., Stoeger, W.R. and Ayala, F.J. (1999) Evolutionary Molecular Biology. University of Notre Dame Press.

Course title: Halophytes Physiology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: yes **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Learning halophytes and the mechanisms of salinity resistance in plants.

The practical objectives of the course:
Explaining the properties of and the mechanisms of resistance in halophytes, the methods of confronting extreme soil salinity, the methods of agriculture in saline soils and the increasing of salinity resistance in plants cultivated in saline soils.

Topics of the course:
1. Introduction, definition of salinity, definition of halophytes, definition of halophytic plant genera, important halophyte species, the significance and applications of halophytes.
2. Plant strategies of salinity resistance. Terminology of resistance, tolerance and avoidance
3. The study and introduction of saline soils of Iran and the world, factors influencing saline soil formation and the approaches to the improvement of different saline soils
4. Plant responses to salinity, salinity resistance in different stages of growth, development and the morphological, anatomical, biochemical and physiological plant responses to salinity
5. Genetic study of salinity resistance in plants, genetic engineering of salinity resistance in agriculture, metabolic engineering of salinity resistance
6. Factors influencing salinity resistance: mineral ions such as calcium, plant hormones, growth regulators, chemicals, mycorrhiza formation
7. Signal transduction pathways involved in salinity response
8. Homeostasis under saline circumstances, potential biochemical features in salinity resistance, osmotic regulation, introduction of adaptive osmolites, enzymatic and non-enzymatic antioxidants, resistance and transport proteins in salinity resistance

Table of assessment

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

References:

1. Ahmad, P., Azooz, M.M., Prasad, M.N.V. (2013) Salt Stress in Plants-Signalling, Omics and Adaptations; Springer
2. Alscher, R. G., Cumming, J. R. (1990) Stress responses in plants: Adaptation and Acclimations, Wiley - Liss, Inc. New York, Chichester, Brinsbane, Toronto, Singapore.
3. Basra, A.S., Basra, R.K. (1997) Mechanisms of environmental stress resistance in plants. Harwood academic publishers.
4. Buchanan, B.B., Gruissem, W., Jones, R.L. (2000) Biochemistry and molecular biology of plants. American society of plant physiologists.
5. Jones, H.J., Flowers, T.J., Jones, M.B. (1992) Plants under stress. Cambridge University Press.
6. Larcher, W. (2003) Physiological plant ecology. Springer.
7. Levitt, J. (1980) Responses of plants to environmental stresses, Academic Press. New York, San Francisco, London.
8. Sunkar, R. (2010) Plant stress Tolerance, methods and protocols; Humana Press.

Course title: Metallophytes Physiology
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:
Learning metallophytes and the mechanisms of their adaptation and physiology with regard to the various factors in their habitats

The practical objectives of the course:
Explaining the properties of metallophytes and mechanisms of their resistance against various metallic tensions especially heavy metals, methods of confronting high metallic levels in soils, methods of cultivation in metallic soils, the increasing of plants' resistance against high metallic levels and the utilization of metallophytes in the clearance of soil metals

Topics of the course:
1. Introduction to metallophytes, characteristics, significance and applications
2. Metals in soil: different metal elements in soil, the bedrock containing metals, mechanisms of metal release into the soil, serpentine soils, different metallic pollutions in soil and water
3. Geobotany: The review of species and plant populations in metal bearing soils, serpentine flora, Zink flora, Selenium flora, Copper and Cobalt flora, characteristic plants, metals and the review of metallophyte populations, pseudo-metallophytes and their propagation
4. Plant tolerance and resistance to metals: A review of plants sensitive to metals, molecular mechanisms of metal resistance, absorption and accumulation of metals in plants, the evolution, physiology and molecular aspects of hyperaccumulator plants
5. The significance and applications of metallophytes: Bioremediation and future perspectives, bioremediation of soil, water filtration by metallophytes, phytomining and some examples
6. Metallophytes in Iran: A review of enriched and metal-polluted soils in Iran, the condition of plants in metal bearing soils, metallophytes ,pseudo-metallophytes, hyperaccumulators in Iran

Table of assessment

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

References:

1. Brook, R. R. (1998) Plants that Hyperaccumulate Heavy Metals: Their Role in Phytoremediation, Microbiology, Archaeology, Mineral Exploration, and Phytomining; CAB International.
2. Ross, S. M. (1994) Toxic Metals in Soil- Plant Systems; John Wiley & Sons.
3. Prasad, M. N. V. (2004) Heavy Metal Stress in Plants: From Biomolecules to Ecosystem; Springer.
4. Terry, N., Bañuelos, G. (2000) Phytoremediation of contaminated soil and water; CRC Press.
5. Tsao, D. T. and Banks M. K. (2003) Phytoremediation; Springer.
6. Willey, N. (2007) Phytoremediation: Methods and Reviews. Humana Press.

Course title: Advanced Plant Ecophysiology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Additional training: yes
Scientific expedition: yes **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Learning plant physiology in harsh conditions and extreme environments
The practical objectives of the course:
Explaining the plant physiological responses to various environmental factors and the signal transductions involved
Topics of the course:

1. The effect of light on plant growth and development: quantity, quality, intensity and the direction of radiation
2. Red light spectrum: Phytochrome structure, growth fluctuations in shade and red light, adaptations
3. UV light spectrum: Cryptochrome characteristics, UV light damages, physiological and morphological adaptations, roles of flavonoids
4. Cold and freezing: Damages caused by low temperature, changes in the pattern of gene expression, the role of lipids especially unsaturated lipids, physio-morphological adaptations
5. Heat and heat stress: Damages caused by high temperatures, changes in the pattern of gene expression, the role of heat shock proteins, physiological and morphological adaptations
6. Plant reactions in metal-enriched soils: Definition of heavy metals, pollutants, growth damages due to heavy metals, heavy metal avoidance, mechanisms of heavy metal resistance
7. Reactive oxygen species (ROS) and the environmental factors affecting their production, interconversion of active oxygen species, Fenton reaction, localization of ROS production in cells, enzymatic antioxidant, Halliwell-Asada cycle and non-enzymatic antioxidants
8. Plant responses to insect and herbivores: the role of isoflavones, protease inhibitors, essential oils, tanins, alkaloids and saponins, the role of salicylic acid and jasmonates in pathogen confrontation
9. Allelopathy: Concepts, different compounds involved in allelopathy, origins, influence on photosynthesis, respiration and plant nutrition, mechanisms of resistance to allelopathy, the role of phenols, flavonoids, essences and long-chain fatty acids in allelopathy
10. Physiological changes of the plants in dry and saline habitats, the synthesis of different osmolites, morphological changes, the role of channels and ionic carriers in the maintenance of water balance, the role of hormones in the regulation of gene expression

Table of assessment

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

References:

1. Fitter, A.H., Hay, R.K.M. (2002) Environmental Physiology of Plants; Academic Press
2. Lambers, H., Chapin, F.S., Pons, T.L. (2003) Plant physiological ecology. Springer.
3. Larcher, W. (2004) Physiological plant ecology. Springer-Verlag.
4. Nobel, P.S. (2009) Physicochemical and Environmental Plant Physiology; Academic Press.

Course title: Plant Biochemistry
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:
Learning the structure and composition of plant cell walls and the various primary and secondary metabolites in plants as well as their biosynthesis.

The practical objectives of the course:
Explaining the importance, structure and biosynthesis of various plant compounds and their applications.

Topics of the course:

1. Introduction: A review on plant biochemistry, its significance and applications
2. Plant cell walls: The structure and chemical composition of cell walls microfibril polysaccharides including: Cellulose, β-1,4 mananes, β-1,3 xylane, chitin, basement polysaccharides including hemicellulose and pectins
3. Methods of cell wall extraction: Lignin, structure and composition of cell wall, structural diversity in different plant taxa
4. Other compounds of the cell walls: Water, proteins, cutin and suberin, physical properties of cell walls in plants and algae
5. Biosynthesis of cell wall material including cellulose and lignin
6. Terpens and terpenoids including hemiterpens, monoterpens, sesquiterpens, diterpens, triterpens and triterpenoids, steroids, tetraterpenoids, polyprenols
7. Biosynthesis of terpens and terpenoids, cellular location of these compounds and their significance and applications
8. Alkaloids: Types, diffusion, cellular location, significance, application and biosynthesis
9. Phenol compounds: types, diffusion, cellular location, significance, application and biosynthesis
10. Glycosides in plants, types significance and biosynthesis
11. Methods of secondary metabolite extraction in plant and the applications of these compounds

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. Gleason, F., Chollet, R. (2012) Plant Biochemistry; Jones and Bartlett Learning.
3. Goodwin, T.W., Mercer, E.I. (1990) Introduction to plant biochemistry. Pergamon press.
4. Heldt, H.-W. (2005) Plant Biochemistry; Elsevier.

Course title: Application of Biotechnology 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 overall objectives of the course:
Learning the significance and applications of plant biotechnology as well as different methods of genetic manipulation in plants as the sources of important valuable products

The practical objectives of the course:
Explaining the various methods of biotechnological manipulations in plants and their applications

Topics of the course:
1. Learning biotechnology, its applications and future perspectives
2. Cell and tissue culture, somatic embryogenesis and micro-propagation
3. Plant cell transfection, vectors, history
4. Genetic engineering of medicinal plants, production of transgenic plants
5. Different approaches to the biotechnological production of medicinal compounds from plants, plant cell culture, transgenic plants, etc.
6. Biological and non-biological tensions and the applications of plant biotechnology in production of resistant plants
7. Phyto-bioreactors and the production of plant metabolites
8. Recombinant health care products

Table of assessment

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

References:

1. Kayser, O., Quax, W.J. (2007) Medicinal Plant Biotechnology, WILEY-VCH Verlag GmbH & Co. KGaA.
2. Lorz, H., Wenzel, G. (2005) Biotechnology in Agriculture and Forestry; Springer
3. Thangadurai, D., Tang, W., Song, S.Q. (2007) Plant Stress and Biotechnology; Oxford Book Company.

Course title: Advanced Plant Growth and Development
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 advanced perspectives on plant growth and development as well as a variety of plant hormones and growth regulators including their physiological roles and the molecular mechanisms of function

The practical objectives of the course:
Acquisition of practical knowledge of plant hormones and regulators that may well be useful in plant breeding, metabolic manipulations and the production of industrially, nutritionally and pharmacologically valuable plant products

Topics of the course:
1. Definition of growth, development, differentiation, morphogenesis and the structure of meristems
2. Growth curves (equations, different types of curves and growth features)
3. Endogenous and environmental factors in plant growth and development
4. Environmental factors affecting plant growth and development including different wavelengths and densities of light, phototropism, temperatures and water
5. Plant hormones and regulators of growth, development, structure and biosynthesis: Auxines, Gibberellins, Cytokinins, Ethylene, Abscisic acid
6. Development: budding, seed dormancy and factor affecting it as well as methods of dormancy relief
7. The formation of flowers, fruits and seeds

Table of assessment

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

References:

1. Leopold, A. C., Kriedemann P. E. (1975) Plant Growth and Development. McGraw-Hill Inc.
2. Srivastava, L. M. (2002) Plant Growth and Development: Hormones and Environment. Academic Press.
3. Fosket, D. E. (1995) Plant Growth and Development: A Molecular Approach. Elsevier Science Ltd.
4. Leyser, O., Day, S. (2003) Mechanisms in Plant Development. Blackwell Publishing.
5. Opik, H., Rolfe, S. A., Willis, A. J., Street, H. E. (2005) The Physiology of Flowering Plants: Their Growth and Development. Cambridge University Press.
6. Taiz, L., Zeiger, E. (2010). Plant Physiology, Fifth Edition, Sinauer Associates Inc.

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

The overall objectives of the course:
Training the master's degree students with fundamental and applied concepts of standard research

The practical objectives of the course:
Acquisition of a definition and applications of creative problem solving methods as well as the development of a researcher's character

Topics of the course:
1- Definition of science, philosophy and the standardization of the researcher's viewpoints
2- A brief review of the history of science and the previously utilized problem solving methods as a guide line for solving of new problems
3- Scientific methodology and the course of human intellectual development in pre-Aristotle era, Aristotelian philosophy of science, mechanical philosophy of science, relativistic philosophy of science and historical philosophy of science
4- The influences of a researcher's habits and personality in research and their improvement in terms of personal and social roles of a researcher
5- Methods of scientific research, creative ways of problem solving based on standard scientific methods, definition of problem, hypothesis, variables and methods of problem evaluation and solving
6- The designing and conduction of scientific experiments, statistical methods utilized in scientific experiments and their advantages as well as disadvantages, definition of experimental errors and methods of avoiding them and a review of how to present and publish the results of a scientific research
7- The ethics of research presentation and publishing, copyright, patent, etc.

Table of assessment

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

References:

1. Folger, H.S., LeBlanc, S., Rizzo B. (2014) Strategies for creative problem solving, Prentice Hall.
2. Kirkup, L. (1995) Experimental methods: an introduction to the analysis and presentations of data, John Wiley and Sons.
3. Kothari, C.R. (2004) Research methodology, methods and techniques. New Age International Ltd.
4. Kumar, R. (2011) Research methodology. A step-by-step guide for beginners. Sage Publications Ltd.

Course title: Methods and Tools in Plant Physiology
No. of units: 2
No. of hours: 48
Unit type: theoretical, practical
Course type: elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** yes **Lab:** yes **Seminar:** no
The overall objectives of the course:
Learning the tools and methods used in plant physiology
The practical objectives of the course:
Proper utilization of the tools and methods of plant physiology in research

Topics of the course:
1- Preparation of different plant samples in the laboratory
2- Different methods of trait measurement, recording and data analysis
3- Learning the proper utilization of different apparatus in the plant physiology laboratory including different types of bench scales, spectrophotometer, flame photometer, fluorescent microscope, invert microscope, lyophilizator, gas-liquid chromatography (GLC), high-performance liquid chromatography (HPLC), electrophoresis, Infrared gas analyzer (IRGA), chlorophyll-meter, photosynthesis measurement systems, leaf surface measurement apparatus, water potential measurement system and its components, soil salinity measurement apparatus (SSM)
4- Types of curves of spectrophotometer, flame photometer, atomic absorption, GLC and HPLC
5- Different culture media and nutritional solutions used in plant physiology
6- Different methods of morphology assessment, plant dissection and data analysis
7- Chromosomal assessments and data analysis
8- Learning protein electrophoresis, enzymology and data analysis
9- 2D electrophoresis, western blotting, PCR, SSR and RFLP, online databases and data analysis
10- The principles and applications of cell and tissue culture
11- The mechanisms of function and the operation of apparatus used in plant cell and tissue culture (Incl. autoclave, oven, laminar flow cabinet, culture room, etc.)
12- The extraction of secondary metabolites and their qualitative and quantitative analyses

Table of assessment

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

References:

1. George, E.F., Hall, M.A., De Klerk, G-J. (2008) Plant Propagation by Tissue Culture; Springer.
2. Gupta, S.D., Ibaraki, Y. (2006) Plant Tissue Culture Engineering; Springer.
3. Jain, S. M., Saxena, P. K. (2009) Protocols for In Vitro Cultures and Secondary Metabolite Analysis of Aromatic and Medicinal Plants. Humana Press
4. Jones, J. B. (2001) Laboratory guide for conducting soil tests and plant analysis; CRC press.
5. Manchenko, G. P. (2003) Handbook of detection of enzymes on electrophoretic gels; CRC Press.
6. Nagata, T., Lorz, H., Widholm, JM. (2006) Biotechnology in Agriculture and Forestry 57-Plant Metabolomics; Springer
7. Pena, L. (2005) Transgenic Plants-Methods and Protocols; Humana Press Inc.
8. Roger, M.J.R. (2003) Handbook of Plant Ecophysiology Techniques; Kluwer Academic Publishers.
9. Sriram, G. (2014) Plant Metabolism: Methods and Protocols, Vol. 1083; Humana Press.
10. Temminghoff, E.E.J.M., Houba, V.J.G. (2004) Plant Analysis Procedures; Kluwer Academic Publishers.

Course title: Mineral Nutrition of 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 overall objectives of the course:
Familiarization with the role of various mineral elements in the different aspects of plant growth and development.

The practical objectives of the course:
Explaining the role and the significance of various elements in plant growth and development as well as methods of confronting mineral deficiencies in plants and the increasing the yield of plant products.

Topics of the course:
1. Introduction, definition and classification of nutritional mineral elements
2. Mechanisms of ionic absorption by cells and roots
3. Material transport in phloem and xylem
4. Absorption and release of mineral elements by leaves and other aerial structures
5. The source and sink relationship
6. Functions of microelements and macroelements
7. Beneficial elements
8. The relationship among nutrition, pests and plant diseases
9. The effect of internal and external factors on plant growth and development
10. Biology and chemistry of rhizosphere and its relationship with nutrition
11. Nitrogen fixation
12. Plant responses to mineral deficiencies and toxicities
13. Molecular physiology of mineral nutrition

Table of assessment

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

References:

1. Barker, A.V., Pilbeam, D.J. (2007) Handbook of Plant Nutrition; CRC Press.
2. Broadley, M.R.,White, P. J. (2005) Plant Nutritional Genomics. Blackwell. CRC Press.
3. Buchanan, B.B., Gruissem, W., Jones, R.L. (2000) Biochemistry and molecular biology of plants. American society of plant physiologists.
4. Glass, A.D.M. (1989) Plant nutrition. Jones and Bartlett Publishers.
5. Holbrook, N., M., Zwieniecki, M.A. (2005) Vascular transport in plants; Elsevier Academic Press.
6. Marschner, H. (2011) Mineral nutrition of higher plants. Academic press.
7. Rengel, Z. (1999) Mineral nutrition of crops. Food products press
8. Epstein, E., Bloom, A. J. (2004) Mineral Nutrition of Plants: Principles and Perspectives.

Course title: Water Relations of Plant and Soil
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:
Familiarization with the relations of soil and plant as a continuous system in terms of the absorption of water and minerals and related theories

The practical objectives of the course:
Explaining the water-based relations of plant and soil, transport of water and minerals in plants and related mechanisms as well as the proposition of methods to optimize water utilization in plants

Topics of the course:
1. Plant as a system (permeability, exchanges with other systems), plant system objectives and ways of achieving them
2. Different root growth (in aqueous and solid systems), oxygen absorption, water, nutrients and buffering system
3. The effect of the physical and chemical properties of water on the maintenance of plant structure as well as plant ecology and physiology, the effect of clay particles in toxicity reduction, elemental deficiency, plant energetics and soil temperature, temperature, illumination, vegetation and leaf surface index
4. The ecological and physiological significance of water, water efficiency, the activation of anabolic and catabolic enzymes by water, water tension, the effects of water tension on plant energetics, carbohydrate production and enzyme distribution
5. Water measurement indices, Different types of plant wilting and their causes
6. Water distribution in plant and cell, cell wall flexibility and extension, the effect of cell wall and vacuole on water relations, bulk motion, Brownian motion, capillary action, the velocity and extent of water motion in plants
7. Water absorption and motion in plants, the apoplastic and symplastic pathways, etc.
8. Transpiration, guttation, stoma opening and closing, water diffusion, etc.
9. Immersion tension: mineral increase and decrease, ethylene formation, displaced root formation, cell disruption, apoptosis, etc.
10. Pathways of water transport through membrane: aquaporins, different types of water channels, the simultaneous transport of water and gases, etc.

Table of assessment

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

References:

1. Kramer, P. J. (1983) Water Relation of Plants; Academic Press.
2. Kramer, P.J., Boyer, J. S. (1995) Water relation of plants and soils; Academic Press USA.
3. Devlin, R. M.,Withman, F. H. (1983) Plant Physiology (4th Ed); Willard Grant.
4. Kirkham, M. B. (2004) Principles of Soil and Plant Water Relations; Academic Press.
5. Taiz, L., Zeiger, E. (2010) Plant Physiology; Sinauer Associates, Inc. Publisher.

Course title: Systems Biology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: yes
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Familiarization with the interdisciplinary field of systems biology, involving the applications of the knowledge produced in various scientific fields in terms of understanding the fundamental principles of cellular function and regulation as well as cellular responses to nearby cells and environmental factors.

The practical objectives of the course:
Explaining the principles, applications and scope of systems biology.

Topics of the course:

1. Different omics (genomics, transcriptomics, metabolomics, etc.), definitions, concepts and applications
2. Genome Projects (methods, analysis and applications)
3. Proteomics (methods, analysis and applications)
4. Familiarization with data collection and analysis in high throughput arrays
5. Definition of network and the method of its analysis
6. Multivariant analysis
7. Processing of the molecular interaction data
8. Gene networks
9. Metabolic and signaling networks
10. Modeling of biological systems

Table of assessment

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

References:

1. Alon, U. 2006, An Introduction to Systems Biology: Design, Principles of Biological Circuits, Taylor and Francis Group.
2. Barillot E., et al, 2012, Computational Systems Biology of Cancer (Chapman & Hall/CRC Mathematical and Computational Biology), CRC press
3. Coruzzi G.M. and Gutiérrez R.A. (2009), Plant Systems Biology, Annual plant reviews, Volume 35, WILEY-BLACKWELL Klipp, E. et al., 2009, Systems Biology. Wiley- Blackwell.

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; 3rd ed; World Health Organization (WHO); Geneva; Switzerland.
2. Biological Safety Manual. 2007; University of Pennsylvania; Pennsylvania; USA.
3. The Laboratory Biosafety Guidelines. 2004; 3rd ed; 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.