



**Universitas Negeri Surabaya**  
**Faculty of Mathematics and Natural Sciences**  
**Biology Undergraduate Study Program**

Document Code

**SEMESTER LEARNING PLAN**

Courses	CODE	Course Family	Credit Weight			SEMESTER	Compilation Date
Plant Physiology	4620104076		T=3	P=1	ECTS=6.36	3	April 24, 2023
AUTHORIZATION		SP Developer	Course Cluster Coordinator			Study Program Coordinator	
		Dr.sc.agr. Yuni Sri Rahayu, M.Si	Dr.sc.agr. Yuni Sri Rahayu, M.Si			Dr. H. Sunu Kuntjoro, S.Si., M.Si.	

Learning model	<b>Project Based Learning</b>
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Program Learning Outcomes (PLO)	<b>PLO study program that is charged to the course</b>																					
<b>PLO-5</b>	Able to communicate scientific ideas, both orally and in writing using appropriate communication media according to the target, as a means of lifelong learning for academic self-development.																					
<b>PLO-7</b>	Able to work independently and collaboratively, as well as responsibly, in completing various tasks in class, in the laboratory and in the field.																					
<b>Program Objectives (PO)</b>																						
<b>PO - 1</b>	Creating an independent and honest character in carrying out tasks related to Plant Physiology.																					
<b>PO - 2</b>	Able to make right decisions based on analysis of information and data, and be able to provide guidance in choosing various alternative solutions independently and in groups in the field of plant physiology																					
<b>PO - 3</b>	Mastering theoretical concepts about the concept of plant physiology and its applications																					
<b>PO - 4</b>	Able to apply Plant Physiology concepts or theories that have been mastered in solving various procedural problems according to their field of knowledge.																					
<b>PO - 5</b>	Having the skills to apply the concepts and principles of Plant Physiology responsibly in a safe day-to-day.																					
<b>PO - 6</b>	Having an entrepreneurial spirit (ecopreneurship), researcher or quality control related to Plant Physiology material that can be developed and applied																					
<b>PLO-PO Matrix</b>																						
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<b>PO Matrix at the end of each learning stage (Sub-PO)</b>																																																																																																																																								
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Short Course Description	This course outlines three basic concepts and their applications, namely plants and their environment; plant metabolism; and plant growth and development. Plants and the environment studies the relationship between plants and water, mineral nutrients, and transport processes in plants, including the factors that influence them, such as the opening and closing of stomata and transpiration. Metabolism includes respiration, photosynthesis, enzymes, nitrogen and fat metabolism in plants. Growth and development discusses the control of genes on growth and development, hormones, movement, morphogenesis, photoperiodism, vernalization, dormancy and senescence and the factors that influence them. Plant Physiology studies are accompanied by various process skills (minds on activity and hands on activity) that will be used to solve problems in the field of plant physiology and their applications to support the growth of the spirit of ecopreneurship, researchers and quality control in the field of plant physiology. Learning is packaged with a student-certified learning approach using various methods according to the characteristics of the material such as presentations, discussions, and practice or other learning strategies such as finding concepts, making resumes, etc.
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References	<p><b>Main :</b></p> <ol style="list-style-type: none"> <li>1. Mohr, H. dan Schopfer, P. 1995. Plant Physiology. Berlin: Springer</li> <li>2. Rahayu, YS. 2019. Hara Tanaman dan Analisisnya. Surabaya: Unesa Press.</li> <li>3. Taiz, L. dan Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</li> <li>4. Salisbury, F.B. dan Ross, C.W. 2001. Plant Physiologi. NewYork: John Wiley &amp; Sons.</li> <li>5. Yuliani.2017.Metabolisme Tumbuhan. Surabaya: Unesa Press</li> </ol> <p><b>Supporters:</b></p>
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	<ol style="list-style-type: none"> <li>Hopkins, W.G.1995. Introduction to Plant Physiology. New York: John Wiley &amp; Sons</li> <li>Loveless, A.R. 1989. Prinsip-prinsip Biologi Tumbuhan untuk Daerah Tropik. Jakarta: Gramedia.</li> <li>Nobel, P.S. 2009. Physicochemical and Environmental Plant Physiology, Fourth Edition. Academic Press.</li> <li>Rahayu, YS, Yuliani, Ratnasari, E, Dewi SK. 2018. Fitohormon. Surabaya: Unesa Press</li> <li>Sastamihardja, Darjat dan Arbayah. 1994. Fisiologi Tumbuhan . Bandung: ITB Press</li> </ol>						
<b>Supporting lecturer</b>	Prof.Dr. Yuni Sri Rahayu, M.Si. Prof. Dr. Yuliani, M.Si. Sari Kusuma Dewi, S.Si., M.Si.						
Week-	Final abilities of each learning stage (Sub-PO)	Evaluation		Help Learning, Learning methods, Student Assignments, [ Estimated time]		Learning materials [ References ]	Assessment Weight (%)
		Indicator	Criteria & Form	Offline ( offline )	Online ( online )		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Understand the structure and function of organelles in plant cells independently and honestly	<ol style="list-style-type: none"> <li>Describe the scope and role of plant physiology</li> <li>Identifying the structure of organelles in plant cells</li> <li>Comparing the structure and function of organelles of plant and animal cells</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>30% of Reports and practical products are rated as TASKS</li> <li>20% of Student activities and responses during learning activities, especially practical, are assessed as participation</li> <li>30% Final Exams</li> <li>Essay questions and multiple choice are accessed jointly at the Midterms and Final Exams</li> <li>Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities</p>	<p>Lecturers facilitate student-centered learning through group discussions and are responsible for finding concepts (based on literature reviews) regarding plant physiology and processes in plant life activities based on the function of plant cell organelles and presenting the results of their group work. Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and underline important concepts of processes in plant cells based on the structure of the organelle function of plant cells and their differences from animal cells.</p> <p>Structural Task: 3x60 minutes Make a resume of the processes in plant cells based on the structure of the organelle function of plant cells and their differences with animal cells. 4 X 50</p>	-	<p><b>Material:</b> Function structure of plant organelles a. The concept of plant physiology and the processes in plant life activities b. The scope of plant physiology c. The Role of Plant Physiology d. Structure and function of organelles in plant cells <b>References:</b> <i>Salisbury, FB and Ross, CW 2001. Plant Physiology. New York: John Wiley &amp; Sons.</i></p> <p><b>Material:</b> Function structure of plant organelles a. The concept of plant physiology and the processes in plant life activities b. The scope of plant physiology c. The Role of Plant Physiology d. Structure and function of organelles in plant cells <b>References:</b> <i>Hopkins, WG1995. Introduction to Plant Physiology. New York: John Wiley &amp; Sons</i></p> <p><b>Material:</b> Function structure of plant organelles a. The concept of plant physiology and the processes in plant life activities b. The scope of plant physiology c. The Role of Plant Physiology d. Structure and function of organelles in plant cells <b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	5%

2	Understand the concept of water and its role in plants	<ol style="list-style-type: none"> <li>1.Explain the concept of water potential, osmotic potential, turgor potential.</li> <li>2.Skilled to do experiments on water potential and osmosis potential</li> <li>3.Calculate PO and PA values based on experimental results</li> <li>4.Summarize the concepts of water potential, osmotic potential, turgor potential, and related concepts based on experimental results.</li> <li>5.Communicating the experimental results of water potential and osmotic potential</li> <li>6.Make a report on the results of the experiment about water potential and osmosis potential</li> <li>7.Show an honest and independent attitude during the learning process based on the observation sheet</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1.30% of Reports and practical products are rated as TASKS</li> <li>2.20% Midterms</li> <li>3.Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4.US weight 30%</li> <li>5.Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6.Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities, Practical Assessment</p>	<p>Lecturers facilitate student-centered case studies through active discussions of students about the implementation of concepts of PT, PO, TO, PA, osmosis, diffusion in daily life based on pictures of various everyday phenomena.</p> <p>Based on the results of group discussions, representative students presented the results of discussions for solving problems of case study in daily life which were given based on the concepts of PA, PO, PT</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes</p> <p>Discussion on solving daily problems (case study) related to the concepts of CL, PO, PT and reporting the written results in groups.</p> <p>Practical Course: 3x60 minutes</p> <p>Structural Task: 3x60 minutes</p> <p>Make a practical report 4 X 50</p>	-	<p><b>Material:</b> Plants and their Environment. a. The structure and properties of water b. Diffusion, osmosis, imbibition c. Osmosis Pressure, Turgor Pressure, Water Potential, Osmosis Potential</p> <p><b>References:</b> <i>Salisbury, FB and Ross, CW 2001. Plant Physiology. New York: John Wiley &amp; Sons.</i></p> <hr/> <p><b>Material:</b> Plants and their Environment. a. The structure and properties of water b. Diffusion, osmosis, imbibition c. Osmosis Pressure, Turgor Pressure, Water Potential, Osmosis Potential</p> <p><b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	6%
3	Analyzing the absorption, transportation and nutrient requirements of plants	<ol style="list-style-type: none"> <li>1.Determine the components of the soil</li> <li>2.Distinguishing macro and micro nutrients in terms of function, deficiency, and absorption form (ions, compounds, etc.)</li> <li>3.Distinguish passive and active transport</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1.Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2.USS/UTS weight 20%</li> <li>3.Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4.US weight 30%</li> <li>5.Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6.Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities</p>	<p>PresLecturers facilitate students using guided discovery by using LKM in groups, discussing, to discover concepts (components of soil, macro and micro nutrients in terms of function, deficiency, absorption form, various kinds of passive and active transport) and presenting the results of the group's work</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 Minutes</p> <p>Read and rediscover the concept of soil components, macro nutrients, micro nutrients, nutrient function, deficiency, passive and active transport</p> <p>Structural Task: 3x60 minutes presentation, discussion and assignment 4 X 50</p>	-	<p><b>Material:</b> Soil and plant nutrition: a. Soil: structure, texture, minerals, organic matter b. Essential nutrients: macro and micro nutrients, function, deficiency. c. Absorption and transport of mineral salts</p> <p><b>Reference:</b> <i>Rahayu, YS. 2019. Plant Nutrients and Their Analysis. Surabaya: Unesa Press.</i></p> <hr/> <p><b>Material:</b> Soil and plant nutrition: a. Soil: structure, texture, minerals, organic matter b. Essential nutrients: macro and micro nutrients, function, deficiency. c. Absorption and transport of mineral salts</p> <p><b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	5%

4	Linking the mechanisms of water absorption and photosynthesis, as well as water circulation, to plant growth	<ol style="list-style-type: none"> <li>1. Identify the function of water in plants</li> <li>2. Distinguishing types and functions of groundwater</li> <li>3. Describe the internal and external factors that affect water absorption in plants</li> <li>4. Describe the mechanism of water circulation in plants</li> <li>5. Describe the mechanism of transport through the phloem and the factors affecting it</li> <li>6. Identify the part of the leaf that plays a role in the transpiration process</li> <li>7. Distinguish various concepts about the opening and closing of stomata in plants</li> <li>8. Skilled doing experiments showing the process of transpiration</li> <li>9. Calculate the transpiration rate in plants</li> <li>10. Explain the importance of the transpiration process for plants</li> <li>11. Describe the factors that affect transpiration</li> <li>12. Create a report on the results of the experiment</li> <li>13. Show an honest and independent attitude during</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities, Practical Assessment</p>	<p>Lecturers facilitate student-centered learning through case studies using:</p> <ol style="list-style-type: none"> <li>1. Animated water and mineral transport, transport through the phloem, opening the stomata</li> <li>2. Figure nutrient transport, the mechanism for opening stomata</li> </ol> <p>Using the guided discovery model, students are guided in an active discussion to discover the concepts of water transport, nutrient transport, transport through the phloem, opening the stomata and its influence. The results of the discussion are presented.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes</p> <p>As a group, writing a resume of the concepts found includes:</p> <ol style="list-style-type: none"> <li>1. Water transport mechanism</li> <li>2. Nutrient transport mechanism</li> <li>3. Phloem transport mechanism</li> <li>4. Stomata opening mechanism</li> <li>5. Transpiration and influencing factors.</li> </ol> <p>Practical course: 3x60 minutes</p> <p>Structural Task: 3x60 minutes</p> <p>Make a practical report Presentation, discussion and practicum (practical work) 4 X 50</p>	-	<p><b>Material:</b> Transport Mechanisms and Influencing Factors:</p> <ol style="list-style-type: none"> <li>a. The structure and properties of water</li> <li>b. Groundwater</li> <li>c. Water in plant cells</li> <li>d. Absorption of water by plant roots</li> <li>e. Apoplast and symplast</li> <li>f. Transport of water through the trachea and xylem</li> <li>g. Factors affecting water transport</li> <li>h. Transpiration concept</li> <li>i. The mechanism of opening and closing the stomata</li> <li>j. Transpiration rate calculation</li> <li>k. Factors affecting transpiration</li> <li>l. Transport through the phloem and the factors affecting it</li> </ol> <p><b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p> <hr/> <p><b>Material:</b> Transport Mechanisms and Influencing Factors:</p> <ol style="list-style-type: none"> <li>a. The structure and properties of water</li> <li>b. Groundwater</li> <li>c. Water in plant cells</li> <li>d. Absorption of water by plant roots</li> <li>e. Apoplast and symplast</li> <li>f. 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5	Communicate an understanding of enzymes and the factors that influence their activity	<ol style="list-style-type: none"> <li>1. Distinguishing primary metabolism and secondary metabolism</li> <li>2. Explain the basic concepts and properties of enzymes</li> <li>3. Describe the mechanism of action of enzymes</li> <li>4. Group enzymes based on their structure and naming</li> <li>5. Describe the distribution of enzymes within cells</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities, Practical Assessment</p>	<p>Lecturers facilitate student-centered learning, guiding active discussions to discover the concept of enzyme properties and enzyme action mechanisms based on related images. Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group, write the results of a review of factors that affect the mechanism of action of the enzyme in the practical report</p> <p>Practical course: 3x60 minutes</p> <p>Structural task: 3x60 minutes Make a practical report 4 X 50</p>	-	<p><b>Material:</b> Enzymes: a. Basic concepts b. Enzyme properties c. Mechanism of action of enzymes c. Structure, naming and grouping of enzymes d. Distribution of enzymes within cells e. Factors influencing enzyme activity f. Metabolic regulation via enzymes <b>Library:</b> <i>Yuliani, 2017. Plant Metabolism. Surabaya: Unesa Press</i></p> <hr/> <p><b>Material:</b> Enzymes: a. Basic concepts b. Enzyme properties c. Mechanism of action of enzymes c. Structure, naming and grouping of enzymes d. Distribution of enzymes within cells e. Factors influencing enzyme activity f. Metabolic regulation via enzymes <b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	6%
6	Understand the concept of photosynthesis and apply the role of photosynthesis to other organisms	<ol style="list-style-type: none"> <li>1. Describe photosynthesis</li> <li>2. Determine the parts of the chloroplast and determine the function of thylakoids and stroma</li> <li>3. Determine the components of photosynthesis</li> <li>4. Describes photosystem, inductive resonance and emerson effect</li> <li>5. Distinguishing photosystems I and II</li> <li>6. Distinguishing cyclic and non-cyclic photophosphorylation</li> <li>7. Describe the carbohydrate synthesis reaction / dark reaction</li> <li>8. Distinguish light reactions and dark reactions based on substrates and products</li> <li>9. Distinguishes the mechanism of the C2, C3, C4, and CAM lines</li> <li>10. Describe the mechanism and function of the Pentose Phosphate pathway</li> <li>11. Describe the mechanism and function of the glycosylate pathway</li> <li>12. Describe the factors that influence photosynthesis</li> <li>13. Skilled doing experiments on chlorophyll content at various ages of leaves</li> <li>14. Skilled using a spectrophotometer</li> <li>15. Create a report on the results of the experiment</li> <li>16. Show an honest and independent attitude during the learning process based on the observation sheet</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. 30% of Reports and practical products are rated as TASKS</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities, Practical Assessment</p>	<p>Lecturers facilitate student-centered learning, through pictures guiding active discussions to discover concepts related to photosynthesis and its mechanisms. Using a case study to find out the plant mechanism to solve the water limitation based on the photosynthesis type of the plant.</p> <p>Using guided discovery to discover the concept of chlorophyll levels in plants through practice.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group write the results of a review about the differences in the mechanisms of the C2, C3, C4, and CAM pathways</p> <p>Practical course: 3x60 minutes</p> <p>Structural task: 3x60 minutes Make a practice reports 4 X 50</p>	-	<p><b>Material:</b> Photosynthesis Concept a. Chloroplast: structure, process of formation b. Absorption of light by chlorophyll and transfer of energy c. Photosystem d. Cyclic and non-cyclic photophosphorylation e. Light reactions and dark reactions f. Differences in the mechanism of the C3, C4, CAM and C2 lines g. Pentose Phosphate Pathway h. Glycosylate Pathway i. Factors affecting photosynthesis <b>Reference:</b> <i>Yuliani, 2017. Plant Metabolism. Surabaya: Unesa Press</i></p> <hr/> <p><b>Material:</b> Photosynthesis Concept a. Chloroplast: structure, process of formation b. Absorption of light by chlorophyll and transfer of energy c. Photosystem d. Cyclic and non-cyclic photophosphorylation e. Light reactions and dark reactions f. Differences in the mechanism of the C3, C4, CAM and C2 lines g. Pentose Phosphate Pathway h. Glycosylate Pathway i. Factors affecting photosynthesis <b>Bibliography:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	6%

7	Understand the concept of respiration and relate respiration to carbon balance in nature (the relationship between respiration and photosynthesis)	<ol style="list-style-type: none"> <li>1.Describes the concept of respiration</li> <li>2.Determine the portions of the mitochondria</li> <li>3.Distinguish the stages of the respiratory mechanism</li> <li>4.Determine the location of the respiration stage</li> <li>5.Describe the various hypotheses related to oxidative phosphorylation</li> <li>6.Calculate the amount of energy obtained from the breakdown of 1 glucose molecule</li> <li>7.Carry out a sprout respiration experiment</li> <li>8.Summing up the factors affecting respiration</li> <li>9.Create a report on the results of the experiment</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1.Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2.USS/UTS weight 20%</li> <li>3.Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4.US weight 30%</li> <li>5.Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6.Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities, Practical Assessment</p>	<p>Lecturers facilitate student-centered learning, through pictures guiding active discussions to discover concepts related to respiration and its mechanisms.</p> <p>Facilitating students through practice to discover the concept of the effect of temperature on the respiration process.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group, write the results of a review about the effect of temperature on the respiration process to be written in the practical report section</p> <p>Practical course: 3x60 minutes Structural task: 3x60 minutes Make a practical report 4 X 50</p>	-	<p><b>Material:</b> a. the portions of the mitochondria b. the stages of the respiratory mechanism c. the location of the respiration stage d. the various hypotheses related to oxidative phosphorylation e. the amount of energy obtained from the breakdown of 1 glucose molecule f. a sprout respiration experiment g. the factors affecting respiration</p> <p><b>Reference:</b> <i>Yuliani, 2017. Plant Metabolism. Surabaya: Unesa Press</i></p> <hr/> <p><b>Material:</b> a. the portions of the mitochondria b. the stages of the respiratory mechanism c. the location of the respiration stage d. the various hypotheses related to oxidative phosphorylation e. the amount of energy obtained from the breakdown of 1 glucose molecule f. a sprout respiration experiment g. the factors affecting respiration</p> <p><b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	5%
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8	Mid Test	<ol style="list-style-type: none"> <li>1. Conclude the concepts of water potential, osmotic potential, turgor potential, and related concepts based on experimental results</li> <li>2. Distinguish between macro and micro nutrients in terms of essentials, function, deficiencies and forms of absorption (ions, compounds, etc.)</li> <li>3. Distinguish between various concepts regarding the opening and closing of stomata in plants</li> <li>4. Distinguish between intra and extra cellular transport</li> <li>5. Distinguish between primary metabolism and secondary metabolism</li> <li>6. Explain the importance of enzymes in the regulation of plant metabolism</li> <li>7. Distinguish between photosystems I and II</li> <li>8. Distinguish between cyclic and non-cyclic photophosphorylation</li> <li>9. Distinguish between light reactions and dark reactions based on substrate and product</li> <li>10. Distinguish the mechanisms of the C2, C3, C4, and CAM pathways</li> <li>11. Distinguish between the stages of the respiratory mechanism</li> <li>12. Calculate the amount of energy obtained from the breakdown of 1 glucose molecule</li> <li>13. Explain the mechanism and function of the Pentose Phosphate pathway</li> <li>14. Explain various hypotheses related to oxidative phosphorylation</li> </ol>	<p><b>Criteria:</b> Mid Test 20%</p> <p><b>Form of Assessment :</b> Test</p>	- 4 X 50		<p><b>Material:</b> Transport and transport mechanisms in plants, plant nutrients, deficiencies and assimilation, plant transpiration and factors that influence it.</p> <p><b>References:</b> <i>Rahayu, YS, Yuliani, Ratnasari, E, Dewi SK. 2018. Phytohormones. Surabaya: Unesa Press</i></p> <hr/> <p><b>Material:</b> Enzymes, respiration, <b>Reference:</b> <i>Yuliani. 2017. Plant Metabolism. Surabaya: Unesa Press</i></p>	10%
9	Understand the concept of nitrogen metabolism and the relationship between photosynthesis, respiration and fat metabolism	<ol style="list-style-type: none"> <li>1. Explain the fixation of nitrogen by plants through pictures</li> <li>2. Describe the reduction mechanisms of nitrates, nitrites and the formation of amino acids</li> <li>3. Describe the stages in which root nodules form</li> <li>4. Describe the role of respiration and photosynthesis</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities</p>	<p>Lecturers facilitate students in groups and discuss, to find concepts based on a case study in Metabolism of N and its relation to photosynthesis and respiration. At the end of the teaching learning process the students will present the results and formulate the solution/recommendation based on the academic review.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Reviewing the literature to find the concept of differences in the mechanism of N metabolism in legume and non-legume plants 4 X 50</p>	<p>Lecturers facilitate students in groups and discuss, to find concepts based on a case study in Metabolism of N and its relation to photosynthesis and respiration. At the end of the teaching learning process the students will present the results and formulate the solution/recommendation based on the academic review.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Reviewing the literature to find the concept of differences in the mechanism of N metabolism in legume and non-legume plants</p>	<p><b>Material:</b> Soil and plant nutrition: a. Soil: structure, texture, minerals, organic matter b. Essential nutrients: macro and micro nutrients, function, deficiency. c. Absorption and transport of mineral salts</p> <p><b>Reference:</b> <i>Yuliani. 2017. Plant Metabolism. Surabaya: Unesa Press</i></p> <hr/> <p><b>Material:</b> Nitrogen Metabolism: a. Nitrogen Cycle, b. nitrogen fixing, c. nitrogen source, d. reduction of nitrates, nitrites, ammonium, and the formation of amino acids, e. formation of nodules and rhizobium associations, f. the role of respiration and photosynthesis</p> <p><b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p>	5%

10	Explain the stages of fat metabolism in plants	<ol style="list-style-type: none"> <li>1. Identify the presence of fat in plants</li> <li>2. Describes fat formation and fat degradation</li> <li>3. Describe the steps in the glyoxylate cycle</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities</p>	<p>Lecturers facilitate students in groups and discuss, to find concepts Metabolism of fat in plants based on case study in plants related to daily life.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Reviewing the literature on types of fat metabolism in plants to solve the problem formulated before based on case study.</p> <p>Structural task: 3x60 minutes Make a report on the results of a literature review on the types of fat metabolism in plants and formulate the solution/recommendation based on the academic review. 4 X 50</p>	<p>Lecturers facilitate students in groups and discuss, to find concepts Metabolism of fat in plants based on case study in plants related to daily life.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Reviewing the literature on types of fat metabolism in plants to solve the problem formulated before based on case study.</p> <p>Structural task: 3x60 minutes Make a report on the results of a literature review on the types of fat metabolism in plants and formulate the solution/recommendation based on the academic review.</p>	<p><b>Material:</b> Fat synthesis a. Fatty acids and glycerol, b. Fat catabolism c. Glyoxylate cycle <b>Reference:</b> Yuliani. 2017. <i>Plant Metabolism</i>. Surabaya: Unesa Press</p> <hr/> <p><b>Material:</b> Fat synthesis a. Fatty acids and glycerol, b. Fat catabolism c. Glyoxylate cycle <b>References:</b> Taiz, L. and Zeiger, E. 2010. <i>Plant Physiology</i>. California: The Benjamin/Cummings Publishing Company, Inc.</p>	5%
11	Understand the various basic concepts of growth and development	<ol style="list-style-type: none"> <li>1. Distinguish the concepts of growth and development</li> <li>2. Describe growth kinetics</li> <li>3. Describe the types of controls in development</li> <li>4. Linking the concept of specialization in growth and development</li> <li>5. Explains the concept of totipotency in plant cells</li> <li>6. Skilled performs an experiment that shows the germination of seeds</li> <li>7. Communicate the results of the seed germination experiment</li> <li>8. Determine the factors that affect seed germination</li> <li>9. Create a report on the results of the experiment</li> <li>10. Show an honest and independent attitude during the learning process based on the observation sheet</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities, Practical Assessment</p>	<p>Lecturers facilitate student-centered learning, through pictures and guiding active discussions to discover concepts related to growth and development based on case studies in the daily life of the plant. At the end, the representative student presents the results to find out the solution based on the previous case study.</p> <p>Facilitating students through practice using a guided discovery model to discover the concept of the effect of immersion time on seed germination.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group, write the results of a review about the effect of immersion time on germination speed to be written in the lab report section</p> <p>Practical course: 3x60 minutes</p> <p>Structural task: 3x60 minutes Make a practical report 4 X 50</p>	<p>Lecturers facilitate student-centered learning, through pictures and guiding active discussions to discover concepts related to growth and development based on case studies in the daily life of the plant. At the end, the representative student presents the results to find out the solution based on the previous case study.</p> <p>Facilitating students through practice using a guided discovery model to discover the concept of the effect of immersion time on seed germination.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group, write the results of a review about the effect of immersion time on germination speed to be written in the lab report section</p> <p>Practical course: 3x60 minutes</p> <p>Structural task: 3x60 minutes Make a practical report</p>	<p><b>Material:</b> Plant morphogenesis: a. Basic growth and development b. Gene control of growth and development c. Specialization, totipotency, germination and factors that influence germination <b>References:</b> Taiz, L. and Zeiger, E. 2010. <i>Plant Physiology</i>. California: The Benjamin/Cummings Publishing Company, Inc.</p> <hr/> <p><b>Material:</b> Plant morphogenesis: a. Basic growth and development b. Gene control of growth and development c. Specialization, totipotency, germination and factors that influence germination <b>Reference:</b> Hopkins, WG 1995. <i>Introduction to Plant Physiology</i>. New York: John Wiley &amp; Sons</p> <hr/> <p><b>Material:</b> Plant morphogenesis: a. Basic growth and development b. Gene control of growth and development c. Specialization, totipotency, germination and factors that influence germination <b>References:</b> Mohr, H. and Schopfer, P. 1995. <i>Plant Physiology</i>. Berlin: Springer</p>	5%



12	Distinguish between various hormones and relate the function of each plant hormone	<ol style="list-style-type: none"> <li>1. Distinguishing 2 groups of plant hormones, namely auxins, cytokinins, based on synthesis, activity, transport in plants and function of growth</li> <li>2. Conduct experiments on the effect of various hormones on tissue growth</li> <li>3. Create a report on the results of the experiment</li> <li>4. Associated experimental results with the function of hormones in plant cells</li> <li>5. Show an honest and independent attitude during the learning process based on the observation sheet</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2. USS/UTS weight 20%</li> <li>3. Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4. US weight 30%</li> <li>5. Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6. Performance questions are integrated during learning</li> </ol> <p><b>Forms of Assessment :</b> Participatory Activities, Practical Assessment, Practical / Performance</p>	Presentation, discussion and practicum (practical work) 4 X 50		<p><b>Material:</b> Plant hormones: a. The function of hormones for plants, auxins, cytokinins b. Use of growing substances to regulate growth and development <b>References:</b> Salisbury, FB and Ross, CW 2001. <i>Plant Physiology</i>. New York: John Wiley &amp; Sons.</p> <hr/> <p><b>Material:</b> Plant hormones: a. The function of hormones for plants, auxins, cytokinins b. Use of growing substances to regulate growth and development <b>References:</b> Taiz, L. and Zeiger, E. 2010. <i>Plant Physiology</i>. California: The Benjamin/Cummings Publishing Company, Inc.</p>	6%
13	Distinguish between various hormones and the function of each plant hormone	<ol style="list-style-type: none"> <li>1. Distinguish 3 groups of plant hormones, namely gibberellin, ethylene and abscisic acid based on synthesis, activity, transport in plants and function of growth</li> <li>2. Conducting experiments on the effect of the hormone auxin on the leaf abrasion process</li> <li>3. Make a practical report</li> <li>4. Associated experimental results with the function of hormones in plant cells</li> <li>5. Show an honest and independent attitude during the learning process based on the observation sheet</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1. 30% of Reports and practical products are rated as TASKS</li> <li>2. 20% Midterms</li> <li>3. 20% of Student activities and responses during learning activities, especially practical, are assessed as participation</li> <li>4. 30% Final Exams</li> <li>5. Essay questions and multiple choice are accessed jointly at the Midterms and Final Exams</li> </ol> <p><b>Forms of Assessment :</b> Participatory Activities, Practical Assessment, Practical / Performance</p>	<p>Continuing the Project from 12th meeting by presenting the report of the project. The 5th and 6th steps of project conducted in the 12th meeting will be assessed and evaluated to measure the PJBL achievement.</p> <p>Lecturers facilitate student-centered learning, through pictures and guide active discussions to discover concepts related to the nature, synthesis mechanisms and the influence of the hormones gibberellin, ABA, and ethylene on growth and development.</p> <p>Facilitating students through practice to discover the concept of the effect of the hormone auxin on leaf abscission.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group and write the results of a review about the effect of the hormone auxin on leaf abrasion to be written in the practical report section</p> <p>Practical course: 3x60 minutes</p> <p>Structural task: 3x60 minutes Make a practical report 4 X 50</p>	<p>Continuing the Project from 12th meeting by presenting the report of the project. The 5th and 6th steps of project conducted in the 12th meeting will be assessed and evaluated to measure the PJBL achievement.</p> <p>Lecturers facilitate student-centered learning, through pictures and guide active discussions to discover concepts related to the nature, synthesis mechanisms and the influence of the hormones gibberellin, ABA, and ethylene on growth and development.</p> <p>Facilitating students through practice to discover the concept of the effect of the hormone auxin on leaf abscission.</p> <p>Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and as a group and write the results of a review about the effect of the hormone auxin on leaf abrasion to be written in the practical report section</p> <p>Practical course: 3x60 minutes</p> <p>Structural task: 3x60 minutes Make a practical report</p>	<p><b>Material:</b> Plant hormones: a. The function of the hormones gibberellin, ABA, ethylene for plants b. Use of growing substances to regulate growth <b>References:</b> Taiz, L. and Zeiger, E. 2010. <i>Plant Physiology</i>. California: The Benjamin/Cummings Publishing Company, Inc.</p> <hr/> <p><b>Material:</b> Plant hormones: a. The function of the hormones gibberellin, ABA, ethylene for plants b. Use of growing substances to regulate growth <b>References:</b> Mohr, H. and Schopfer, P. 1995. <i>Plant Physiology</i>. Berlin: Springer</p>	6%

14	Explain the mechanisms of various plant responses (plant movement, photoperiod, vernalization and phytochrome) based on observations and experiments	<ol style="list-style-type: none"> <li>1.Describes the concept of motion, photoperiodism, vernalization, phytochromes and biological work hours</li> <li>2.Relate the concepts in part a to plant growth and development</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1.Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2.USS/UTS weight 20%</li> <li>3.Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4.US weight 30%</li> <li>5.Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6.Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities</p>	<p>Lecturers facilitate students in groups and discuss, to discover photoperiodic, vernalization and phytochromic concepts for Plants based on case study of plant growth and development in daily life. At the end of the teaching learning process, the representative student presents the solution based on the case study formulated before.</p> <p>Lectures: 3x50 minutes Self Learning: 3x60 minutes</p> <p>Review the literature on photoperiodic, vernalization and phytochromic events that occur in resume form</p> <p>Structural task: 3x60 minutes Making material for presentations on plant motion and doing presentations on plant motion 4 X 50</p>	<p>Lecturers facilitate students in groups and discuss, to discover photoperiodic, vernalization and phytochromic concepts for Plants based on case study of plant growth and development in daily life. At the end of the teaching learning process, the representative student presents the solution based on the case study formulated before.</p> <p>Lectures: 3x50 minutes Self Learning: 3x60 minutes</p> <p>Review the literature on photoperiodic, vernalization and phytochromic events that occur in resume form</p> <p>Structural task: 3x60 minutes Making material for presentations on plant motion and doing presentations on plant motion</p>	<p><b>Material:</b> Plant response to stimuli: a. Movement of plants b. Photoperiod c. Vernalization d. Phytochrome <b>Library:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p> <p><b>Material:</b> Plant response to stimuli: a. Movement of plants b. Photoperiod c. Vernalization d. Phytochrome <b>Library:</b> <i>Sastamihardja, Darjat and Arbayah. 1994. Plant Physiology. Bandung: ITB Press</i></p>	5%
15	Explain the various responses of plants (dormancy, abscission, senescence) to environmental conditions	<ol style="list-style-type: none"> <li>1.Comparing the effect of gibberellin and ABA on dormancy</li> <li>2.Describe environmental factors that influence the breakdown of dormancy</li> <li>3.Conduct experiments on seed dormancy</li> <li>4.Summing up the concepts of dormancy and abscission based on the experimental results</li> <li>5.Linking the concepts of dormancy and abscission with the response of plants to the environment</li> <li>6.Create a report on the results of the experiment</li> <li>7.Show an honest and independent attitude during the learning process based on the observation sheet</li> </ol>	<p><b>Criteria:</b></p> <ol style="list-style-type: none"> <li>1.Practical reports and products are assessed as ASSIGNMENTS with a weight of 30%</li> <li>2.USS/UTS weight 20%</li> <li>3.Student activities and responses during learning activities, especially practicums, are assessed as participation, with a weight of 20%</li> <li>4.US weight 30%</li> <li>5.Essay and multiple choice questions are assessed jointly on USS and US</li> <li>6.Performance questions are integrated during learning</li> </ol> <p><b>Form of Assessment :</b> Participatory Activities</p>	<p>Lecturers facilitate student-centered learning, through pictures and guide active discussions to discover the concept of the role of the hormones gibberellin and ABA in students' seed dormancy</p> <p>Facilitating through practice to discover the concept of the influence of environmental factors on breaking seed dormancy. Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and in groups and write the results of a review about the influence of environmental factors on the breakdown of seed dormancy to be written in the literature review section of the practical report</p> <p>Practical course: 3x60 minutes Structural task: 3x60 minutes Make a practical report 4 X 50</p>	<p>Lecturers facilitate student-centered learning, through pictures and guide active discussions to discover the concept of the role of the hormones gibberellin and ABA in students' seed dormancy</p> <p>Facilitating through practice to discover the concept of the influence of environmental factors on breaking seed dormancy. Lectures: 3x50 minutes</p> <p>Self Learning: 3x60 minutes Read and in groups and write the results of a review about the influence of environmental factors on the breakdown of seed dormancy to be written in the literature review section of the practical report</p> <p>Practical course: 3x60 minutes Structural task: 3x60 minutes Make a practical report</p>	<p><b>Material:</b> Plant response to stimuli: a. Dormancy b. Absence c. Senescence <b>Library:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i></p> <p><b>Material:</b> Plant response to stimuli: a. Dormancy b. Absence c. Senescence <b>Bibliography:</b> <i>Salisbury, FB and Ross, CW 2001. Plant Physiology. New York: John Wiley &amp; Sons.</i></p>	5%

16	Final Test	<ol style="list-style-type: none"> <li>1.Understand the concepts of photosynthesis, respiration and nitrogen (N) metabolism</li> <li>2.Relates the concepts of respiration and photosynthesis to nitrate assimilation</li> <li>3.Explain fat formation and fat degradation</li> <li>4.Communicate the results of seed germination experiments and the factors of growth regulators that influence the seed germination process</li> <li>5.Relates the concept of dormancy to the plant's response to the environment</li> <li>6.Able to relate experimental results to the function of hormones in plant cells</li> <li>7.Explains the concepts of movement, photoperiodism, vernalization, phytochromes and the biological working clock</li> <li>8.Relate the above concept to plant growth and development</li> </ol>	<b>Criteria:</b> Final Test 30%  <b>Form of Assessment :</b> Test	-	-	<b>Material:</b> Photosynthesis, respiration, Nitrogen metabolism, Fat Metabolism <b>Reference:</b> <i>Yuliani.2017.Plant Metabolism. Surabaya: Unesa Press</i>  <b>Material:</b> Germination, Growth and Development, Plant Hormones, concept of movement, photoperiodism, vernalization, phytochrome and biological working hours <b>References:</b> <i>Taiz, L. and Zeiger, E. 2010. Plant Physiology. California: The Benjamin/Cummings Publishing Company, Inc.</i>	15%
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#### Evaluation Percentage Recap: Project Based Learning

No	Evaluation	Percentage
1.	Participatory Activities	50.5%
2.	Practical Assessment	20.5%
3.	Practice / Performance	4%
4.	Test	25%
		100%

#### Notes

1. **Learning Outcomes of Study Program Graduates (PLO - Study Program)** are the abilities possessed by each Study Program graduate which are the internalization of attitudes, mastery of knowledge and skills according to the level of their study program obtained through the learning process.
2. **The PLO imposed on courses** are several learning outcomes of study program graduates (CPL-Study Program) which are used for the formation/development of a course consisting of aspects of attitude, general skills, special skills and knowledge.
3. **Program Objectives (PO)** are abilities that are specifically described from the PLO assigned to a course, and are specific to the study material or learning materials for that course.
4. **Subject Sub-PO (Sub-PO)** is a capability that is specifically described from the PO that can be measured or observed and is the final ability that is planned at each learning stage, and is specific to the learning material of the course.
5. **Indicators for assessing** ability in the process and student learning outcomes are specific and measurable statements that identify the ability or performance of student learning outcomes accompanied by evidence.
6. **Assessment Criteria** are benchmarks used as a measure or measure of learning achievement in assessments based on predetermined indicators. Assessment criteria are guidelines for assessors so that assessments are consistent and unbiased. Criteria can be quantitative or qualitative.
7. **Forms of assessment:** test and non-test.
8. **Forms of learning:** Lecture, Response, Tutorial, Seminar or equivalent, Practicum, Studio Practice, Workshop Practice, Field Practice, Research, Community Service and/or other equivalent forms of learning.
9. **Learning Methods:** Small Group Discussion, Role-Play & Simulation, Discovery Learning, Self-Directed Learning, Cooperative Learning, Collaborative Learning, Contextual Learning, Project Based Learning, and other equivalent methods.
10. **Learning materials** are details or descriptions of study materials which can be presented in the form of several main points and sub-topics.
11. **The assessment weight** is the percentage of assessment of each sub-PO achievement whose size is proportional to the level of difficulty of achieving that sub-PO, and the total is 100%.
12. TM=Face to face, PT=Structured assignments, BM=Independent study.