University of Tehran

College of Science

School of Biology

Description of program and course syllabi

Plant Physiology

Ph.D.

Table 1- Specialty - Optional courses

Major: Plant Physiology Program: Ph.D.

No.	Course name	Units			Hours			Prerequisite
		Theoretical	Practical	Total	Theoretical	Practical	Total	
1	Absorption Physiology in Plants	2	0	2	32	0	32	None
2	Plant Stress Physiology	2	0	2	32	0	32	None
3	Plant Developmental Physiology	2	0	2	32	0	32	None
4	Plant Growth Regulators	2	0	2	32	0	32	None
5	Plant Secondary Metabolites	2	0	2	32	0	32	None
6	Plant Advanced Metabolism	2	0	2	32	0	32	None
7	Plants Biotic Interactions	2	0	2	32	0	32	None
8	Plant Molecular Genetics	2	0	2	32	0	32	None
9	Plant Biotechnology	2	0	2	32	0	32	None
10	Plant Primary Metabolites	2	0	2	32	0	32	None
11	Phytoremediation	2	0	2	32	0	32	None
12	Application of Bioinformatics in Plants	2	0	2	32	0	32	None
13	New Topics in Plant Physiology	2	0	2	32	0	32	None
14	Seminar	2	0	2	32	0	32	None
Total		28	0	28	448	0	448	-

Students must take all 14 units in this table.

Topics of Specialty - Optional courses

Major: Plant Physiology

Program: Ph.D.

January 2016

Course title: Absorption Physiology in Plants
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
The purpose of this course is to familiarize Ph.D. students with the mechanisms of absorption of materials by plants.
After completing this lesson, students can explain the structure, function, and adjustment of different types of carriers and carriers in plants at cellular and molecular levels, while fully familiar with the types of absorption of materials by plant cells.
Topics of the course:

1- Water absorption and transport in plants (physicochemical properties of water: hydrogen bond and its results for osmotic force, cohesion, adhesion and stretch-capillarity, surface tension and tensile strength).Water transportation mechanisms in plants (diffusion, mass flow, osmosis), The path of water movement in plants, transport mechanism in xylem (CTT theory and expression of restriction and its benefits (air nucleation, Description of structure xylem) transpiration and guttation, water channels or aquaporins (regimentation, structure and topology, regulation, phylogenetic).
2- Physico - chemical mechanisms of absorption and transport of elements in plants (chemical potential, electrochemical potential, Fick's law, Nernst potentioal, donan, Goldman-Mitchell's relationship.
3- Physiological mechanisms of absorption and transport of elements in plants (kinetics absorption, high affinity transport system (HATS), low affinity transport system (LATS), Michaelis – Menten equation, the position of carriers and channels in absorption kinetics, the position of the most important transducers in plant cells), anatomy and topology, physiological, molecular, biochemical and regulatory functions of three important groups of transducers: pumps, channels and carriers.
4- Mechanisms of absorption elements from plasma membrane and cell sorting / compartmentalization and distribution in plant separately (Nitrate, Ammonium, Urea, low weight organic compounds such as amino acids and amides and peptides), (Sulphate) (Phosphate), (Magnesium), (Calcium: carriers, channels, pumps in various membranes), (Potassium: various types of potassium channels and carriers in different cell membranes), (Ferrum: in two strategies for root absorption and loading), (Zinc, Copper, Manganese and Molybdenum), Boron (importer and excipients), Chlorine (chlorine channels).
5- Absorption in plants under growth conditions in soil: Rhizosphere (chemistry and biology of the rhizosphere) and its importance.
6- The mechanism of absorption heavy elements by plant cells and types of transporters.
7- Molecular methods for studying the structure and role of transporters and carriers.
8- Study of phylogenetic of carriers and transporters in plants.

Table of assessment

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

References:

- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Glass, A.D.M. (1989) Plant nutrition. Jones and Bartlett Publishers Taiz, L. and Zeiger, E. (2015) Plant physiology. 6rd ed. Sunderland: Sinauer Association.
- Holbrook, N., M., Zwieniecki, M.A. (2005) Vascular transport in plants; Elsevier Academic Press.
- Marschner, H. (1986). Mineral nutrition in higher plants. Academic press.
- Rengel, Z. (1999) Mineral nutrition of crops. Food products press.
- Taiz, L. and Zeiger, E. (2015) Plant physiology. 6rd ed. Sunderland: Sinauer Association.
- Yeo, A. and Flowers, T. (2007) Plant solute transport; Blackwell Publishing.

Course title: Plant Stress Physiology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with a variety of biotic and non - biotic stresses and resistance mechanisms of plants against environmental stresses.

After passing this lesson, students can acquaint themselves with the characteristics of plants resistant to environmental stress and explain the mechanisms of resistance of plants to biotic and non - biotic stresses and to learn ways to deal with environmental stress.

Topics of the course:

1- Introduction: terminology of stress and strain, types of biotic and non-biotic stresses.
2- Key strategies for plants resistant to environmental stress.
3- Physiological, biochemical and molecular responses of plants to non-biotic stresses (salinity, drought, chemical, temperature, light, radiant, etc.) and effective factors in plant response to stress.
4- Tolerance of non-biotic and biotic stresses in plants.
5- Molecular mechanisms of resistance to environmental stresses.
6- The role of growth regulators in tolerating environmental stresses in plants: salicylic acid and jasmine acid, biosynthesis and their role in response to stresses.
7- Epigenetic changes in plants and tolerance of environmental stresses.
8- Tolerance of environmental stresses: proteomics approaches.
9- Transcription regulation networks in response to environmental stress.
10- Signal transduction pathways in response to non-biotic stresses (including dependent abscisic acid and independent abscisic acid pathway) and biotic.
11- Accustom with various techniques used for physiological studies of plants under environmental stresses including osmotic stress (salinity and drought) in plants.
12- Molecular studies in research done in halophyte plants such as transcriptome analysis in response to drought and salinity stress, micro - RNAs and their role in non-biotic stress tolerance.
13- Genomic analysis of plants response to environmental stresses.

Table of assessment

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

References:

- Ahmad, P., Azooz, M.M. and Prasad, M.N.V. (2013) Salt Stress in Plants-Signalling, Omics and Adaptations; Springer.

- Alscher, R. G., Cumming, J. R. (1990) Stress responses in plants: Adaptation and Acclimations, Wiley - Liss, Inc. New York, Chichester, Brinsbane, Toronto, Singapore.
- Basra, A.S., Basra, R.K. (1997) Mechanisms of environmental stress resistance in plants. Harwood academic publishers.
- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Jenks, M.A., Hasegawa, P.M., Jain, S.M. (2007) Advances in Molecular Breeding toward Drought and Salt Tolerant Crops; Springer.
- Jones, H.J., Flowers, T.J., Jones, M.B. (1992) Plants under stress. Cambridge University Press.
- Hirt, H. (2009) Plant Stress Biology, From Genomics to Systems Biology; WILEY-VCH Verlag GmbH & Co. KGaA.
- Larcher, W. (2003) Physiological plant ecology. Springer.
- Levitt, J. (1980) Responses of plants to environmental stresses, Academic Press. New York, San Francisco, London.
- Mattew, A., Jenks, A. and Hasegawa, P.M. (2005) Moleculat stress Physiology of Plants. Springer India.
- Orcutt, D.M., Nilsen, E.T. (2000) The Physiology of Plants Under Stress: Soil and Biotic Factors. John Wiley & Sons, Inc.
- Rout, G.R. and., Das, A.B. (2005) Plant Abiotic Stress. Blackwell Publishing Ltd.
- Sunkar, R. (2010) Plant Stress Tolerance, methods and protocols; Humana Press.
- Taiz, L. and Zeiger, E. (2015) Plant physiology. 6rd ed. Sunderland: Sinauer Association.

Course title: Plant Developmental Physiology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with developing phenomena and how these phenomena are regulated in plants.

After completing this lesson, students can explain the biochemical and molecular mechanisms of development control in plant.

Topics of the course:

1- Development in cell dimension: the structure of a plant cell is based on how cell division is arranged (from the molecular point of view and the role of cyclins and kinases) and regulate cell expansion, biogenesis of wall (anatomy of wall, and its formation by based on the enzymes concerned, in particular the manner and composition of cellulose synthase
2- Development in complete plant dimension: vegetative development: root and shoot (Include leaf) development in plants: physiological description and types of genes involved.
3- Genes involved in the development of vegetative meristems (including the clavata system and homeodomin genes).
4- Genes involved in phyllotaxis and genes involved in the formation of leaf morphology and development of stomata, cork and root hair.
5- Development in complete plant dimension: generative development: signal transduction light in plants (Phytochromes and blue light pigments include the structure and way components, and the molecular and physiological mechanisms of their action).
6- Flowering and controlling flower development in plants and genes associated with flower development.
7- Flowering control: self-guided paths, dependent on gibberllin, vernalization, florigen and how to regulation response to long and short days point of view physiologically and molecularly (Genes… , FD, FT).
8- Coordination of developmental responses and the role of environmental factors in the development of plants.
9- Regulation of hormone development and physiological processes in plants.
10- Embryogenesis in plants and its hormone control.
11- Molecular mechanisms of regulation of development epigenetic in plants and regulation of development molecular genetic (RNA Silencing, DNA Methylation).
12- Gene regulation models for plant development and evolution.

Table of assessment

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10%	**-**	**70%- written**	**20%**

References:

- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Fosket, D. E. (1995) Plant Growth and Development: A Molecular Approach. Elsevier Science Ltd.
- Howell, S.H. (1998). Molecular Genetics of Plant Development. Cambridge University Press.
- Inze, D. (2008) Cell cycle control and plant development; Springer.
- Leyser, O., Day, S. (2003) Mechanisms in Plant Development. Blackwell Publishing.
- Lyndon, R.F. (1990) Plant Development, the cellular basis. Unwin Hyman Ltd.
- Opik, H., Rolfe, S. A., Willis, A. J., Street, H. E. (2005) The Physiology of Flowering Plants: Their Growth and Development. Cambridge University Press.
- Pua, E-C, Davery, M.R. (2010) Plant Developmental Biology - Biotechnological Perspectives, Volumes 1 and 2; Springer.
- Srivastava, L. M. (2002) Plant Growth and Development: Hormones and Environment. Academic Press.

Course title: Plant Growth Regulators
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
The purpose of this course is to complete learn with the types, structure, biosynthesis, function and mechanisms of the action types of growth regulators in plants.

After completing this lesson, students can explain the functions and mechanisms of the action of these compounds in plants, while fully familiar with the types of growth regulators in plants and biosynthesis of this compounds.

Topics of the course:

1- Signal transduction of plant hormones – principle and patterns of paths signal transduction (chemical) in plants, introduction to receptors (common receptors and kinase receptors in plants), classification and description of examples of the components of the signal transduction by lignin component (PLC - PLA - PLD signal path), secondry messenger in plants (ROS, NO, Ca, IP_3, IP_6, DAG, CADPR, ROS, NO) base on calcium ion.
2- Descriptions and general recognition of hormones and growth regulators in plants.
3- Biosynthesis and metabolism of plant hormones: Auxins, Cytokinins, Gibberellins, Ethylene, Abscisic acid, Brassinososteroids, Jasmonates and Salicylic acid and Strigolactones.
4- Regulation biosynthesis of plant hormones by genetic, environmental and hormone factors.
5- Tasks and role of plant hormones.
6- Transport of plant hormones.
7- Molecular mechanism of action of plant hormones.
8- The role of hormones in defense against jassid and diseases.
9- The role of hormones in tolerance environmental stress.
10- Commercial application of growth regulators.
11- The molecular aspects of hormones (biosynthesis genes of hormones, transgenic plants in biology hormones, molecular approaches to study the mechanism of action of hormones, ethylene genes in ripening of fruit, the role of hormones in gene activation in response to environmental stresses, including plant injuries).
12- Manipulation of plant hormones.
13- Genetic engineering of biosyntesis pathways of plant hormones

Table of assessment

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10%	**-**	**70%- written**	**20%**

References:

- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Davies, P.J. (2010) Plant Hormones: Biosynthesis, signal Transduction, Action; Springer.
- Davies, P. (2013) Plant Hormones: Physiology, Biochemistry and Molecular Biology. Springer Science & Business Media.
- Park et al. (2015) Agrochemical control of plant water use using engineered abscisic acid receptors. Nature 520:545-562. Macmillan Publishers Limited.
- Taiz, L. and Zeiger, E. (2015) Plant Physiology. 6rd ed. Sunderland: Sinauer Association.
- Weyers, J.D.B. and Paterson, N.W. (2001) Plant hormones and the control of physiological processes. New Phytologist.152:375-407.

Course title: Plant Secondary Metabolites
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with types, structure, biosynthesis, function and application secondary metabolites in plants.

After completing this lesson, students can fully understand the types of secondary metabolites and biosynthesis of these compounds in plants, explain their use in the food and pharmaceutical industries, and the role of these compounds in plants.

Topics of the course:

1- Terpenes and terpenoids: type, biosynthesis, cell position and application.
2- Alkaloids: type, biosynthesis, cell position and application.
3- Phenolic component: type, biosynthesis, cell position and application.
4- Glycosides in plants: type, biosynthesis, cell position and application.
5- Sulfur secondry metabolites in plants: type, biosynthesis, cell position and application.
6- The role of secondary metabolites in the interaction of plants with bacteria, fungi and viruses.
7- Mechanisms and mode of action molecular of secondary plant metabolites.
8- Applications of secondary plant metabolites include new applications in medicine.
9- Production of secondary plant metabolites by tissue culture and cell and capillary roots plant.
10- Methods of extraction and measurement of various secondary metabolites.
11- Genetic engineering of biosynthetic pathways of secondary metabolites in plants.

Table of assessment

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

References:

- Ashihara, H., Crozier, A. and Komamine, A. (2011) Plant Metabolism and Biotechnology. John Wiley & Sons, Ltd
- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Crozier, A., Clifford, M.N. and ashihara, H. (2006) Plant Secondary Metabolites: Occurrence, structure and role in human diet. Blackwell Publishing Ltd.

- Gleason, F., Chollet, R. (2012) Plant Biochemistry; Jones and Bartlett Learning.
- Goodwin, T.W., Mercer, E.I. (1990) Introduction to plant biochemistry. Pergamon press.
- Makkar, H.P.S., Siddhuraju, P. and Becker, K. (2007) Plant Secondary Metabolites. Humana Press Inc.
- Wink, M. (2010) Functions and Biotechnology of Plant Secondary Metabolites. Blackwell Publishing Ltd.
- Wink, M. (2010) Biochemistry of Plant Secondary Metabolism. Blackwell Publishing Ltd.

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

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with metabolic reactions regulation in plant with emphasis on molecular bases.

Students, after completing this lesson, have the ability to explain how the control mechanisms and regulating metabolic reactions in plants can use the information to increase the amount of product and production of specific metabolites in plants and to counteract the effects of biotic and non-biotic stresses.

Topics of the course:

1- Concepts and general mechanisms of regulating metabolic reactions in plants.
2- Molecular regulation of carbohydrate metabolism.
3- Molecular regulation of lipid metabolism.
4- Molecular regulation of nitrogen metabolism.
5- Molecular regulation of sulfur metabolism.
6- Metabolic reactions regulation of secondary metabolites with emphasis on molecular bases.
7- Molecular regulation of biosynthesis and analysis of photosynthetic pigmentation (chlorophylls, carotenoids and phycoblins).
8- Regulation of light - photosynthesis reactions.
9- Regulation of carbon reactions with emphasis on regulation of molecular bases in plants C_3, C_4 and CAM.
10- Molecular regulation of light - respiratory reactions.

Table of assessment

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

References:

- Ashihara, H., Crozier, A. and Komamine, A. (2011) Plant Metabolism and Biotechnology. John Wiley & Sons, Ltd.
- Blankenship, R.E. (2002) Molecular Mechanisms of Photosynthesis; Blackwell.
- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Edwards, G. and Walker, D.A. (1983) C_3 and C_4: Mechanisms, and cellular and environmental regulation of photosynthesis. Packard Publishing Limited.

- Leegood, R.C., Sharkey, T.D. and Caemmerer, S. (2000) Photosynthesis: Physiology and Metabolism. Kluwer Academic Publisher.
- Wink, M. (2010) Biochemistry of Plant Secondary Metabolism.

Course title: Plants Biotic Interactions
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with biological interactions in plants.
After completing this lesson, students while fully familiar with the types of biological interactions in plants can explain the mechanism of forming these interactions and the role of these phenomena in plants at cellular and molecular levels.

Topics of the course:

1- The mechanical integrity of plant cells.
2- Define the subject of interaction and classification types of plant communications with living creatures: (1) mutualism and symbiosis with bacteria, fungi and algae and (2) contact with pathogens, insects, herbivores and parasite plants.
3- Ecology and physiology of rhizosphere and philosopher.
4- Ecological, physiological and molecular (assessment and signal transduction) study and division, symbiosis plants with bacteria including nitrogen fixing bacteria (*proteobacteria* and *actinomyces*) include: (1) classification, physiology and molecular genetics of *Rhizobium* and *Actinomyces*, (2) physiological function of symbiosis, nitrogenase activity and its regulation, formation nodule, physiology and molecular regulation of the number of nodules, nodule metabolism and function symbiosome.
5- Ecological, physiological and molecular (assessment and signal transduction) study and division, symbiosis plants with Algae (including *cyanobacteria* with the low evolution vascular plants and cycades).
6- Ecological, physiological and molecular (assessment and signal transduction) study and division, symbiosis plants with fungi (fungus-root or mycorrhizae) include: (1) types of sheathed mycorrhizal (*Actinomycor*hizae, *arbotoide* and *monotropoid*) as well as, classification and ecology of hosts and fungi, (2) types of without sheath mycorrhizal (arbuscular mycorrhizal, *Orchid mycorrhizae, ericoide*). classification and ecology of hosts and fungi, arbuscular mycorrhizal fungi and their role in the physiology and tolerance of stresses and phosphorus absorption in plant, the mechanisms of absorption and transport of phosphorus to the host plant.
7- Defense in plants: includes plant security, physiological responses (the role of jasmonate and salicylic acid) and molecular (assessment and signal transduction) to pathogens and jassid includes institutional and inductive defense, systemic defense (including systemic aquisitive resistance (SAR) with salicylic acid) and locality, direct and indirect defense, protease inhibitors (PI), Pathogenesis - related gene (PR) and signal transduction and their physiological function.

8- Parasitism relationship in plants (hemiparasite and holoparasite: classification, physiology, ecology, evolution of parasitism in plants.
9- Other interactions of plants (interaction with pollination, great animals, …)
10- Knowledge in plants.
11- Memory in plants: the memory of non-biotic actuator in plants and the role of calcium.

Table of assessment

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

References:

- Baluška, F. (2009) Plant-Environment Interactions-From Sensory Plant Biology to Active Plant Behavior. Springer-Verlag Berlin Heidelberg
- Bouarab, K., Brisson, N. and Daayf, F. (2009) Molecular Plant–Microbe Interactions. CAB International.
- Jeger, M.J. and Spence, N.J. (2001) Biotic Interactions in Plant-Pathogen Associations. CABI Publishing
- Heide-Jørgensen, H.S.. (2008) Parasitic flowering plants. Brill Academic Publishers
- Iqbal Ahmad, John Pichtel andShamsul Hayat (2008) Plant-Bacteria Interactions. WILEY-VCH Verlag GmbH & Co. KGaA,Weinheim
- Robert E. Wilkinson (2000) Plant–Environment Interactions Marcel Dekker, Inc.
- Ronald, P. C. (2007) Plant–Pathogen Interactions. Methods and Protocols Humana Press Inc.
- Smith, S.E. and Read, D. (2008) Mycorrhizal Symbiosis. 3rd Edition, Academic Press.

Course title: Plant Molecular Genetics
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with recent developments in the field of plant genetic.

After completing this lesson, students can elucidate structure and function of nucleus genome and plastids.

Topics of the course:

1- Structure, function, nucleus genome and plastids.
2- Replication DNA, recombination and repair in the nucleus and plastid.
3- Transcription and Regulation of transcription in the nucleus and plastids.
4- Processing, decomposition and adenylation of nuclear transcripts and chloroplast.
5- Splicing and editing of RNA in the nuclear and the plastids.
6- Translation and replication of translation in cytosol and chloroplasts.
7- Assemble of proteins in chloroplasts.
8- Stabilization and decomposition of proteins in plastids.
9- The entry of proteins into chloroplasts.
10- Exchange information between nucleus and plastids.
11- Genetic transplantation of plastids.

Table of assessment

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

References:

- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.
- Bock, R (2007) Cell and Molecular Biology of Plastids. Springer
- Grotewold, E., Chappell, J. and Kellogg, E. (2015) Plant genes, genomes, and genetics. JohnWiley & Sons, Ltd

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

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with the principles of plant biotechnology.

After completing this lesson, while fully familiar with the principles of plant biotechnology, students can fully utilize the learned lessons learning in research on their treatise.

Topics of the course:

1- Biotechnology, totality, application and future of this science.
2- Familiar with the principles of tissue culture, cell and plant protoplast, applications of tissue culture and plant cell, somatic embryogenesis in plant, micropropagation of plants.
3- Gene transfer to plants, history, types of gene transfer methods to plants, types of vectors.
4- Genetic engineering of crop and pharmaceutic plants, introduction, genetically transgenesis and production of transgenic plants.
5- Biotechnology approaches for produce pharmaceutical compounds, plant cell culture, biological transgenesis, production of compounds such as podophylotoxin.
6- Biotic and non – biotic stresses and application of plant biotechnology to create resistance to stress in plants.
7- Phytobioreactors and their application in the production of secondary vegetable metabolites.
8- Production of recombinant products.

Table of assessment

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

References:

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

Course title: Plant Primary Metabolites
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with types, structure, biosynthesis, function and application primary metabolites in plants.

After completing this lesson, students can fully understand the types of primary metabolites and biosynthesis of these compounds in plants, explain their use in the food and pharmaceutical industries, and the role of these compounds in plants.

Topics of the course:

1- Introduction: the importance of plant biochemistry, a general look at the topics, applications of science plant biochemistry.
2- The walls of plant cells: the structure and chemical composition of the walls.
3- Microfibrylic polysaccharides: cellulose, β - 1,4 mannanes, 1,3 xylan, chitin.
4- Polysaccharides: hemicelluloses, pectins.
5- Methods for extracting wall compounds.
6- Lignin: structure and chemical composition, structural diversity in various plant groups.
7- Other compounds in the wall: water and proteins.
8- Crustal compounds such as cuticle and suberines.
9- Physical composition of the walls in excellent plants and algae.
10- Biosynthesis of wall compounds (cellulose, lignin).
11- Molecular study of wall compounds.

Table of assessment

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

References:

- Ashihara, H., Crozier, A. and Komamine, A. (2011) Plant Metabolism and Biotechnology. John Wiley & Sons, Ltd
- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015) Biochemistry and molecular biology of plants. American society of plant physiologists.

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

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

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with the phytoremediation and biodegradation.

After completing this lesson, students while fully familiar with the phenomenon of phytoremediation and biodegradation, they can explain the mechanism of this phenomenon and its various applications, in particular the role of this phenomenon in improving the environment.

Topics of the course:

1- Definition of the phytoremediation and its types: Phytoextraction, Phytostabilisation, Rhizofiltration, Phytofiltration, Phytodegradation, Rhizodegradation, Phytodesalination, Phytovolatilization.
2- Mechanisms of the phytoremediation.
3- Applications of the phytoremediation.
4- Applications of biotechnology and genetic engineering in phytoremediation.
5- Advantages and limitations of the phytoremediation.
6- Heavy metal phytoremediation, definition and origin of heavy elements, soil elements polluter and its dangers, soil polluter sources, absorption mechanism, transport and resistance of heavy elements in plants, bioaccumulation of heavy elements in soil.
7- Factors affecting in mechanism of absorption of heavy elements in the plant.
8- Potential of the heavy metal phytoremediation of some plant species.
9- Importance and application of aquatic plants and algae in biodegradation of heavy elements.
10- Molecular mechanisms of accumulation of heavy metals and phytoremediation.
11- Phytoremediation of saline soils for sustainable agricultural production.
12- Phytoremediation of radioactive contaminant soils.
13- The role and application of fungi in the biodegradation of pollutants.
14- The role and application of bacteria in the biodegradation of pollutants.

Table of assessment

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

References:

- Ashraf, M., Ozturk, M. and Ahmad, SA. (2010) Plant Adaptation and Phytoremediation. Springer
- Kvesitadze, G., Khatisashvili, G., Sadunishvili, T. and Ramsden, J.J. (2006) Biochemical Mechanisms of Detoxification in Higher Plants, Basis of Phytoremediation. Springer-Verlag Berlin Heidelberg.
- MACKOVA, M., DOWLING, D. AND MACEK, T. (2006) PHYTOREMEDIATION RHIZOREMEDIATION. Springer.
- Willey, N. (2007) Phytoremediation. Humana Press Inc.

Course title: Application of Bioinformatics in Plants
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with the principles and application of bioinformatics science in plant. due to the expansion of Omics (Genomics, Proteomics, Transcriptomics, Metablolomics) in plant sciences and there is an urgent need to be aware of the software used in them to take this lesson.

After completing this lesson, students while fully understand the principles of bioinformatics science and softwares and databases, using their knowledge in the processing of information from professional research in the case of plants.

Topics of the course:

1- Concepts and foundations of bioinformatics.
2- How to use the NCBI Gene Bank in plants.
3- Familiar with a variety of botanical databases as TAIR Database, GrainGenes, Gramene, MaizeGDB, BarleyBase/PLEXdb.
4- Transcriptome analysis, How to analyzation data from SAGE analysis (Serial analysis of gene expression), different methods of gene expression analysis in plants by using MPSS(Massively parallel signature sequencing).
5- Sequence analysis of nucleotides and amino acids.
6- Analysis of metabolomics data in plants.
7- Computational proteomics.
8- KEGG bioinformatics source for genomics research in plants.
9- International Crop Information System (ICIS) to manage germplasm data.
10- Analyzing new generation sequence data (NGS) and Use of SSRs and SNPs in genetic analysis of plants.
11- Methods of annotation gene ontology.
12- Analysis of complex plant molecular data from multiple sources.

Table of assessment

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

References:

- Edwards, D. (2007) Plant Bioinformatics– Methods and Protocols. Humana Press Inc.
- Edwards, D. and Batley, J. (2004) Plant bioinformatics: from genome to phenome. Trends in Biotechnology.Volume 22, Issue 5, p232–237, 1 May 2004
- Rhee, S.Y., Dickerson J, Xu D. (2006) Bioinformatics and its applications in plant biology. 1 Annu Rev Plant Biol. 2006;57:335-60.

Course title: New Topics in Plant Physiology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialty - Optional
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize Ph.D. students with the latest advances in plant physiology.

After completing this lesson, students while familiar with the latest advances in plant physiology science can take advantage of these findings in their research.

Topics of the course:

The latest findings and achievements in plant physiology according to the research field of the supervisor and Ph.D. students.

Table of assessment

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

References:

Acceptable academic journals published over the past two decades with the ISI and JCR profile as well as related authoritative books.