Program	13IG Bachelor's Degree in Forest Engineering

Course number and name	
Number	135004303
Name	Structure and Function of Woody Plants
Semester	S3 [(September-January)]

Credits and contact hours	
ECTS Credits	6
Contact hours	72

Coordinator's name	Álvaro Soto de Viana (alvaro.soto.deviana@upm.es)

Specific course information
Description of course content
This course offers the student a comprehensive overview of how plants acquire essential resources and how these resources are employed to sustain growth and survival. Ecological, evolutionary and technological aspects are highlighted. The first part of the course is focused on essential anatomical aspects, and the second one on physiological ones. Theory classes are combined with lab practices where different plant tissues are viewed under magnification, seedlings are grown hydroponically to analyze the effects of nutrient deficiencies and several physiological parameters, such as chlorophyll fluorescence, chlorophyll content or leaf water potential are measured. The course has been designed to provide a better understanding of how environmental factors influence plants' growth. Numerous examples taken from most cited journals and results obtained by our research group are used to illustrate key concepts and promote discussion in theory classes.
List of topics to be covered
Lesson 1. Introduction. The plant cell. Cell membranes. Nucleus and organelles. Cytoskeleton Lesson 2. The plant cell wall. Chemical composition. Wall structure. Primary and secondary walls; layers. Plasmodesmata. Pit pores. Sieve areas and plates. Cell wall modifications: Reaction wood. Lesson 3. Plant Tissues: Parenchyma, collenchyma, sclerenchyma. Xylem. Phloem. Epidermis and periderm Lesson 4. Primary growth. Apical meristems. Primary growth in stems and roots. Stem-root vascular connection. Branching in the primary body. Lesson 5. Secondary growth. Vascular cambium and cork cambium. Secondary growth in stems and roots. Development of branches with secondary growth. Knots and pruning. Growth seasonality. Earlywood and latewood. Wood decay, wood damage,

healing.
Lesson 6. The leaf. Leaf types. Bifacial normal leaves. Epidermis, mesophyll, vascular system. Monocot leaves. Gymnosperm needles. Drought adaptations. Anatomic differences between C3 and C4 species.
Lesson 7. Secretory cells and tissues in plants. Mucilage, essential oils, gums, tannins. Resin. Latex.
Lesson 8. Propagation. The reproductive cycle in gymnosperms and angiosperms. Evolution.
Lesson 9. Water relations (I). Measuring plant water status: relative water content and water potential. Measurement of water potential and its components. The pressure-volume curve and the Höfler diagram. Water transport processes: diffusion and bulk flow.
Lesson 10. Water relations (II). Absorption of water by roots and water transport through the xylem. Soil water. Oxygen isotopic composition and hydraulic redistribution in the soil. Root pressure. Guttation. The cohesion-tension theory and the ascent of sap. Hydraulic conductance. Efficiency of water conduction, sap velocity and composition. Cavitation and Embolism. Vulnerability.
Lesson 11. Mineral Nutrition. Membrane structure and function. Fluidity and selective permeability. Transport across membranes. Chemical potential. Passive and active transport. The Nernst equation. Membrane potential. Facilitated diffusion. Transport proteins. Essential nutrients. Nutrient availability in soils. Internal and external factors affecting mineral nutrient acquisition by plants. Kinetics of nutrient uptake by roots: responses to plant nutrient demand and nutrient availability at the root surface. Nutritional deficiencies. Luxury consumption of mineral nutrients: risks and chances. Toxicity. Phytoremediation. Absorption of nutrients from extreme soils. Rizosphere. Rizodeposition. Mycorrhizae. Calcicole and Calcifuge species. Biogeochemical cycles: Main disturbances in forest ecosystems.
Lesson 12. Gas exchange: Transpiration. Transpiration as a physical process. Factors affecting transpiration. Stomatal conductance. Stomatal responses to hydraulic and chemical signals. Water balance. Water use strategies. Isohydric and anisohydric species. Water use efficiency and carbon isotopic discrimination.
Lesson 13. Photosynthesis. Absorption of light. Photosynthetic pigments. Quantum yield. Chlorophyll fluorescence. Photosystems: location and functioning. Electron transport and photophosphorylation. The stages of the Calvin cycle: carboxylation, reduction and regeneration. Photorespiration. Differences between C3 and C4 species. Photosynthetic responses to light, CO2 and temperature. Net photosynthesis as a function of stomatal conductance.
Lesson 14. Respiration. Overview of respiration: glycolisis, citric acid cycle, electron transport and oxidative phosphorilation. Ecologic relevance of plant respiration. Environmental factors affecting plant respiration. The effects of flooding on root respiration.
Lesson 15. Phloem transport. Risks of phloem location in the trunk of trees: tree girdling. Phloem transport: from sources to sinks. Modification of the translocation pattern after wounding or pruning. Competition for photo assimilates. Phloem sap composition and velocity. Phloem loading: the apoplastic and symplastic pathways. The pressure-flow model for phloem transport.
Lesson 16. Secondary metabolites and plant defense. Cutin, waxes and suberin. Terpenes. Phenolics. Nitrogen-containing compounds. Defense mechanisms:

qualitatively and quantitatively important secondary plant compounds.
Lesson 17. Analysis of plant's growth. Cell walls and cell expansion. Stress relaxation of the cell wall. Kinetics of plant growth: relative growth rate, net assimilation rate, specific leaf area. Slow and fast-growing species. Growth in species adapted to harsh habitats. Invasive species. Growth of tree stands: the leaf area index.
Lesson 18. Plant hormones. Actions of auxins: phototropism, gravitropism, apical dominance. Gibberellins. Cytoquinins. Ethylene. Abscisic Acid.
Lesson 19. Light control of plant development. Phytochrome-induced responses. Germination. Circadian rhythms. Shade-tolerant and shade-avoiding species. Blue-light responses and stomatal opening.
Lesson 20. Growth under stress. Plant's responses to stress: avoidance and tolerance. Phenotypic plasticity. Water stress. Flooding. Chilling and freezing. Heat stress.

Prerequisites or co-requisites

None

Course category in the program

_X_ R (required)	**__ E (elective)** *(elective courses may not be offered every year)*

Specific goals for the course

Specific outcomes of instruction

RA16 – Analyze the structure and ecological function of plants as driving part of ecosystems.
RA250 – Describe the levels of organization in the plant body and methods applied to their study.
RA251 – Describe the structure of cells, specially the chloroplasts and cell wall as differential elements of plant cells. Discuss the role of cell walls in plant biomechanics, wood composition and commercial plant fibers.
RA252 – Recognize the function and differential traits of plant tissues: parenchyma, collenchyma, sclerenchyma, xylem, phloem, epidermis and periderm.
RA253 – Describe the structures resulting from plant development throughout primary and secondary plant growth. Distinguish microscopically plant tissues in stems, leaves and roots from gymnosperms and angiosperms. Describe the differences in wood anatomy in relation with the ecology of the species and technological traits of the wood.
RA254 – Know the anatomical bases of sexual reproduction in gymnosperms and angiosperms. Distinguish the role of seed production for reforestation.
RA255 – Explain the mechanisms by which plants acquire and use water
RA256 - Explain the mechanisms by which plants acquire and use mineral nutrients
RA257 – Examine the mechanisms by which plants acquire and transform solar energy
RA258 - Examine the mechanisms by which plants acquire and transform the atmospheric CO2.
RA259 – Analyze the physiological bases of plant growth
RA17 – Discuss the ecological role of plant acclimation and adaptation.

Bibliography and supplementary materials
– Beck, CB (2010) An introduction to plant structure and development. Cambridge University Press, Cambridge, UK – Cutler DF, Botha T, Stevenson DW (2008) Plant Anatomy. An applied approach. Blackwell Publishing. Oxford, UK. – Schweingruber, FH (2007) Wood structure and environment. Springer Verlag, Berlin-Heidelberg-New York. – Taiz L, Zeiger E, Moller IM, Murphy A (2018). Plant Physiology and Development. Sinauer Associates, an imprint of Oxford University Press. – Lambers H, Oliveira JS (2019). Plant Physiological Ecology 3rd Ed. Springer ……

Teaching methodology			
_X_ **lectures**	__ **problem solving sessions**	__ **collaborative actions**	_X_ **laboratory sessions**
Other:			