Plant physiology essay

Introduction

In the study of general biology, a number of fields such as plant anatomy, plant taxonomy, plant physiology, comparative ecosystems, comparative animal physiology, neurophysiology, physiological ecology, endocrinology, and principles of electronic instrumentation may be topics of interest.

In this paper, the writer will discuss plant physiology. The paper contains the definition of plant physiology in different dimensions, notes related study fields that complement or overlap the topic and explains the branches (or specific study areas) in the topic, detailing examples of what is studied within each subtopic. A general conclusion is given at the end of the presentation. An accompanying reference to the discussed topics is provided at the end of the paper.

Definition of plant physiology

Physiology has been defined as ‘ the science of the normal functions and phenomena of living things’. The current understanding of physiology crops from the works in Europe during the Renaissance interest in experimentation with animals. William Harvey (1628) who was a doctor to Charles I described the working of the heart in sparkling analyses after observations lead to the conclusion of experimental proof and functionality and which informs the importance of physiological analysis as ‘ physiology’.

Physiology is based on hypothesis testing or functionality of given living phenomena. Harvey’s work also emphasized the natural relation between physiology and anatomy (structure of living things) which makes the understanding of the former easier. The successive meanings of ‘ physiology’ are illustrated by instances of its use.

Harris (1704) in Lexicon Technica describes physiology as part of medicine that teaches the constitution of the body so far as it is sound, or in its Natural State; and endeavors to find Reasons for its Functions and Operations, by the Help of Anatomy and Natural Philosophy’. Another definition by Huxley150 years later is clearer and closer to the current definition: ‘ whereas that part of biological science which deals with form and structure is called Morphology; that which concerns itself with function is Physiology’ to make a distinction between structure and function in living organisms.

From the foregoing, plant physiology can be described as that aspect of study that deals with the functioning of plants both microscopically and macroscopically. It assumes the system of understanding the functionality of plant life within itself, without it and within its immediate environment.

The field of plant physiology relates closely to cell morphology which studies development, formation and structures of different species of plant, ecology, which studies the plant habitat, biochemistry which lumps all the biochemical activities of cells, and molecular processes inside the cell. All these fields interact or overlap in the study of plant physiology.

The general field of plant physiology involves the study physical processes and chemicals that describe life and elucidates how they occur in plant. The study is at many levels that encompass various scales, time and sizes. The smallest scale is the molecular interactions that include the photosynthesis interaction in the leaves and diffusion of water in cells.

Diffusion also happens for mineral and nutrients within the plants. In the large scale there are concepts of plant development, dormancy, seasonality and reproduction. Other major disciplines of plant physiology include phytopathology that studies diseases in plants and the study regarding biochemistry of plans, also called phytochemistry. Plant physiology as a unit is divided into many areas of research.

Elementary study of plant physiology mainly concentrates on stomata function, circadian rhythms, transpiration , respiration, environmental stress physiology, hormone function, photosynthesis, tropisms, photoperiodism, nastic movements, seed germination, dormancy, plant hormone functions, photomorphogenesis and plant nutrition.

Branches of Plant Psychology

The subtopics of plant physiology can safely take the forms of photochemistry, biological and chemical processes, internal cell, tissue and organ interaction within the plant, control and regulation of the internal functions (anatomy) and the response to external conditions and environmental changes (environmental physiology). In the following section, these branches of physiology will be discussed in details.

Photochemistry refers to the chemical actions that take place within or without the cell. Plants are considered unique in their chemical reactions since as opposed to animals or other organisms, they have to produce chemical compounds to be used within the same plant. These chemicals are in the form of pigments or enzymes directly used within the plant.

The functions of these chemicals are various. They may be used for defence against external interference from such quarters as herbivores or primary consumers and pathogens. This mechanism is advanced in plants because they are immobile. This, plants do through the production of tissue toxins and foul smells.

Toxicity from plants is associated with plants alkaloids which have pharmacological effects on animals. The Christmas setta if eaten by dogs causes poisoning to them. Another plant in its fresh form, the wolf's bane (the Aconitum genus; Aconitum carmichaelli) has toxic aconite alkaloid that is known to kill wolves and causes tingling, nausea or numbness of tongue or vomiting if tasted by mouth. Some other plants also have secretions or chemical compounds that make them less digestible to animals.

Plants also produce toxins to repel invasion form other plants or in instances of competition for similar nutrients. They produce secretions that are repellent thereby maintaining autonomy over competed for resources. The foul smell exhibited by other plants help to keep herbivores away. The rafflesia (Rafflesia arnoldii) of the Magnoliophyta division has flowers with distinctive smell of rotting flesh of animals to keep herbivores that are known not to eat flesh away.

Toxins or smell can also be produced to guard against encroachment of disease causing organisms or to guard the plant from the effects of drought or unfavourable weather conditions. Enzyme or hormone secretion has been observed in the behaviour such as in preparation for dormancy for the seed, shedding of leaves for deciduous trees in preparation for dry conditions and withering in some plants are caused by chemical reactions in plants.

Innate immune systems such as those of plants are known to repel pathogenic invasions. In an experiment, small protein secreted by strains of the fungus caused it to overcome two a tomato’s disease- resistant genes. A third resistance gene, however, would target this suppressor protein, making the tomato plant fully immune to any form of fungal strain that produced the protein. With the right combination of resistance genes, tomatoes can overcome invasion of fungus despite the fungus’ molecular tricks.

Attraction of possible pollinators for the furtherance of the species of plants is also employing the chemical reactions in plants. Some plants, during their reproduction cycles are known to produce very pleasant smells to attract insect which then help in pollination. An example is the night rose or the Aloysia triphylla that smell so to attract insects that symbiotically gain their nectar and help in pollination of their flowers.

Photochemistry involves the understanding of the metabolic actions of compounds within the plant cells. Studies of these metabolic compounds have been successful through the use of extraction techniques, isolation processes, structural elucidation and chromatography. Modern approaches are numerous and thus expand the field for further studies.

Plant cells vary so much from cells of other organisms. This necessitates different behaviour in order to perform their productive actions. Plants cells have cell walls that are rigid and thus restrict their shape as opposed to animal cells that have both cell walls and cell membranes. This is primarily responsible for plants' immobility and limited flexibility. The internal cell structures vary according to specializations required of the plant to adapt to its life.

For example, the cell vacuole is responsible for storage of cell food material, for intracellular digestion and storage and discharge of cell waste material. It also protects the cell and is also fundamental in endocytosis processes of the cell such as the regulation of the turgor pressure of the cell in response to cell fluid uptake.

The chloroplast is responsible for photosynthesis within the cell and contains the sugars for the photosynthesis. It is also the manufacturer of food for the other organelles. The ribosome use genetic instructions form the Ribonucleic acid (RNA) to link amino acids in long chain polypeptides to form proteins. These plant proteins are very important in plant structures.

Golgi complexes store packages and distribute proteins within the cell endoplasmic reticulum. The smooth endoplasmic reticulum synthesizes lipids while the rough endoplasmic reticulum synthesizes proteins.

The plastid is found in the cytoplasm and possesses double membranes surroundings that depend on the environmental conditions of the parent plant and the plant's adjustment to these conditions. They store molecules such as pigments which give the characteristic colours of flowers and fruits during plant reproduction. They also store photosynthetic products.

The plant cell contains chlorophyll, pigments that are responsible for the manufacture of the plant's own food. The cell physiology is such that the adaptations of different internal cell organelles are commensurate to the ability of the plant to live in a given environment. The cell structure thus plays a major role in plant adaptation.

Plant cells are the smallest unit in building a special system of a plant life. Cells make up tissues that specialize in given plant functions. Tissues coordinate to form organs within the plant that respond to environmental needs as appropriate as is required of the plant.

The specialization of difference types of plant cells such as the parenchyma cells, the collenchyma cells and the scherenchyma cells make it possible for plants to coordinate its functions in its habitat. The parenchyma cells are divided to storage cells for storing cell material, the photosynthetic chlorenchyma cells that are adapted to photosynthesis and transfer cells that are responsible for phloem loading functions of transfer of manufactured food within the plant. These cells have thin cell walls for mediation or simply passage of material from cell to cell.

The collenchyma cells also have only one thin cell wall. They mature from the meristems of the plant tissues. The scherenchyma cells have strong sclereids and fibres made of lignin that provides mechanical support to the plant. This rigidity has also found value in discouraging herbivory.

The tissue systems include the meristematic tissues- the xylem and the phloem as well as the epidermal cells of the external plant cells. The xylem is made up of cells specialized in uptake of minerals active transport. The phloem has a composition of cells mostly of the transfer cells. The epidermal cells are rigid and cuticular to prevent the loss of fluid and are also for protecting the inner weaker placid cells.

All these systems focused to perform different function within the plant both chemically and physical. For example, the roots and the rhizoids help to hold the plant into position for vantage production of its food. For earth plants, the roots have the penetrative power while the aqueous plants have roots helpful in buoying them in place for mineral acquisition.

The leaves are adapted to trap sunlight that is instrumental in photosynthetic process of making food. The leaf structure is such that it is adapted to the habitat of the plant. The position of the stomata in the leaves, for example, is atop and not under the leaf to regulate the flow of gases. The specialized guard cell for the opening and closure of the stomata depicts just how the specialization befits the functionality of the cells, tissues and the plant organs.

Plants also possess transport systems that rely on physical processes in absorption and use of nutrients, air and water within and without the plant. The absorption of minerals depends on a combination of diffusion and active transport that is regulated by the plant in its environment. The roots are developed to successfully execute this process.

Up into the plant the uptake of minerals and water has a developed xylem system that relies on osmosis, diffusion and even active transport in tissues specially adapted to this function. The phloem system successfully executes the transport of manufacture food from the leaves and the stems to other parts of the pant body. The vascular tissues are just an indication of how these forms of interactions work for the benefit of the plant.

Plants have internally developed mechanisms that coordinate responses. These mechanisms are developed on hormonal systems that are instrumental in the development and maturity of the plants. Examples of hormonal coordination in plants include reproduction in flowering plants, ripening of fruits and subsequent expulsion of the same from the mother plant and loss of leaves in response to impending drought or inadequacy of water, just to mention but a few.

The ripening of fruits result from the reactions of the Brix acid in the fruit. The amount of the acid in the fruit determines its ripening. A gas called ethylene is usually created from a compound called methionine acid belonging to the amino group. The ethylene increases the intercellular levels of enzymes.

The amylases hydrolyze starch into sugars while the pectinases hydrolyzes pectin that are responsible for the hardness of fruits while breaking down the green pigment with the colour turning to orange, red or yellow depending on the plant pigments. The process of ripening is related the degree of pollination such that properly pollinated fruits ripen during maturity while those not properly pollinated may have to be shed off before maturity

Abscission in plants is associated with the hormone ethylene. It is believed that ethylene (and not abscisic acid as was previously thought), stimulates the process of abscission. It takes the forms of falling leaves of deciduous trees to conserve water, shedding mostly branches for reproduction purposes, abscission after fertilization, fruit drops to conserve sources or dropping of damaged leaves to conserve water and for photosynthetic efficiency

Paradoxically, ecological physiology is on one hand a new field of learning in plant ecology while again, it is one of the oldest. Physiology of the Environmental is the favoured name of the sub-discipline among botanical physiologists. It however goes by other names in the field of applied sciences. It is more or less synonymous to eco-physiology, ecology of crops, agronomy and horticulture. The discipline overlaps with the field of ecology since the plants act in response to the surrounding.

Ecological physiologists scrutinize plant reaction to factors that are physical such as radiation such as visible light and ultraviolet radiation from the sun, fire, wind and temperature, Of particular interest are water interactions and the stress of deficiency of water or inundation, exchange of gases with the ambient air as well as cycling of nitrogen and carbon nutrients.

Ecological physiologists also analyse and examine plant reaction to biotic factors. This includes not only unfavourable relation, such as rivalry, parasitism, disease and herbivory, but also favourable interactions, such as pollination, symbiosis, and mutualism.

Plants react to environmental changes in a very fantastic way. These reactions are only comparable to the homeostatic processes hitherto experienced splendidly in animals. Environmental changes may impact the plants either positives or negatively and the plants have developed systems to change appropriately. It is however, important to note that environmental variations may sometimes be too extreme to be avoided by plants leading to their demise or possible extinction. This may be understood well in topics such as evolution or more specifically, the ecological succession.

Plants respond to stresses from loss of water in their habitats. Since they are usually stationery, the water usually has to find the plant and not vice versa. An example is the wilting process associated with non woody plants or non-woody parts of woody plants. This process is a reaction to turgidity in non-lignified cells of the plant such that the plant loses rigidity. This results from inadequate water. The process modifies the effective photosynthetic area of the leaf so that the angle of leaf exposed to the sun such that erectophile conditions are enhanced.

This condition may result from drought, reduced soil moisture, increased salinity; saturated soils or a blockage of the vascular tissues of the plant by bacteria or fungi to cause clogging that deprives the leaves of water.

Changes in the composition of the air are also another determinant of plant reaction to its environment. The greatest effect comes from the amount of water vapour in the air. The humidity of the air determines the rate of photosynthesis. Wind also plays a major role in actuating the rate of photosynthesis. Some substances are also toxic to photosynthetic plants. These therefore trigger varied response from plants.

Plants act in response both to directional and non- directional stimuli like gravity or sunlight hence it is called “ tropism”. A reaction to a non-directional stimulus, such as humidity or temperature is called a nastic movement.

Tropisms in plants result from differential cell growth. This is where the cells on a single side of the plant become longer than those on the other side of the plant. This causes a bend toward with less growth. Most common tropisms experienced in plants include autotropism, that signifies a bed towards a side where light comes from. This allows the plant to maximize on its absorption of the much needed light or to allow the plant to receive associated heat from the source of light.

Geotropism is the reaction of the roots of a plant to gravitational pull that reacts on all substances. This growth is usually downward towards the earth enables the plant roots to grow downwards due to direction of gravity. Tropism is a direct influence of hormonal communication within a plant.

Nastic movements on the contrary are reactions from the influence of turgor pressure and may occur within a short period of time. A good example is the thigmonasty reaction that is a reaction of a carnivorous plant or yet still the Venus fly trap that react to touch to trap insects that acts as their food. Mechanisms used here are a network of blades with sensitive trigger thin hairs that shut closed and traps the invader instantly. This is done for additional nutrient. The leaf has to grow slowly between successive catches and readjust before the next catch.

Another recent and most important area of ecological physiology is the study the way plants resist or cope with these diseases in them. Plants, just like animals and other organism are susceptible to a host of pathogenic organism such as bacteria, fungi and viruses.

The morphology of plants differed from that of animal. This implies that their reaction to diseases also vary greatly. Plants may react to an invasion only by shedding their leaves. Animals however have to obtain either innate immunity or tackle the intrusion through other antibodies.

Diseases organisms affecting plants also vary from those causing that cause disease to animals. Plants cannot usually spread diseases because of their immobile nature thus physical contact infections are rarely the case. Their pathogens thus usually spread through spores or are transmitted by animals that act as vectors.

Plant habitat and competitive environmental conditions also necessitate readjustments in plants. Competition for nutrients due to encroaching competitors may force the plant to change its morphology or other aspects of plant functionality.

Many phototrophic plants use a photoreceptor protein such as phytochrome or cryptochrome to sense changes in seasons, changes in length of day and take to allow them to flower. In a broader sense, phototropic plants can be grouped into short, long or neutral day plants.

When the day extends past the critical period such that night is shorter that day the long day plant flowers. The plants generally flower during spring or in the early summer with longer days approaching. Short day plants flower when the day is shorter than a standard or critical length. This is when the night is longer than a critical length. The plants generally flower during late summer or during fall when the shorter days are approaching.

Scientist concur that the night length and not that of day controls the pattern of flowering. Thus flowering in a longer day plant is necessitated by shorter nights which mean longer days. The opposite is true; short day plants will flower when the nights get longer than the critical duration of day. This has been done by using night break experiments. For instance, a long night (long day) will not flower if a pulse of say 10 minutes of artificial beam of light is shone at it during midnight. This occurrence is not possible with natural light such as the moon in the night, fire flies or even lighting since the light from these light sources are not sufficiently intense to help trigger the response.

Day neutral plants are not affected by photoperiodism. They always flower regardless of the presence of light or absence of the same, the length of light in day or night variations. Some have adapted to use temperature instead of light. Long or short day plants will have their flowering enhanced or interfered with inn the presence of variations in length of day or night.

They will however flower in sub optimal or half day lengths and temperature is a likely effect to their flowering time. Contemporary biologists believe that it is the happenstance of the active kinds of phytochrome or cryptochrome, resulting from the light during daytime, with the sync of the circadian clock that enables plants to determine the duration of the night. Other occurrences of photoperiodism in plants are like the growth of stems or roots within some seasons or the loss of plant leaves at other seasons.

Transpiration and stomata actions also greatly affect the plant in almost all the cited circumstances above. Transpiration in plants is the process by which evaporation of water molecules usually through the leaves but also takes place from flowers, roots and even stems. The stomata are the major site for transpiration. The opening of the stomata is a regulated process through the stomata guard cells and the process of water loss may be considered both unfortunate and necessary.

The stomata open to allow the diffusion of the photosynthetic gas, carbon dioxide and allows out oxygen. Transpiration has a dual action of cooling the plant in excessive heating and will also aid the loss of unwanted water within the plant system. It also enables the mass flow of mineral nutrients that is aided by the flow of plant water. This is a hydrostatic process that thrives on diffusion of water out of the stomata.

The rate of transpiration is directly affected by the rate of stomata opening. The evaporation demand of the atmosphere is also another factor that influences the release of water. Humid conditions don't favour evapotranspiration. Wind also enhances this rate. The amount of water through the process also depends on the individual plant size, the surrounding intensity of light the ambient temperature, soil water supply and the soil temperature.

Genetic, physical and chemical factors affects all the environmental responses, internal cell functions and external adjustments. The plant functioning is a complex that embraces all the aspects of botanical science and one cannot be studied alone in isolation. All the functions may vary from one plant to another depending on the cell morphology, anatomy or ecological niche but essentially, for all photosynthetic plant, the general functions are read along similar lines.

Deviations may occur as a result of evolutional characteristics or adaptations. These deviations, however, have not deterred the organization of the study of plant physiology. Research on physiology of plants is still developing and a great understanding of the topic is essential if it is approached from all aspects of the study of Biology as a discipline and may call for inclusion of other disciplines.

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