
Glossary

- ABA receptors** Proteins that have been proposed to regulate responses to ABA upon binding it. Three classes of ABA receptors have been identified till date. These include (i) the plasma membrane-localized G-proteins GTG1 and GTG2, (ii) a plastid localized enzyme that coordinates nucleus to plastid signaling, and (iii) cytosolic ligand-binding proteins of START (Steroidogenic Acute Regulatory Protein-Related Lipid Transfer) domain superfamily.
- ABC model** A model that explains the development of floral organs in response to the pattern of gene expression of a set of floral meristem-identity genes. According to this model, three homeotic genes, namely, A, B, and C, are responsible for organ identity in each whorl of a flower. A unique combination of these three genes determines the organ formed in each whorl.
- ABC transporters** Members of a transport system superfamily which consist of multiple subunits, one or two of which are transmembrane ATPases.
- ABCB transporters** Transmembrane proteins that are phosphoglycoproteins in nature and belong to ABC transporter superfamily. They facilitate IAA efflux or influx across the plasma membrane (and also tonoplast), but unlike PIN proteins, they do not show preferential basal localization in the cells.
- Abiotic stress** Stress which originates from excess or deficit in the physical, chemical, and energetic conditions to which plants are exposed, for example, salinity stress, flooding, and drought.
- ABP1 (auxin-binding protein 1)** A glycoprotein auxin receptor localized in the lumen of the ER and plasma membrane. It is proposed to form a complex with a transmembrane docking protein which provides lipid solubility to anchor ABP1 to the membrane.
- Abscission** The process of natural detachment of plant parts, such as senesced leaves, flowers, and ripened fruits.
- Absorption spectrum** A graph depicting measurement of light absorption by a pigment (e.g., chlorophyll) as a function of wavelength.
- ACC (1-aminocyclopropane-1-carboxylic acid)** A disubstituted cyclic alpha-amino acid in which a three-membered cyclopropane ring is fused to the C-atom of the amino acid. It is an intermediary compound in ethylene biosynthesis.

- Acid growth hypothesis** A hypothesis which explains plant cell enlargement on the basis of cell wall acidification resulting from proton extrusion across the plasma membrane into the apoplast by the action of plasma membrane-associated H^+ -ATPases.
- Action spectrum** A graph depicting the magnitude of response of a biological system as a function of varying wavelengths of light, for example, rate of photosynthesis as a function of wavelength.
- Activation energy** The minimum amount of energy which the reacting species must possess to undergo specific chemical reaction or the difference in free energy of ground state and transition state of the substrate molecule.
- Active site** The catalytic region of an enzyme molecule at which it binds with the substrate.
- Active transport** An uphill transport of molecules across a membrane against their electrochemical gradient with the help of pumps that utilize ATP hydrolysis as a source of energy.
- Acyl carrier protein** A highly conserved protein which serves as the carrier of acyl intermediates during fatty acid and polyketide biosynthesis. It transports growing fatty acid chain between different enzymatic domains of fatty acid synthase.
- Adaptive immune system** Refers to actions against pathogens that are able to evade or overcome innate immune system. This system is activated in the presence of infectious agents and is proliferated to other cells for eliminating the microbes, for example, antibodies produced by lymphocytes. Plants lack this type of immunity.
- Adenine nucleotide translocase (ANT)** A mitochondrial protein that facilitates the exchange of ADP and ATP across inner mitochondrial membrane.
- Adenylate kinase** A phosphotransferase enzyme that catalyzes the conversion of two ADP molecules to ATP and AMP and vice versa.
- Adhesion** The force of attraction between two dissimilar substances. This force can be mechanical (sticking together) or electrostatic (attraction due to opposite charges). For example, wetting of any surface is due to the effect of adhesive forces between liquid and the surface.
- Aerenchyma** A spongy tissue with large air spaces which forms channels in the leaves, stem, or roots of some plants. It imparts buoyancy and facilitates exchange of gases in aquatic plants.
- Aeroponics** A technique of growing plants in which roots are suspended in growth chamber in air and roots are periodically wetted with a fine mist of nutrients.
- After-ripening** Prolonged dry storage of seeds at room temperature to overcome dormancy.
- Aging** Aging-Gradual loss of physiological and metabolic activities in an organism over a period of time, ultimately leading to death.
- Air-seeding hypothesis** The breakage of water column due to trapping of air in the xylem elements leading to embolism (blockage).
- Aleurone layer** The outermost layer of cells rich in protein bodies distinctly surrounding the starchy endosperm in cereal grains. It is mainly involved in the

synthesis and release of hydrolytic enzymes to mobilize stored starch to support seed germination.

Alkaloids A large group of secondary metabolites which contain nitrogen in their structure mostly as heterocyclic ring, for example, nicotine, codeine, morphine, and caffeine. They are involved in plant defense and are of great medicinal importance to humans.

Allelochemicals Chemicals produced by the plant which are toxic in nature and detrimentally affect the growth and survival of neighboring plants when released into the environment.

Allelopathy A biological phenomenon of release of various chemicals (allelochemicals) into the environment by certain plants and inhibition of growth of neighboring plants.

Allocation (ref. photoassimilate translocation) The regulation of diversion of photoassimilates into various metabolic pathways in the source tissue.

Allosteric inhibition The inhibition of an enzyme caused by binding of an inhibitor molecule at the allosteric site. The inhibitor is capable of inducing changes in the conformation of the enzyme rendering it inactive.

Allosteric site A site present on the enzyme, other than the active site, where an effector (either negative or positive) molecule can bind to regulate the activity of the enzyme.

α -Amylase An enzyme which catalyzes the conversion of starch into low molecular weight sugars, i.e., glucose and maltose, via hydrolysis of the internal α -1,4-glycosidic linkages.

Alternative oxidase (AOX) The non-energy-conserving terminal enzyme which forms a part of mitochondrial electron transport chain in different organisms and catalyzes the cyanide-resistant oxygen reduction.

Amensalism Any relationship between organisms of different species in which one organism is negatively affected or destroyed while the other organism remains unaffected.

Aminotransferases A group of enzymes which catalyze the transfer of an amino group from one α -amino acid to an α -keto acid so that the donor amino acid is converted to its respective α -keto acid while the amino group acceptor α -keto acid is converted to its respective α -amino acid. They are also called transaminases.

Ammonification A process carried out by a variety of microorganisms present in the soil during which organic nitrogen of the soil (present in the soil due to decay of dead animals, plants, and excreta of animals) is broken down to ammonia which becomes available to plants.

Amphibolic pathway A metabolic pathway involving both anabolism and catabolism. For example, TCA cycle provides precursors for anabolic pathways while plays catabolic role in degradation of complex organic molecules to the simpler ones.

Amphipathic molecules Molecules containing both polar (hydrophilic) and non-polar (hydrophobic) regions, for example, phospholipids which have a polar phosphate head and a nonpolar fatty acid tail.

- Amyloplasts** Starch-storing plastids found in storage tissues of shoots and roots which also serve as gravity sensors.
- Anion exchange capacity (AEC)** The ability of the soil colloids to hold and exchange anions. It increases as the soil pH decreases.
- Anisotropic** Having different properties along different axis, for example, optical anisotropy which causes polarization of light.
- Anoxia** A condition of complete depletion of oxygen in solutions or a condition characterized by the absence of oxygen to an organ or a tissue.
- Anoxygenic photosynthesis** A form of photosynthesis in which light-driven ATP and NADPH synthesis occurs with the utilization of sources other than water, such as hydrogen sulfide, as the electron source and the process are coupled with accumulation of free sulfur. This type of photosynthesis occurs in purple bacteria and green-sulfur bacteria.
- Antenna pigments** Pigments which are associated with subunit proteins to form light-harvesting complex. These serve as sites for absorption of light energy which is then supplied to the reaction center.
- Antiauxins** Compounds which inhibit auxin action by competing for the same receptors. They closely resemble auxin in structure but lack auxin-like activity, for example, α -p-chlorophenoxy isobutyric acid (PCIB).
- Antiflorigen** A hypothetical hormone proposed to inhibit the formation of flowers in certain long-day plants under noninductive photoperiod.
- Antifreeze proteins** A group of proteins which are produced during cold acclimation and prevent the nucleation of ice crystals or re-formation of ice crystals post a freeze-thaw cycle.
- Anti-nutritional proteins** Chemicals present in food that reduce nutrient utilization or food intake, thereby contributing to impaired gastrointestinal and metabolic performance.
- Antioxidants** Molecules which inhibit the oxidation of other molecules, such as free radicals, that may damage cells through chain reactions, for example, vitamins A, C, and E.
- Antiport** A type of secondary active transport of solutes which couples the movement of two solutes but in opposite directions across a membrane. The movement of one species is down its electrochemical gradient which drives the active transport of the other against its gradient.
- Antiporters** Integral membrane proteins or cotransporters which facilitate movement of two solutes in opposite directions across the membrane (i.e., antiport), for example, $\text{Na}^+/\text{Ca}^{2+}$ antiporter that exchanges one Ca^{2+} ion for extrusion of three Na^+ ions out of the cell.
- Antitranspirants** Chemicals which decrease water loss from surface of plant leaves due to transpiration. They can be either physical or physiological in nature. Physical antitranspirants include the use of polymers, resins, latex, and waxes to coat the leaf surface and minimize water loss by blocking the stomatal aperture. On the other hand, physiological antitranspirants reduce transpiration by inducing plants to close stomata, for example, ABA and phenyl mercuric acid (PMA).

- Apical dominance** The phenomenon of inhibition of axillary bud growth by the continued meristematic activity in the shoot apex. It is best observed in herbaceous plants and also in trees during first year of growth.
- Apoenzyme** The proteinaceous part of a holoenzyme without a cofactor.
- Apomixis** Asexual formation of seed from the maternal tissues of the ovule without the process of meiosis and fertilization.
- Apoplast** The continuous system of spaces that lies outside plasma membrane consisting of cell wall in plant cells and the intercellular spaces. It allows free diffusion of materials from one cell to another cell.
- Apoptosis** A type of programmed cell death in multicellular organisms, involving all biochemical events leading to characteristic cell changes and death.
- Appressorium** A flattened and thickened hyphal branch that facilitates penetration of fungal hyphae inside the host plant.
- Aquaporins** Integral membrane proteins in the phospholipid bilayer membranes, allowing cell-to-cell rapid transport of water molecules. Some plant aquaporins have now been reported to additionally transport other small, uncharged solutes, stress response factors, or signaling molecules. They are present on plasma membrane and tonoplast.
- Arabidopsis* histidine phosphotransfer (AHP) protein** A protein similar to bacterial and yeast histidine phosphotransferases (HPTs) which is a positive regulator of cytokinin signaling. It is responsible for cytokinin signal propagation from the plasma membrane receptor to the nucleus in a multistep signaling pathway.
- Arabidopsis* response regulators (ARRs)** Proteins identified in *Arabidopsis* that are similar to bacterial two component signaling proteins called response regulators. There are two classes of these proteins: Type-A ARR, whose transcription is upregulated by cytokinin, and Type-B ARR, whose expression is not affected by cytokinin.
- Arabinan** A polysaccharide, mostly a polymer of arabinose. It consists of a main chain of 1,5- α -linked L-arabinofuranosyl to which other L-arabinofuranosyl residues are linked by 1,3- α and 1,2- α linkage in either a comb-like or a ramified manner.
- Arabinogalactans (of extensin family)** A class of long, densely branched high-molecular polysaccharides consisting of monosaccharides—arabinose and galactose. These are often found attached to proteins forming arabinogalactan proteins (AGPs). Localized movement of AGP from plasma membrane to the cell wall is a component of mechanism of tip growth in plant cells. AGPs also serve as an intercellular signaling molecule and play a major role in cell-to-cell interaction during development and in sealing of wounds.
- Arabinoxylan** A hemicellulose consisting a linear β -1,4-xylose residues with arabinose substitution. It is found in both primary and secondary cell wall of plants.
- Arbuscular mycorrhizal (AM) fungi** A type of mycorrhizal association between a fungus (belonging to phylum *Glomeromycota*) and the roots of higher vascular plants in which the fungus penetrates and forms arbuscules (branched structures that are sites of nutrient exchange between the fungus and plant host) in the cortical cells of the roots.

- Ascent of sap** The upward movement of water and minerals through the xylem tissues from the roots to the aerial parts of the plant.
- Asparagine synthetase (AS)** An enzyme which catalyzes the formation of asparagine from aspartate.
- Aspartate aminotransferase** An enzyme that catalyzes reversible transfer of α -amino group between aspartate and glutamate and uses pyridoxal 5'-phosphate as the cofactor. It is also known as aspartate transaminase.
- ATP synthase** The multi-subunit protein complex that synthesizes ATP from ADP and P_i in response to an electrochemical gradient created by proton movement in response to proton motive force during oxidative phosphorylation and photophosphorylation in mitochondria and chloroplasts, respectively.
- ATP synthasome** A complex of the ATP synthase with adenine nucleotide translocase (ANT) and phosphate translocase.
- Autocatalytic cycle** A metabolic cycle in which one of the products is also a reactant, for example, glycolysis, where two molecules of ATP are consumed and four are produced.
- Autogamy** The process of transfer of pollen onto the surface of stigma present in the same flower.
- Autolysis** Destruction of a cell through the action of its own hydrolytic enzymes.
- Autophagic body** The membrane-bound organelle derived from autophagosomes which enters the vacuole and releases its contents for degradation by hydrolytic enzymes.
- Autophagosomes** Double membrane-bound organelle that transfers cellular components to the vacuole for degradation.
- Autophagy-related genes (ATG genes)** A group of genes that code for proteins required for autophagy.
- Autophagy** A physiological process that is instrumental in maintaining cell homeostasis and involves transport of cellular macromolecules to lytic vacuoles for degradation.
- Autophosphorylation** The process of addition of phosphate group to serine, threonine, or tyrosine residues in the structure of a kinase protein by itself so as to regulate its own enzymatic activity.
- Autotoxicity** A form of allelopathy in which a species inhibits the growth of members of the same species through production of chemicals which are released into the environment.
- Autotroph** A living organism which is capable of manufacturing its own organic food from simple inorganic materials using external energy sources, for example, green plants, algae, and some bacterial species.
- AUX1** An auxin uptake carrier protein that functions in leaf vascular tissue and root apices and belongs to a family of proteins similar to permeases in prokaryotes.
- Avirulent** Strain of pathogen lacking virulence (the ability of an organism to cause disease).
- Avr gene** Refers to avirulence gene which is present in all pathogens. It codes for effector protein.

- Bacteriorhodopsin** A protein from halobacteria (a class of archaeobacteria) which acts like a pump. It uses light energy to pump H^+ out of the cell.
- Bacteroid** The nitrogen-fixing form of *Rhizobium* which develops in the root nodules upon a signal from the host plant.
- Basal defense mechanism** The first level of preformed, inducible defense that protects plants against several types of pathogens.
- Beneficial elements** Mineral elements which are not essential to all plants but benefit certain plant species under defined conditions. Elements including silicon, aluminum, selenium, and cobalt are considered beneficial by various means such as acting as agents for stimulating the resistance mechanism, uptake of other nutrients, and detoxification of toxins and other metals.
- Bioactive compound** A compound that has an effect on a living organism, tissue, or cell.
- Bioassay** Quantitative estimation of a biologically active substance by measuring its effect on a living organism under standard conditions.
- Bioenergetics** The biological science which deals with the study of energy transduction and transformation within a living system and exchange of energy between living system and the environment.
- Biogenic volatile organic compounds (BVOCs)** Organic atmospheric trace gases (other than carbon dioxide and monoxide) produced by plants. They include isoprenoids (isoprene and monoterpenes), alkanes, alkenes, carbonyls, alcohols, esters, ethers, and acids.
- Biosensor** An analytical device used for detection of an analyte using a biological component and a physicochemical detector. In other words, it is a device that utilizes biological components, for example, enzymes, to detect a biomaterial, for example, surface plasmon resonance (SPR).
- Biotic stress** Stress which is imposed by direct or indirect interactions with other organisms, for example, infection by bacterial, fungal, and viral pathogens.
- Biotrophic pathogens** Plant pathogens that grow in or on the living cells and derive energy from the host.
- Bolting** A process observed in plants, such as spinach, lettuce, and cabbage, in which flowering stems are produced prematurely before harvesting. Exogenous application of gibberellin is known to promote bolting in a wide range of species. This leads to lengthening of stem, decrease in stem thickness and leaf size, and pale green coloration of leaves.
- Boom and bust cycle** The periodic reoccurrence of epidemics in crops due to control in disease (boom year) and failure of disease control (bust year).
- Boundary layer resistance** The resistance posed by the thin layer of air immediately around the leaf surface (known as boundary layer) to heat and vapor transfer from the leaf surface to the atmosphere during transpiration.
- Brassinosteroids (BRs)** A group of plant polyhydroxy steroidal hormones (C_{27} to C_{29}) derived from castasterone. They are known to modulate de-etiolation and rolling of leaves among grasses.

- BRI1 (Brassinosteroid insensitive 1)** Brassinosteroid receptor located on plasma membrane belonging to the family of leucine-rich repeat (LRR) receptor and endosomes as a dimer. Its cytosolic loop exhibits LRRs for binding with BR molecule leading to signaling.
- Bulk flow** The concerted, long-distance movement of water and solutes in the tracheids and sieve-tube elements down a pressure gradient from the soil up through the plant. It is also applied to the movement of larger solutes in phloem.
- Bulliform cells** Enlarged epidermal cells present in leaves of grasses having a role in the rolling and unrolling of leaves.
- Calcium sensor proteins** Calcium-binding proteins which monitor temporal and spatial changes in Ca^{2+} concentrations and undergo conformational changes upon calcium binding. They further trigger downstream signaling responses.
- Calcium/calmodulin-activated kinase (CCaMK)** A protein kinase which is a central regulator in plant root endosymbiosis and decodes Ca^{2+} oscillations in the nucleus occurring in response to symbiosis. It adopts different modes of action upon binding with either free form of calcium or calcium bound with calmodulins.
- Calcium-dependent protein kinases (CDPKs)** A large family of serine/threonine protein kinases. They may function in perceiving intracellular changes in Ca^{2+} concentration and translate them into enhanced protein kinase activity and initiate further downstream signaling processes.
- Callose** A β -1,3-glucan synthesized in the plasma membrane and deposited between the plasma membrane and cell wall. It plays important roles in plant development (e.g., development of pollen) and responses to biotic and abiotic stresses (e.g., by forming plugs at plasmodesmata).
- Callus** A mass of undifferentiated, growing, and dividing tissue produced during wound healing (to cover wound) or in tissue culture.
- Calmodulin** Calcium-binding conserved protein found in all eukaryotes which regulates many Ca^{2+} -driven metabolic reactions.
- Capillary action** The process by which water rises in the xylem elements of roots and stem of a plant body as a result of cohesive and adhesive forces between water molecules.
- Carbon dioxide compensation point** The concentration of carbon dioxide at which the rate of photosynthesis exactly matches the rate of respiration. As a result, there is no net change in concentrations of carbon dioxide and oxygen.
- Carotenoids** Naturally occurring pigments synthesized by plants, algae, and photosynthetic bacteria. They are responsible for yellow, orange, and red colors in leaves and fruits and are involved in quenching of excessive light energy to prevent photooxidative damage to chlorophyll and reaction center.
- Casparian bands** Bands of cell wall material particularly rich in suberin (waxlike, hydrophobic material) deposited on the radial and transverse wall of the endodermis. The Casparian strips prevent water from traveling through the apoplast once it reaches the endodermis.

- Catalase (CAT)** A heme-containing enzyme that acts directly on hydrogen peroxide and catalyzes its decomposition into water and oxygen, thus preventing cells from oxidative damage.
- Cation adsorption sites** Negatively charged sites on root surface due to carboxyl groups of polygalacturonic acid in the pectic substance of middle lamella which attract cations from soil solution, thereby causing their migration in the cell wall.
- Cation exchange capacity (CEC)** The ability of soil colloids to hold and exchange cations.
- Cavitation** The process of breakage of water column in xylem due to air entrapment.
- Cell autonomous responses** Signaling events in plants where signal perception and response occur in the same cell, for example, opening of stomatal aperture which involves activation of membrane-associated ion transporters in response to blue light, ultimately leading to swelling of guard cells via phototropin activation.
- Ceramide** A sphingolipid consisting of sphingosine and a fatty acid which forms component of sphingomyelin, a major lipid found in lipid bilayer. It plays an important role in coordinating cellular response to extracellular stimuli and stress.
- Chaperonins** Proteins which assist in the assembly and folding of other proteins in cells.
- Chemiosmotic mechanism** Process by which electrochemical gradient of protons is established across a membrane due to electron transport which drives ATP synthesis.
- Chemiosmotic model** A model proposed by Peter Mitchell which explains the establishment of an electrochemical gradient of protons across membrane in response to electron transport which drives ATP synthesis.
- Chemoautotroph** Any living organism which is able to synthesize carbon compounds for its growth, utilizing the energy released during the oxidation of the chemical compounds carried out by them.
- Chemocyanin** A small, secreted protein (chemotropic substance) in the style that acts as a directional cue for pollen tube growth toward ovule.
- Chemonastic response** A type of plant growth response or movement in response to an external chemical stimulus, either toward (positive chemotropic) or away from it (negative chemotropic), or a change in concentration of a chemical inside the plant, for example, growth of pollen tube through the style toward ovule in response to chemicals released by ovary.
- Chitin elicitor-binding protein (CEBiP)** It is a pattern recognition receptor (PRR) present on a host membrane. It has extracellular domain (with LysM motifs) which binds with chitin elicitor. It does not have an intracellular kinase domain and is always found in association with CERK1 (chitin elicitor receptor kinase 1) for signaling in PAMP-triggered immunity (PTI).
- Chitin** A polymer of N-acetyl-D-glucosamine and is the main component of fungal cell wall.

- Chlorine** A class of large heterocyclic tetrapyrroles derived from porphyrins consisting of three pyrroles at the core and one pyrroline coupled through four CH linkages, for example, chlorophyll.
- Chlorosis** Loss of chlorophyll leading to yellowing in leaves. It is caused by the deficiency of elements like potassium, magnesium, nitrogen, sulfur, iron, manganese, zinc, and molybdenum or due to destruction of chlorophyll by certain toxins, high alkalinity of soil, poor drainage, and infection by pathogens.
- Cholesterol** A sterol which is an essential structural component of all animal (not plant and bacterial) cell membranes. It is required both for structural integrity and fluidity of membranes.
- Chromophore** The prosthetic group of an organic molecule which is light-absorbing and non-proteinaceous, for example, the phycobilins serving as chromophores for phycobiliproteins. It changes conformation when it absorbs light.
- Circadian rhythms** Biological processes that display endogenous, entrainable oscillation of 24 hours.
- Climacteric** Stage of fruit ripening associated with increased ethylene production and a rise in cellular respiration. Apples, bananas, melons, and tomatoes are climacteric fruits which release large amounts of ethylene.
- Climacteric fruit ripening** The process of fruit ripening associated with increased ethylene production and rate of respiration.
- Coenzyme** A small organic non-protein molecule that binds with the protein molecule (apoenzyme) to form the active enzyme (holoenzyme). Coenzymes cannot function on their own. For example, NAD⁺ is a coenzyme non-covalently bound to the protein part of many dehydrogenases.
- Coevolution** The evolution of complementary traits in two different species due to environmental interaction between them.
- Cofactor** The non-proteinaceous inorganic or organic component of a conjugated enzyme that assists during the catalysis of a reaction. For example, heme is a cofactor of hemoproteins.
- Coincidence model** A model for flowering in photoperiodic plants in which the circadian oscillator controls the timing of light-sensitive and light-insensitive phases during the 24-hour cycle.
- Commensalism** An association between two organisms in which one benefits and the other neither benefits nor is harmed, for example, bromeliads and orchids growing on trees.
- Companion cells** Metabolically active cells located in phloem which are closely associated with sieve elements through branched plasmodesmata and help in the transport of photoassimilates from the mesophyll cells into sieve elements and vice versa, thus regulating phloem loading and unloading.
- Compatible disease reaction** An interaction (host and pathogen) where symptoms are expressed clearly in the host.
- CONSTANS (CO)** A key component of the pathway that regulates the transcription of other genes and promotes flowering in *Arabidopsis* in long days.

- Constitutive defense** A type of defense which is always present irrespective of the attack by the microbes.
- Continuous-flow solution culture** A hydroponic technique in which plants are grown by constantly flowing nutrient solution over their root systems.
- COP1 (constitutive photomorphogenesis 1)** An E3 ligase that is a constitutive repressor of photomorphogenesis in dark and acts by promoting degradation of photomorphogenesis promoting factors such as HY5 via 26S proteasomal pathway.
- COP1-SPA (COP1 suppressor of PHY) complex** A protein complex that represses photomorphogenesis in dark by associating with and stabilizing PIF3 (phytochrome-interacting factor 3).
- Corpus** The core of an apical meristem consisting of cells that divide in various planes and contribute to growth in volume.
- Coumarins** Chemical compounds found in many plants which belong to the class of phenylpropanoid lactones, also known as benzopyrones, for example, scopoletin, aflatoxin, and umbelliferone.
- Crescograph** An instrument used to measure growth movements of plants in response to various stimuli. It was invented by Sir J.C. Bose.
- Critical concentration** The minimum concentration of a nutrient element that results in 90% of maximum yield or growth below which there is significant reduction in the yield. It is usually used in plant nutrient analysis.
- Critical day length** The minimum length of the day required for induction of flowering in a long-day plant.
- Critical elements** The elements in which soils are generally deficient, for example, nitrogen, phosphorus, and potassium. These are supplied to plants in the form of chemical fertilizers, called complete fertilizers.
- Critical toxicity level** The minimum concentration of a potentially toxic micronutrient (e.g., zinc, lead, and copper) in tissue which results in 10% reduction in dry matter.
- Cryptochromes** A class of flavoproteins that serve as sensitive photoreceptors to blue light and are implicated in many blue light responses, namely, promotion of cotyledon expansion, suppression of hypocotyl elongation, membrane depolarization, anthocyanin production, and circadian clock function. These are photolyase-like receptors having an N-terminal PHR (photolyase-homologous region) domain that binds chromophore FAD and the CCE (CRY C-dinucleotide) domain that is crucial for the regulation of their function.
- Cyanogenic derivatives** Non-alkaloid, nitrogen-containing compounds which produce hydrogen cyanide upon breakdown. They are involved in plant defense, for example, amygdalin in almonds.
- Cyclic electron flow** Cycling of electrons around photosystem I where electrons flow from electron acceptors through cytochrome b_6/f complex and return to photosystem I. In higher plants this results in the formation of a proton gradient due to proton pumping in the lumen. As a result, ATP is synthesized without any photolysis of water and reduction of $NADP^+$.

- Cyclic nucleotide-gated ion channels (CNGCs)** Nonselective cation channels which function in response to cyclic nucleotide binding and altered membrane potential. These channels are also modulated by calcium/calmodulin or phosphorylation events and thus triggering signaling cascades.
- Cyclin-dependent kinases (CDKs)** A class of protein kinases that regulate the transitions from G₁ to S and from G₂ to M (mitosis) phases during cell cycle.
- Cysteine synthase** An enzyme responsible for the formation of cysteine from O-acetyl serine and hydrogen sulfide with concomitant release of acetic acid.
- Cytochrome b5 (cyt b5)** A membrane-bound heme-containing protein which acts as a carrier of electrons for several membrane-bound oxygenases.
- Cytochrome oxidase** An oxidizing enzyme containing iron and porphyrin which is part of the electron transport chain. It is able to catalyze oxidation of cyt *c* by transferring electrons from reduced cyt *c* to molecular oxygen.
- Cytochrome P450 (cyt P450)** A family of heme-containing proteins belonging to the superfamily of monooxygenases. It is involved in the detoxification of potentially toxic compounds, for example, drugs, xenobiotics, and other toxins, processing and transport of proteins, and production of energy. 450 term is derived from spectrophotometric peak at 450 nm when it is in reduced state and is complexed with carbon monoxide.
- Cytochromes b₆f complex** A large multi-subunit complex, consisting of two *b*-type hemes, one *c*-type heme (cyt *f*) and a Rieske Fe-S protein, distributed equally between grana and stroma lamellae.
- Cytokinin oxidase** Enzyme that catalyzes the catabolism of specific cytokinins to inactive products that lack the N 6-unsaturated side chains.
- Damage-associated molecular patterns (DAMPs)** Self-derived molecules produced in the cells and released in response to stress. They initiate immunity in the cell.
- Day-neutral plants** Plants in which flowering is not affected by day length, for example, sunflower, tomato, and maize.
- DELLA proteins** A family of proteins that are putative transcriptional regulators and act downstream of the GA receptor (GID1) and negatively modulate gibberellin signaling in plants and inhibit growth processes. Binding of GA with GID1 induces binding of GID1-GA complex to DELLA which, in turn, leads to tagging of DELLA by ubiquitination followed by its degradation via 26S proteasomal pathway.
- Desaturases (soluble)** A group of enzymes found in the stroma of plastids that catalyze the insertion of double bond into saturated fatty acids bound to ACP producing monounsaturated fatty acids.
- Determinate growth** Growth for limited duration which is characteristic of floral meristems and leaves.
- Development** A change in the pattern of growth of an organism or organ. For example, transition from leaf primordium to fully mature leaf or from vegetative to flowering condition.
- Dextrins** A group of low molecular weight carbohydrates composed of glucose molecules linked by α -1,4 and α -1,6 glycosidic bonds. These can be produced by hydrolysis of starch or glycogen through the action of amylases.

- Diacylglycerol** A glyceride containing two molecules of fatty acids covalently bonded to a glycerol molecule via ester linkages.
- Diagravitropic** Gravitropic response perpendicular to the stimulus as seen in rhizomes and stolons.
- Diaheliotropic leaves** Leaves which maximize light capture by heliotropism by continuous adjustment of their orientation with respect to the direction of sunlight.
- Dialysis** The process of separation of particles in a liquid through a membrane on the basis of differences in their size and concentration gradient.
- Dichogamy** The production of stamens and pistils at different times in hermaphroditic flowers in order to prevent self-pollination. It is of two types: protandry (anthers mature first) as seen in Apiaceae and Asteraceae and protogyny (pistil matures first) as observed in Brassicaceae and Rosaceae.
- Dieback** A symptom of copper deficiency in woody plants, particularly citrus, which brings about progressive death of shoots, branches, and roots beginning from the tip and spreading to rest of plant body. It is also caused by many fungal and bacterial pathogens.
- Differentiation** Processes by which distinct cell types arise from precursor cells, for example, differentiation of xylem and phloem from cambium.
- Diffusion** A spontaneous physical process of movement of any substance or molecule from the region of its higher concentration to the region of its lower concentration without the use of energy due to kinetic energy of the molecule. The rate of diffusion is also affected by the size of the molecule, its concentration gradient, viscosity of the medium, and temperature, for example, diffusion of carbon dioxide and oxygen via the stomata.
- Diffusion coefficient or diffusivity (Ds)** A proportionality factor that measures the ease of movement of a particular substance through a particular medium. Higher the diffusion coefficient of the substance with respect to the medium, faster will be its diffusion through the medium. The diffusion coefficient is a characteristic of a substance and depends on the medium.
- Diffusion potential** A potential that develops as a result of diffusion.
- Dimethylsulfide** An organosulfur compound produced by the breakdown of dimethylsulfoniopropionate (DMSP). It is a volatile compound released during cooking of certain vegetables, such as cabbage and beetroot.
- Dimethylsulfoniopropionate (DMSP)** An organosulfur compound found in marine microbes, phytoplanktons, and seaweeds which is broken down to produce two major volatile sulfur products, i.e., methanethiol and dimethylsulfide.
- Dormancy** A period of biological rest in an organism's life cycle when growth, development, and metabolic activity are temporarily stopped.
- Dry matter** A measure of the mass of a plant or animal tissue after complete drying. In plants, dry matter mainly consists of cell wall (polysaccharides and lignin) and protoplasmic components (proteins, lipids, amino acids, organic acids, and certain ions).

- Effector** Any molecule produced by a pathogen that enhances its (pathogen's) ability to overcome basal defense of the plant and enables it to colonize, grow, and reproduce within the host plant.
- Effector-triggered immunity (ETI)** Activation of defense response triggered by the effectors produced by a pathogen.
- Effector-triggered susceptibility (ETS)** Interference or suppression of defense response due to effector molecules resulting in susceptibility in the host.
- EFR protein** A leucine-rich receptor kinase which is a pattern recognition receptor (PRR) for EF-Tu.
- Einstein** A quantity representing one mole of photon.
- Electrochemical gradient** A type of potential energy developed across membrane because of development of gradient of ion and electrical charge across membrane.
- Elicitor** A molecule produced by pathogens which is extrinsic to the metabolism of host and triggers defense response in the host cells upon perception.
- Elongation factor Tu (EF-Tu)** The most abundant highly conserved bacterial protein which acts as a PAMP in *Arabidopsis* and other members of Brassicaceae.
- Embolism** The process of obstruction of the xylem elements due to trapping of air and breakage of water column in the vessels or tracheids.
- Embryogenesis** The development of a fully mature embryo from a zygote after effective fertilization (zygotic embryogenesis) or from a somatic cell (somatic embryogenesis).
- Emerson enhancement effect** The synergistic effect of deep red (680 nm) and far-red light (700 nm) on the rate of photosynthesis as compared with the sum of rates when the two wavelengths are delivered separately.
- Endoamylases** A glucanohydrolase that hydrolyzes internal glycosidic bonds in high molecular weight oligosaccharides. For example, α -amylases hydrolyze internal α -1,4 glycosidic linkages in starch, dextrans, and glycogen.
- Endomembrane system** The system composed of different membranes suspended in the cell cytoplasm which facilitates exchange of molecules by diffusion or transport vesicles. It consists of nuclear envelope, ER, Golgi, plasma membrane, vacuole, and various secretory vesicles.
- Endophyte** An organism which lives within a plant for a significant part of its life cycle asymptotically without causing any disease, for example, [arbuscular mycorrhizal fungi](#) which live as fungal endophytes within plants.
- Endopolygalacturonase** Enzyme that catalyzes the fragmentation and solubilization of homogalacturonan (major component of primary cell wall). It is secreted by plants and fungal and bacterial pathogens to facilitate invasion into plant tissues.
- Endosomes** Intracellular membrane-bound vesicles created by endocytosis which function in the delivery of internalized material (through endocytosis) to the inside of the cell and transport of materials from Golgi apparatus to vacuoles and lysosomes. They increase the membrane area available for signaling interaction. Migration of endosomes by cytoplasmic streaming also enables their proximity to the nucleus to evoke a signaling response.

- Endospermous seeds (or albuminous seeds)** Seeds in which endosperm persists even after they mature and serves as storage tissue, for example, cereal grains.
- Energy fluence** A measure of the total amount of energy incident on unit area (unit = $\text{J}\cdot\text{m}^{-2}$).
- ENOD (early nodulins)** Nodule-specific proteins synthesized by the plant significantly earlier during the process of nodulation (much before the expression of *nif* and *fix* genes).
- Entrainment** The phenomenon of synchronization or alignment of internal circadian rhythm to external cue, for example, entrainment of circadian rhythms to light-dark cycle.
- Epigenetics** Stable and heritable covalent modification of DNA, RNA, or protein molecules which result in the changes of function without altering their primary sequences.
- Epinasty** The phenomenon of downward curvature of plant parts, such as leaves, that occurs when the upper side of the petiole grows faster than the lower side. It is also exhibited by petals of a flower.
- Epiphytes** Plants which grow harmlessly on or attached to other plants for the physical support and derive the moisture and nutrients usually from the air, the rain, or the debris that collect on the supportive plant, for example, orchids.
- Epistatic gene** A gene that masks the expression of other genes.
- Epithem** The tissue surrounding the hydathodes. The cells of epithem are isodiametric in shape, are loosely arranged, have few or no chloroplasts, and enclose lot of intercellular spaces filled with water.
- Equilibrium constant (K_{eq})** The constant expressing the ratio of products to reactants at equilibrium during a reaction.
- Equilibrium** A state in which there is no net change in the concentration of reactants and products over time.
- Ergosterol** A sterol found in cell membranes of fungi but absent in animals. Its function in membrane fluidity in fungi is similar to that of cholesterol in animal cells. It was first isolated from ergot which is the common name for members of the fungal genus *Claviceps*.
- Essential elements** The nutrients or elements necessary for the growth and development of a plant, for example, nitrogen, phosphorus, potassium, calcium, and magnesium. These are integral part of structure and metabolism of plants and their deficiency results in abnormal growth characterized by a set of deficiency symptoms.
- Exoamylase** A glucanohydrolase that hydrolyzes glycosidic bond near the nonreducing end of high molecular weight oligosaccharides. For example, β -amylase hydrolyzes terminal α -1,4 glycosidic linkages in starch, dextrans, and glycogen, releasing successive maltose units from the ends.
- Expansins** A group of nonenzymatic proteins occurring in plant cell walls which cause cell wall loosening in response to acidic pH and facilitate cell wall extension.

- Export (ref. photoassimilate translocation)** The movement of photoassimilates in the sieve elements away from the source tissues (e.g., from leaf to stem and root).
- Extensins** A group of hydroxyproline-rich glycoproteins present in the cell wall which are involved in the cell wall growth and expansion of cell.
- Extracellular matrix (ECM)** A collection of extracellular molecules secreted by cells that provides structural and biochemical support to the surrounding cells.
- Facilitated diffusion** A passive movement of specific solutes with the help of membrane transporter proteins whereby they diffuse across the membrane according to their concentration gradient without the use of energy. It involves the activities of uniporters and ion channels.
- Facultative parasites** Parasites which adopt parasitism but are able to complete their life cycle and survive on their own in the absence of host plant.
- Feed-forward regulation** Control of a metabolic pathway by a metabolite that acts in the same direction as the metabolic flux.
- Feedback regulation** A regulatory mechanism in which output of a process is used as an input to control the behavior of the process either in a positive or negative way.
- Ferredoxin reductase/oxidase** Enzyme responsible for reduction of Fe^{3+} to Fe^{2+} on the surface of the plasma membrane of the root cells.
- Ferredoxin** A small, water-soluble iron-sulfur (Fe-S) protein involved in electron transport in photosystem I (PS I).
- Ferritin** An iron-storage protein localized in plastids which is involved in the buffering of iron in chloroplasts.
- Fe-S proteins** Proteins having iron-sulfur clusters, which are involved in electron transport without themselves undergoing any significant structural changes.
- Fick's law of diffusion** A law stating that the rate of diffusion is directly proportional to the concentration gradient. It depends on the medium in which diffusion takes place.
- Filiform apparatus** A convoluted, thickened cell wall forming fingerlike projections that increases the surface area of the plasma membrane at the extreme micropylar end of a synergic cell.
- Flavocytochromes** Protein that contains both flavin and heme groups as cofactors. The flavin can be flavin adenine dinucleotide (FAD) or flavin mononucleotide (FMN), and the heme is usually heme-*b* or heme-*c*.
- Flavonoids** A class of plant secondary metabolites whose structure is similar to flavones. They consist of two phenyl rings and a heterocyclic ring that can be abbreviated as C6-C3-C6. They serve various functions in plants such as imparting color and fragrance to flowers and fruits, photoprotection, detoxification of harmful compounds, and antioxidants and also act as allelopathic and antimicrobial compounds.
- Fig22** A 22-amino acid flagellin peptide which has a core domain necessary for binding. It determines the specificity of the flagellum in eliciting the immune response.

- Floral meristem-identity genes** Genes encoding products which are responsible for development of individual whorls in a flower based on the pattern in which they are expressed.
- Floral pathway integrator genes** Genes whose expression transmits the environmental and endogenous signals in response to flowering time to enable adaptation to changing environmental factors such as light and temperature.
- Florigen** A hypothetical hormone which is synthesized by the leaf and translocated to the shoot apex to induce flowering under inductive conditions.
- FLOWERING LOCUS C (FLC)** A gene whose product inhibits flowering in *Arabidopsis* by repressing the activity of flowering promoting genes, namely, *FLOWERING LOCUS T (FT)*, *FLOWERING LOCUS D (FD)*, and *SUPPRESSOR OF OVEREXPRESSION OF CONSTANS 1 (SOC1)*.
- FLOWERING LOCUS T (FT)** A key floral signal that promotes the transition from vegetative growth to flowering in *Arabidopsis*.
- Fluence** A measure of the quantity of radiant energy in terms of number of photons falling on a small sphere, divided by the cross section of the sphere. It is expressed either as photons or quanta (in moles, mol) or as amount of energy (in Joules, J).
- Fluorescence** The emission of light photons produced by certain compounds during a relatively slow process of return of electron from first excited singlet state to ground state upon absorption of light of a shorter wavelength. The emitted photon has lower energy than its excited form, and thus emission is in longer wavelength range. For example, chlorophyll, a molecule in solution, when excited by blue light absorption (430 nm), emits red fluorescence at 663 nm.
- Frataxin (FH)** A mitochondrial protein involved in making Fe-S clusters and biosynthesis of heme. It is a highly conserved protein which is required for efficient regulation of cellular iron homeostasis.
- Free space** Cell wall fraction of roots outer to Casparian strips in the endodermis which allows unhindered movement of water and solutes from soil by diffusion.
- Fungal chitin** Fragments of the fungal cell wall formed by the degradation of chitin (main component of fungal cell wall) via the action of chitinase released from plant cells during fungal infection. It acts as pathogen-associated molecular pattern (PAMP), and its recognition results in the activation of defense signaling pathway in the host cell.
- Fusicoccin** A diterpenoid glycoside produced by the fungus *Fusicoccum amygdali*. It activates the H⁺-ATPase (proton pump) on the plasma membrane.
- Futile cycles** Two metabolic pathways running in opposite directions simultaneously with no net gain and dissipation of energy.
- G-protein-coupled receptors (GPCRs)** A family of membrane-associated proteins with an extracellular ligand-binding domain, a transmembrane domain, and an intracellular domain that interacts with inactive G-protein trimer. They bind extracellular ligands and transmit the signal via activation of G-proteins.
- G-proteins** A family of heterotrimeric GTP-binding proteins involved in signal transduction, whose activity is regulated by G-protein-coupled receptors (GPCRs).

G-proteins consist of three subunits— G_α , G_β , and G_γ . They regulate responses to a variety of stimuli.

GABA (gamma-aminobutyric acid) A non-protein amino acid which gets accumulated in plant cells in response to variety of abiotic and biotic stress factors.

Gametophytic self-incompatibility (GSI) A type of self-incompatibility in which the incompatibility phenotype of the pollen is determined by genotype of pollen grain itself. A pollen will only grow in a pistil that does not contain the same allele. It occurs in members of Solanaceae, Rosaceae, and Liliaceae.

Gating The conformational shifts between permeable (or open) and non-permeable (or closed) states of ion channels. Gating is controlled either by voltage or ligands (chemicals that bind to channel proteins), such as hormones, Ca^{2+} and G-proteins, and pH.

Geitonogamy The process of transfer of pollen onto the surface of stigma of a flower present on the same plant.

Gene for gene model A model for plant-pathogen interactions which explains the relationship between genes which encode effector molecules in pathogens and the genes that encode resistance proteins in hosts.

General elicitor An elicitor which is able to induce general resistance in both host and nonhost plants and is not different in its effect on different plant species.

Gerontoplasts Plastids found in senescing tissue exhibiting structural modification of thylakoid membrane with simultaneous formation of plastoglobuli with lipophilic materials.

Gibberellins A group of plant hormones which are tetracyclic diterpenoid acids and involved in the promotion of growth. They are known to stimulate cell elongation and influence various developmental processes like stem elongation, seed germination, dormancy, flowering, sex expression, enzyme induction, and leaf and fruit senescence.

Girdling Removal of a ring of bark from woody stem of a tree or shrub that severs the vascular system resulting in restriction of transport of nutrients between roots and aerial parts such that the aerial parts above the girdle become dead.

Globulins A major class of storage proteins in seeds which are rich in lysine. It is a source of nutrition for young embryo during seed germination.

Gluconeogenesis A metabolic pathway that results in the generation of glucose from noncarbohydrate carbon sources such as pyruvate.

Glucosinolates A subclass of secondary metabolites which are sulfur- and nitrogen-containing glycosides. They are particularly abundant in members of Brassicaceae. Breakdown of glucosinolates releases compounds such as isothiocyanate and nitrile which are responsible for plant defense against herbivory.

Glutamate-like receptors A highly conserved family of ligand-gated ion channels present in mammals and plants. They play roles in plant defense mechanisms.

Glutathione A tripeptide which is a non-specific reducing agent in the cell and is an important antioxidant in plants, animals, fungi, and certain bacteria.

- Glycophytes** Terrestrial plants which are unable to tolerate high concentration of salt.
- Glyoxylate** A two-carbon acid aldehyde which is an intermediate in the glyoxylate cycle.
- Glyoxylate cycle** A pathway of conversion of acetyl-CoA to succinate that occurs in glyoxysomes.
- Glyoxysomes** Specialized peroxisomes which harbor enzymes of glyoxylate cycle. These are found in fat storage tissues of germinating seed where they serve as sites for hydrolysis of fatty acids into acetyl-CoA by β -oxidation.
- GOGAT** Refers to glutamine oxoglutarate aminotransferase which, in association with glutamine synthetase, is crucial for assimilation of ammonia. It catalyzes the synthesis of two molecules of glutamate from glutamine and 2-oxoglutarate. It is also known as glutamate synthase.
- Grana lamellae (sing. granum)** The unstacked thylakoid membranes that connect grana.
- Granum (pl. grana)** Stacked thylakoid membranes in the chloroplast.
- Gravitational potential (ψ_g)** A measure of the influence of gravity on water potential of a system. It is measured in terms of the energy a substance possesses under the influence of gravity.
- Gravitropism** A differential growth response to gravity, either in the direction of gravity (positive geotropism) as shown by roots or in the opposite direction (negative geotropism) as shown by shoots.
- Green leaf volatiles** Volatile organic compounds released when plants suffer from tissue damage.
- Green manure** Refers to the manure generated from crop plants by leaving them to wither and get incorporated into the soil, either uprooted or still rooted in the soil. The crop plants that are employed as green manure crops can be either non-leguminous (e.g., wheat, mustard, and carrot) or leguminous (e.g., riverhemp, sannhemp, fenugreek, and crimson clover).
- Green window** Visible light spectrum not absorbed by green algae growing on top of the ocean such that the light reaching the deeper part of ocean mainly consists of green light.
- Growth** Increase in a measured parameter or attribute of a cell, tissue or organism as a function of time.
- GTPase-activating proteins (GAPs)** A family of regulatory proteins that inactivate GTPases by promoting GTP hydrolysis to GDP. For example, GAPs of heterotrimeric G-proteins inactivate the GTPase of the activated G-protein by promoting GTP hydrolysis, thereby switching off the signaling event.
- Guanine nucleotide exchange factors (GEFs)** A family of regulatory proteins that activate inactive GTPases by replacing GDP with GTP, for example, GEFs of heterotrimeric G-proteins which activate the GTPase of the inactivated G-protein by replacing GDP with GTP, thereby switching on the signaling event.
- Guttation** The process of extrusion of liquid droplets comprising xylem sap from tips or the margins of the leaves through special structures called hydathodes. It is common in grasses and small herbaceous plants like strawberry and tomato.

- Guttation burn** Leaf burn at the margin of leaves caused due to salts and minerals present in the droplet of water that remain after the evaporation of the liquid.
- Halophytes** Salt-tolerant plants which can grow at considerably high concentrations of salt, for example, *Spartina alterniflora* and *Salicornia*.
- Harvest index** Ratio of dry weight of harvestable part (economically important) of the plant to the total dry weight of the plant.
- Haustorium** Specialized sucking roots of a parasitic plant or a specialized branch of fungal hyphae formed inside a living cell of the host plant to obtain nutrients.
- Haustorium initiation factors (HIFs)** Host root-derived haustorium-inducing chemicals which trigger initiation of haustoria in the parasitic plants.
- HC toxin** A fungal toxin produced by *Cochliobolus carbonum* which is involved in inducing pathogenesis. It is a cyclic peptide which inhibits the activity of enzyme histone deacetylase in maize plants.
- Heading-date1 (Hd1)** A gene found in rice which is homologous to *CONSTANS* and inhibits flowering.
- Heading-date3a (Hd3a)** A gene which stimulates flowering in rice. It is translocated via sieve tubes to the apical meristem.
- Heartrot** A symptom of boron deficiency occurring in plants, such as sugar beet, carrots, and turnips, whereby the young leaves turn black and die, resulting in a rosette of small dead leaves. The root becomes dark in the center due to death of tissue.
- Heat shock proteins (HSPs)** A set of proteins that are synthesized as a generalized physiological response in both prokaryotic and eukaryotic organisms to high temperature stress. These act as molecular chaperones to assist synthesis and folding of proteins.
- Heliotropism (or sun tracking)** Continuous adjustment of the orientation of leaves or other parts of a plant in the direction of sunlight such that their surfaces are perpendicular to sun rays and receive maximum light. For example, leaves of cotton, alfalfa, soybean, and lupine as well as young inflorescence of sunflower exhibit heliotropism.
- Heme** The iron-porphyrin prosthetic group of many heme proteins.
- Hemibiotrophic parasite** A pathogen that is initially parasitic (biotrophic) but over time leads to the death of the host tissue (necrotrophic), for example, *Phytophthora infestans* that causes late blight of potato.
- Hemiparasites** Parasites which rely partially on their host plants for resource acquisition but are able to photosynthesize, for example, mistletoe.
- Herbicides** Chemical substances used to kill the unwanted plants while leaving the desired crop rather unharmed, for example, 2,4-D and glyphosate.
- Herbivore-associated molecular patterns (HAMPs)** Molecules derived from herbivores which function as signal for triggering plant defense responses, for example, fatty acid-amino acid conjugates (FACs).
- Herbivore-induced plant volatiles** Volatile organic compounds produced by plants in response to herbivory.

- Herbivory** Feeding by animals on plant material. It includes different types of feeding strategies, such as sap-sucking, cell-content feeding, wood boring, leaf-mining, feeding on fruits, spores, etc.
- Heterostyly** The condition of having two or three different floral morphs characterized by different length of stamens and pistils. For example, it occurs in *Primula* and *Linum*.
- Heterotropic allosteric modulation** Allosteric regulation in which molecules other than substrate act as modulator of the activity of the enzyme. For example, ATP and CTP are heterotropic effectors of aspartate transcarbamoylase, acting to activate and inactivate the enzyme, respectively.
- Hexose monophosphate pool** The intracellular pool consisting of hexose monophosphates, i.e., glucose 1-phosphate, glucose 6-phosphate, and fructose 6-phosphate, which are interconvertible and can be removed or added to the pool according to the need in the cell.
- Histidine kinase receptors** Receptor proteins for signaling molecules which are multistep derivatives of bacterial two-component system. They may be membrane associated or soluble and exist as dimers. They play key roles in the two-component signal transduction and function via autophosphorylation.
- Histogenesis** A series of organized, integrated processes by which cells of the primary germ layers of an embryo differentiate and assume the characteristics of the tissues into which they will develop.
- Hoagland's solution** A nutrient solution used for plants that consists of all the essential elements which are necessary for growth of nearly all plants in a defined proportion. It was developed by D.R. Hoagland in 1933.
- Holoenzyme** A functionally active enzyme protein conjugated with cofactor (if any).
- Holoparasites** Parasites which are completely dependent on their host plants for photosynthates, water, and minerals.
- Homeostasis** Regulation of endogenous levels of biomolecules such as plant growth regulators, ions, and other molecules through modulation of their biosynthesis, catabolism, sequestration, conjugation, efflux/influx, and release from internal stores, such as ER and vacuoles.
- Homeotic genes** A set of genes responsible for development of specific organs and regulation of anatomical structures in various organisms. They encode transcription factors that regulate the expression of target genes and lead to establishment of pattern. Mutations in these genes result in displaced body parts.
- Homotropic allosteric modulation** Allosteric regulation in which substrate acts as modulator of the activity of the enzyme. For example, aspartate is a homotropic effector of aspartate transcarbamoylase.
- Horizontal resistance** Resistance that acts against a wide range of pathogens. It is also called polygenic resistance as it is governed by multiple genes.
- Hormone receptor** A hormone-binding protein which brings about a physiological effect after interacting with the hormone.

- Hormone sensitivity** The extent of response to a hormone. Sensitivity to a hormone depends on the concentration of hormone at the site of action and the abundance of receptor and hormone—receptor affinity.
- Humus** A dark, colloidal carbonaceous (organic) residue formed in the soil by the microbial decomposition of plant and animal tissues. It acts as a nutrient reservoir and increases soil fertility.
- Hydathodes** The specialized pores in the epidermal layer normally found at the tip and margins of the leaves, which are surrounded by a special parenchymatous tissue, called epithem. They are involved in extrusion of xylem sap in the form of droplets.
- Hydraulic conductance** The property which describes the ease with which a fluid (usually water) can move through pore spaces of a material. For example, the leaf hydraulic conductance represents the capacity of the water transport system in leaves.
- Hydraulic lift** The lifting of water from deep moist layers to shallow drier layers of soil by large woody trees. It influences the water content of the rhizosphere and delays the drying of soil.
- Hydraulic resistance** The property which describes the resistance faced by a fluid (usually water) while moving through porous spaces, for example, hydraulic resistance to bulk flow of water moving through the xylem elements.
- Hydroponics** A technique of growing plants in absence of soil in which roots of the plants are exposed to a nutrient solution consisting of all essential elements.
- Hydrotropism** Plant growth or movement determined by gradient of water.
- Hydroxyproline-rich glycoproteins (HRGPs)** A group of glycosylated hydroxyproline-rich proteins which are major constituents of plant cell walls rich in hydroxyproline. They contain arabinose and galactose in the attached oligosaccharides chains.
- Hygrometer** An instrument to measure moisture content in the atmosphere.
- Hyperaccumulators** Plants which accumulate high concentrations of metal elements from soil and store them in their aerial tissues. These are capable of growing in soils with high concentration of metals and can be used for phytoremediation, for example, *Agrostis castellana*, which is a hyperaccumulator of arsenic, manganese, lead, and zinc.
- Hypersensitive response** A localized response of plant cells to microorganisms characterized by rapid death of the infected cells and the cells surrounding the site of infection so as to prevent further invasion in adjacent cells. The invasion of pathogen is restricted due to deprivation of nutrients.
- Hypertonic solution** The solution with a higher concentration of solutes relative to that of another solution separated by semipermeable membrane. There is a movement of water into the hypertonic solution from the hypotonic solution across the membrane.
- Hyponasty** A nastic movement which involves upward bending of organs, such as leaves, petals, and petioles, caused by increased growth on their lower surface as compared to the upper surface. For example, young flowers remain tightly closed as a result of hyponasty.

- Hypotonic solution** The solution with a lower concentration of solutes relative to that of another solution separated by semipermeable membrane. There is a movement of water from the hypotonic solution into the hypertonic solution across the membrane.
- Hypoxia** A condition in which cells or tissues are deprived of oxygen.
- Ice nucleation active (INA) proteins** A family of proteins that promote nucleation of ice at relatively warm temperature by promoting alignment of water molecules (above -5°C). These proteins are localized on the outer surface of the membrane and can cause frost damage to many plants.
- Imbibition** The process by which the molecules of a liquid or gas diffuse into a solid substance causing it to increase in volume, for example, swelling of raisins and dry seeds in water.
- Immobile elements** Elements which upon absorption from soil cannot be relocated from the older to newly formed leaves, for example, calcium, iron, and copper. Plants deficient in immobile elements exhibit symptoms in the growing region, while the old leaves remain unaffected.
- Impaction** A process in which seeds with hard seed coat are subjected to vigorous shaking in order to remove the corky outgrowth blocking the opening for gaseous exchange.
- Import (ref. photoassimilate translocation)** The movement of photoassimilates through sieve elements into sink tissue.
- Incipient plasmolysis** The point at which the protoplast begins to pull away from the cell wall marking initiation of plasmolysis. However, for the estimation of osmotic potential of the cell, incipient plasmolysis is considered to have occurred when 50% of the cells have become plasmolyzed.
- Incompatible disease reaction** An interaction between host and pathogen with minimum effect on the host where symptoms are not expressed clearly.
- Indeterminate growth** Unrestricted or unlimited growth, as with a vegetative apical meristem that produces an unrestricted number of lateral organs indefinitely.
- Induced systemic resistance (ISR)** Ability of selected strains of plant growth-promoting microbes, like *Pseudomonas*, *Rhizobacteria*, *Bacillus*, and mycorrhizal species, to suppress the infection of disease-causing pathogens by providing systemic resistance.
- Inducible defense** The activation of defense mechanism after interaction with pathogen.
- Innate immune system** Refers to the immunity in the cell that occurs naturally because of genetic factors or physiology and is not caused by infection or vaccination. It is readily mobilized to fight microbes at the site of infection.
- Integument** The natural covering which forms a tough protective layer around the ovule. After the egg cell is fertilized, integument forms the seed coat.
- Intermediary cell** A type of companion cell with several plasmodesmata connecting the surrounding cells, particularly the adjacent bundle sheath cells.

- Intermediary metabolism** Combined activities of all metabolic pathways involved in interconversion of precursors, metabolites, and products of a pathway resulting in the formation of a series of intermediate compounds.
- Interveinal chlorosis** The yellowing of green leaf tissue between the veins.
- Ion channels** Integral membrane proteins which form a passageway for passive flow of ions according to a concentration gradient. They are driven solely by electrical potential difference across the membrane.
- Ionophores** Compounds capable of binding with metal ions and carrying them across the membrane. For example, valinomycin is known to facilitate transport of potassium ions across membranes.
- Iron-regulated transporters (IRT1)** Transporters localized in plasma membrane which are mainly responsible for iron uptake from roots.
- Irradiance** The flux of energy per unit area on a flat surface (units = $W.m^{-2}$).
- Isoamylase** A debranching enzyme which acts on α -1,6 glycosidic linkages in high molecular weight branched oligosaccharides, such as glycogen and amylopectin. It removes branches that are very close to other branches. It accelerates crystallization of nascent amylopectin molecule during starch synthesis.
- Isoprene** An unsaturated pentahydrocarbon (2-methyl-1,3-butadiene) derived from phenylpropanoid pathway which serves as the basic structural unit in terpene structure.
- Isotonic solution** Two solutions separated by a semipermeable membrane having same concentration of a solute in them. There is no net movement of water.
- JA receptors** F-box proteins which target downstream JAZ (JASMONATE ZIM DOMAIN) family of negative transcriptional repressors for degradation, thereby activating the expression of JA-sensitive genes.
- Jasmonic acid (JA)** A lipid-derived signaling molecule derived from α -linoleic. It participates in the regulation of a number of plant processes, including growth, reproductive development, photosynthesis, and responses to biotic and abiotic stress factors.
- Karrikins** A class of butanolide compounds derived from burnt plant material which can stimulate seed germination in a number of plants.
- Kranz anatomy** Wreath-like arrangement of mesophyll cells around the vascular bundles, forming a bundle sheath. This anatomical feature is typical of C4 plants.
- Late embryogenesis abundant (LEA) proteins** A family of hydrophilic and thermostable proteins which perform protective function against desiccation and oxidative stress. They have the ability to form viscous liquid with very slow diffusion and limited chemical reactions by forming hydrogen bonds with sucrose. They prevent other proteins from aggregation.
- Lateral heterogeneity** Unequal distribution of the components of photosynthetic electron transport systems in thylakoid membrane.
- Law of minimum** A law (proposed by Liebig) which states that yield is proportional to the amount of the most limiting nutrient and the growth is impaired if it is deficient even when all the other nutrients are available. If the deficient nutrient is

supplied, yield is improved, but then some other nutrient may become limiting, and now the law of minima will be applicable to that nutrient.

Leaf stomatal resistance The resistance offered by guard cells on the exchange of carbon dioxide and water vapor through stomata.

Lectins Carbohydrate-binding proteins.

Leghemoglobin An oxygen carrier protein having chemical and structural similarity to hemoglobin present in humans. It is produced by the leguminous host plants in response to the symbiotic association with rhizobia. It facilitates the transport of oxygen for the respiration of symbiotic bacteria.

Ligand A molecule that binds to another (usually larger) molecule.

Light-harvesting complex (LHC) Antenna pigment-protein complex associated with photosystems which absorbs and funnels light energy to the reaction center.

Lignin A complex branched polymer of phenolic alcohols associated with cellulose in cell walls, especially deposited in the secondary walls and thickenings in the xylem elements. It is responsible for providing mechanical strength to plants. It is a type of phenylpropanoid.

Liming Treating soil with calcium and magnesium rich materials to reduce acidity and improve fertility or oxygen levels.

Limit dextrinase or R-enzyme An enzyme that hydrolyzes α -1,6 glycosidic bonds in amylopectin and branched dextrans.

Lipase An enzyme that hydrolyzes triglycerides into glycerol and fatty acids. It is generally found in germinating oil seeds.

Lipid transfer proteins A group of highly conserved proteins of about 9 kDa found in tissues of higher plants which are responsible for shuttling of phospholipids and other fatty acid groups between cell membranes. They possess a tunnelloid hydrophobic cavity which facilitates the binding of lipids.

Lipidome Complete lipid profile within a cell.

Lipidomics Large-scale study involving structures, pathways, and networks of cellular lipids in biological systems. It is a subset of metabolome.

Lipo-chitooligosaccharides (LCOs) Signaling molecules made up of acylated oligosaccharides that are released by rhizobia. They play a key role in the initiation of symbiosis between the legume and the symbiotic bacteria.

Liposomes Small spherical vesicles consisting of at least one phospholipid bilayer which are formed spontaneously when phospholipids are suspended in an aqueous buffer.

Lipoxygenase A family of non-heme iron enzymes that catalyze the oxidation of polyunsaturated fatty acids and lipids containing a *cis,cis*-1,4-pentadiene structure.

Lodging Displacement of stem or roots of grain crops from their vertical and proper placement which makes them difficult to harvest and significantly reduces yield.

Long-day plant A plant which flowers only in long days when the day length exceeds the critical day length, for example, spinach, lettuce, sugar beet, cabbage, and henbane.

- LUREs** Cysteine-rich polypeptides secreted from synergid cells that attract pollen tubes.
- Lycopene** A type of carotenoid pigment responsible for red color of fruit and vegetables.
- Lysimeter** An instrument to measure the amount of evapotranspiration in plants.
- Lysophosphatidate** A phospholipid derivative that can act as a signaling molecule in different signaling cascades.
- Lysophospholipids** Lipid molecules derived from the action of phospholipase A on fatty acids. They consist of a single carbon chain and a polar head group and are more hydrophilic than their corresponding phospholipids.
- Macroelements or macronutrients** Essential elements, for example, hydrogen, carbon, oxygen, nitrogen, potassium, calcium, magnesium, phosphorus, and sulfur, which are required in relatively large amounts for a plant to grow and remain healthy. They are present in plant tissue in quantities ranging from 0.2% to 4.0% of its dry weight.
- MAP kinases (MAPKs or mitogen-activated protein kinases)** Highly conserved family of serine/threonine protein kinases which are major components of signaling cascades in response to a variety of stimuli regulating developmental processes like embryogenesis, proliferation, and death.
- Matric potential (ψ_m)** A component of water potential expressed as the adsorption affinity of water to colloidal substances and surfaces in the plant cell, such as plasma membrane, and soil particles.
- 1-MCP (1-methylcyclopropane)** A cyclopropane derivative used as a synthetic plant growth regulator which inhibits ethylene biosynthesis.
- Melatonin (or N-acetyl-5-methoxytryptamine)** A tryptophan-derived indoleamine which is pleiotropic in function and affects various plant physiological processes and also acts as a potent ROS scavenger.
- Metabolic channeling** Direct transfer of biosynthetic intermediates from one enzyme to another in a pathway minimizing their diffusion.
- Metabolic flux** Rate of turnover of metabolites in a particular metabolic pathway in a biological system or the movement of metabolites in a pathway.
- Metabolic plasticity** The capacity of plants to alter their metabolism when subjected to any kind of stress essential for their survival.
- Metabolic redundancy** A feature of metabolism of an organism whereby different pathways serving a similar function are operating and, therefore, can be replaced by each other without apparent loss in function. It is a common feature in plant metabolism.
- Metabolism** All the chemical reactions involved in maintaining the living state of a cell and an organism as a whole leading to production of energy, synthesis of new materials, and breakdown of others.
- Metabolites** Any substance produced in one of the various metabolic pathways or chemical intermediates taking part in the enzyme-catalyzed reactions taking place during metabolism.

- Metabolons** A temporary structural-functional complex formed as a result of close association among sequential enzymes of a metabolic pathway held together by non-covalent interactions and with the help of other proteins and cytoskeleton. This assembly permits the direct channeling of metabolites between the enzymes.
- Metallochaperone** A family of proteins involved in the movement of metal ions to target sites in a cell.
- Metallothioneins** A family of cysteine-rich proteins that bind metals using thiol groups. They are localized in the membrane of Golgi apparatus.
- Methanogens** Microorganisms which produce methane as a byproduct of metabolism under anoxic conditions, for example, *Methanobacterium*, *Methanospirillum*, and *Methanococcus*.
- Methionine sulfoximine (MSO)** An irreversible inhibitor of glutamine synthetase. It binds to the glutamate binding site and undergoes phosphorylation resulting in an irreversible non-covalent inhibition of the enzyme.
- Methylerythritol phosphate (MEP) pathway** The pathway involved in terpene biosynthesis. It leads to formation of isopentyl diphosphate (IPP) in plastids from glyceraldehyde 3-phosphate and pyruvate.
- Mevalonic acid pathway** The pathway involved in terpene biosynthesis. It leads to a stepwise condensation of three acetyl-CoA molecules to form mevalonic acid.
- MFS (major facilitator superfamily) transporters** A subfamily of membrane transport proteins that facilitate movement of small solutes across cell membranes in response to chemiosmotic gradients.
- Mg-protoporphyrin** Any plant porphyrin having magnesium in the center of the ring.
- Michaelis-Menten constant (K_m)** A constant value representing the substrate concentration at which the velocity of enzyme-catalyzed reaction is half of the maximum velocity. It gives a measure of the binding affinity of a given enzyme with its substrate (unit = mM).
- Microbial-associated molecular patterns (MAMPs)** Highly conserved molecules produced across large groups of pathogens as well as nonpathogenic microbes which are indispensable for their survival, for example, flagellin, elongation factor Tu (EF-Tu), chitin, lipopolysaccharides, and β -glucans.
- Microelements or micronutrient** Essential elements, for example, iron, manganese, boron, molybdenum, copper, zinc, and chlorine, which are required in relatively small amounts or traces for a plant to grow and remain healthy. They are present in plant tissue in quantities ranging from 5 to 200 ppm or less than 0.02% of its dry weight.
- Mitochondrial iron transporter (MIT)** A mitochondrial iron transporter essential for growth and function in rice plants.
- Mitogen-activated protein (MAP) kinase cascade** A series of kinases (proteins which are capable of phosphorylating other target proteins) which, upon binding of a ligand, phosphorylate each other in a defined sequential manner, leading to their activation, for example, MAPK, MAPKK, and MAPKKK. MAPK serves as the anchor of the relay sequence from cell surface to the nucleus.

- Mobile element** Element which upon absorption by the plant from soil can move from old leaves to younger plant parts, for example, nitrogen, phosphorus, and potassium. Plants deficient in mobile elements exhibit symptoms in the older leaves first as these are transported to growing parts.
- Monoculture** The cultivation of a single variety of crop on large scale.
- Monoglycerides** A glyceride in which each glycerol molecule is linked by an ester bond with one fatty acid molecule. It is also known as monoacylglycerol.
- Morphogenesis** The process of origin and development of the physical form and external structure of plants as a result of differentiation of tissues and organs.
- Morphogen** A biomolecule that plays a key role in providing positional cues in certain types of position-dependent development. They determine cell pattern formation in a concentration-dependent manner during morphogenesis. At different concentrations, they lead to different outputs. Typically, morphogens are produced from a source tissue and diffuse in neighboring tissue in an embryo (e.g., among mammals) to affect development.
- Motor cell** A cell which is capable of expanding or contracting, thereby facilitating movement of a plant part. It functions by adjusting the internal K^+ concentration to alter the turgidity.
- Movement protein** A protein encoded by virus genome in plant cell cytoplasm to facilitate the migration of virus from one cell to another through plasmodesmata.
- Multifunctional protein (MFP)** A protein having different catalytic functions residing in separate domains of the same polypeptide chain. For example, peroxisomal multifunctional protein possesses up to four enzymatic activities, each responsible for catalyzing a different step in the process of β -oxidation in peroxisome.
- Mutualism** The beneficial interaction between two organisms of different species in which each individual benefits from the activity of the other, for example, mycorrhiza which is a symbiotic relationship between some fungi and plant roots.
- Mycorrhiza** A symbiotic relationship of a fungus growing in association with roots of vascular plants. The fungal partner receives essential nutrients for its growth from the host and, in turn, increases the ability of the plant roots to absorb nutrients by increasing the surface area for absorption.
- Necrosis** Localized death of tissue that occurs in response to various agents including physical injury, exposure to toxins, deficiency of oxygen, and infection by pathogens.
- Necrotroph** Parasitic organism that invades and kills host organism and obtains nutrients from its dead tissues, for example, *Botrytis cinerea* on *Blumeria graminis*.
- Neochrome** A photoreceptor with LOV (light, oxygen, voltage) domain, found in ferns and algae, representing a fusion between phytochrome and phototropin. It has a phototropin-like protein sequence fused with a phytochrome chromophore-binding domain. Neochrome acts as a dual red/blue light photoreceptor. It is involved in regulation of chloroplast movement in *Mougeotia*, a filamentous green alga.

- Nitrite oxidoreductase** A membrane-bound enzyme involved in nitrification, containing iron-sulfur and molybdenum as the cofactors. It is present in the membranes of nitrifying bacteria, like *Nitrobacter*, and is a part of electron transport chain that channels electrons from nitrite to molecular oxygen.
- Nodulin** An organ-specific plant protein induced during symbiotic nitrogen fixation. It plays both metabolic and structural roles in infected and uninfected nodule cells.
- Non-cell autonomous responses** Signaling events where signal perception and response occur in different cells, for example, transcription and translation of SHORT-ROOT (SHR), a transcription regulator which occurs in cells of stele. The SHR protein moves to endodermis via plasmodesmata where it activates the expression of a cell plate regulator, SCARECROW (SCR).
- Non-climacteric ripening** Fruit ripening without increase in ethylene production and respiratory burst. Fruits, like citrus, grapes, and strawberries, are non-climacteric.
- Noncyclic photophosphorylation** The process of ATP synthesis which occurs as a result of proton gradient created across thylakoid membrane due to noncyclic electron transport involving both the photosystems. It is coupled with photolysis of water, NADP⁺ reduction, and ATP synthesis.
- Non-endospermous seeds** Seeds in which endosperm is consumed during embryo development and does not persist till maturity, for example, pea, bean, and gram.
- Non-photochemical quenching** Harmless dissipation of excess light energy absorbed by plants as heat. It is a protective mechanism against excess light intensity.
- Non-protein amino acids** Unusual amino acids, such as canavanine and azetidine-2-carboxylic acid, which are normally not incorporated into proteins but have a role in plant defense.
- NRAMPs (natural resistance-associated macrophage proteins)** A family of metal ion transporters which play a major role in metal ion homeostasis. It is a novel family of functionally related proteins defined by a conserved hydrophobic core of ten transmembrane domains.
- Nuclear bodies** A cluster of small particles or speckles found in the nucleus which accumulate phy A and phy B. The number and size of these speckles is correlated with light responsiveness.
- Nucleophilic group** An electron-rich chemical species which donates electron to a positively charged species (electrophile) to form a chemical bond.
- Nutrient film technique (NFT)** A hydroponic cultivation technique in which dissolved nutrients required for normal growth of plants are continuously pumped over the roots through a channel or a tube.
- Nyctinasty** A nastic movement of periodic folding of leaves and closing of petals in flowers in response to onset of darkness. It is exhibited by many leguminous plants.
- Obligate parasite** Parasite which fully relies on its host to complete its life cycle and fails to reproduce in the absence of a suitable host.

- Octadecanoid pathway** Biosynthetic pathway for production of jasmonic acid from α -linolenic acid.
- Oleosin** A structural protein found in the phospholipid monolayer of oil bodies in oil seeds, for example, sunflower and soybean.
- Oleosomes** Specialized structures surrounded by phospholipid monolayer (half unit membrane) that serve as oil storage bodies for triacylglycerols in oil-bearing seeds. They are also known as oil bodies or sphaerosome.
- Oligomycin** An antibiotic that inhibits ATP synthesis by blocking channel (F_0) of ATP synthase.
- Organogenesis** Development of organized structures such as shoots, roots, and flower buds from cultured cells or tissues.
- Orthodox seeds** Seeds that can tolerate desiccation and remain viable when stored in a dry state, for example, pea, corn, and tomato.
- Ortho-gravitropism** The phenomenon whereby plant organs adopt vertical orientation with respect to the axis of the plant body in response to gravity.
- Osmolytes** Soluble compounds which affect osmosis in a cell and maintain cell volume and fluid balance, for example, betaine aldehyde and proline.
- Osmometer** An instrument to measure the osmotic strength of a solution.
- Osmoprotectant** A small polar molecule with neutral charge and low toxicity which helps survive extreme osmotic stress by maintaining osmotic balance.
- Osmoregulation** The maintenance of osmotic pressure in a cell or an organism by regulating internal water and solute concentration.
- Osmosensor** A pressure sensor protein on the plasma membrane which is involved in the primary perception of water deficit.
- Osmosis** A biological process in which solvent moves from the region of higher concentration (lower solute concentration) to the region of lower concentration (higher solute concentration) through a semipermeable membrane.
- Osmotic potential or solute potential (ψ_s)** A component of water potential expressed as the influence of dissolved solutes on the water potential of the cell. It is the potential of solute to bring about osmosis in a cell.
- Outcrossing** Cross-pollination of two plants belonging to different genotypes.
- Oxidative burst** Rapid release of reactive oxygen species (ROS), such as superoxide radical, hydrogen peroxide, and hydroxyl radical, within the cell.
- Oxidative deamination** A reaction of amino acid catabolism in which amino ($-NH_2$) group of α -amino acid is released as ammonia, and the amino acid is converted to its respective keto acid. Released ammonia is utilized in urea cycle, for example, conversion of glutamate to α -ketoglutarate catalyzed by glutamate dehydrogenase.
- Oxidative phosphorylation** Synthesis of ATP from ADP and P_i which is coupled with electron transfer from a compound to molecular oxygen.
- Oxidative stress** A stressful condition created as a result of imbalance between the production of free radicals in the body and their detoxification.
- Oxygen Evolving Complex (OEC)** A complex of proteins and manganese ions associated with the reaction center of photosystem II. It is also known as water

splitting complex as it is the site for photooxidation of water during the light reaction of photosynthesis.

Oxygenic photosynthesis A type of photosynthesis in which light-driven ATP and NADPH synthesis occurs in organisms utilizing water as the reductant, and the process is coupled with release of free oxygen.

PAMP-triggered immunity (PTI) The defense mechanism in plants involving recognition of pathogen-associated molecular patterns (PAMPs) present on the cell wall of microbes by the pattern recognition receptors (PRRs) present on the surface of the plant cells.

Paraheliotropic leaves Leaves which utilize heliotropic movement to avoid or reduce light capture in order to reduce the injuries sustained due to intense illumination.

Parasite An organism living in or on another organism (host) to obtain its nutrient supply.

Parthenocarpy Development of ovary into fruit without fertilization thus leading to the development of seedless fruits. It occurs naturally in banana and pineapple.

Passage cells Cells in the endodermis which are devoid of suberin (Casparian band) and allow free passage of water.

Passive transport The spontaneous transport of ions or molecules across a membrane down their electrochemical gradient without the utilization of energy.

Patch clamp An electrophysiological technique used to resolve the ionic activity (in the form of measurement of ion currents) of single or multiple protein molecules (channels) in individual intact cells or patches of membranes as they catalyze ion translocation across membrane.

Paternally expressed genes (PEGs) Genes for which only the paternal alleles are expressed.

Pathogen Disease-causing agent.

Pathogen-associated molecular patterns (PAMPs) Highly conserved molecules produced across large groups of pathogens which are indispensable for their survival. They are recognized by respective PRRs of the host plant.

Pathogenesis The process of infection, colonization, and reproduction of pathogen in the host.

Pathogenesis-related proteins (PR proteins) A group of small proteins encoded by host plants when attacked by pathogens. They function either as antimicrobial agents or initiate systemic defense responses.

Pathogenicity The ability of a pathogen to cause disease.

Pathogenicity gene cluster (*hrp*) Genes that control the ability of type III S bacteria to cause infection and elicit hypersensitive response in the host plant.

Pattern recognition receptors (PRRs) Receptors present in the plasma membrane of organisms which are important constituents of innate immunity system and recognize extracellular pathogens, such as bacteria or fungi via recognition of PAMPs (pathogen-associated molecular patterns), like lipooligosaccharides.

Perception of a signal Sensitization of plant cells to signals by employing sensor proteins (receptors).

- Permeability coefficient** A measure of resistance encountered by the transport of a material through a membrane per unit driving force per unit membrane. It is a constant that depends on pressure difference across the membrane and the size and solubility of molecule to be diffused.
- Peroxidases (POXs)** Heme-containing enzymes that utilize a wide variety of organic and inorganic substrates as electron donors and hydrogen peroxide as the electron acceptor to catalyze a number of oxidative reactions. They prevent cells from oxidative damage by reducing hydrogen peroxide to water.
- Phagophore** A double-membrane structure that encloses portions of cytoplasmic components during macrophagy. They develop via expansion of autophagosome through lipid acquisition.
- Phaseic acid (PA)** An inactive catabolite of ABA formed as a result of spontaneous cyclization of 8'-hydroxy ABA. PA does not exhibit any ABA-like activity. Very recently, however, it has been observed to activate a subset of ABA receptors.
- Phenolics** A subgroup of secondary metabolites which contain at least one phenol group, for example, caffeic acid, lignin, flavonoids, and tannin. They protect plants against herbivores; provide color; thus act as attractants, as UV protectants, and as fungicides; and are allelopathic.
- Phenylpropanoids** Diverse group of compounds derived from the carbon skeleton of phenylalanine.
- Phloem filament protein (PP1)** A phloem-specific protein synthesized in companion cells and transported into the sieve-tube elements. It is present in all developmental stages and forms filaments around the inner wall of sieve-tube elements.
- Phloem lectin protein (PP2)** A phloem-specific protein which is a dimeric lectin and forms the major constituent of phloem sap. It is translocated to sieve-tube elements upon complete maturation. It specifically binds to poly(β -1,4-N-acetylglucosamine) and is involved in formation of filaments along with phloem filament protein (PP1) that plug the damaged sieve elements.
- Phloem loading** The movement of photoassimilates from the mesophyll cells to the sieve elements of leaves via companion cells involving loading of sieve-tube elements.
- Phloem unloading** The movement of photoassimilates from sieve elements into the sink cells which store or metabolize them.
- PHO1** A phosphate transporter which uploads inorganic phosphate into xylem which is then transported from roots to the aerial parts of the plant.
- Phosphatidic acid** Simplest type of diacylglycerophospholipids which upon hydrolysis releases two molecules of fatty acid and one molecule of glycerol. It is a major constituent of membranes.
- Phospholipase A (PLA)** An enzyme responsible for cleaving one of the acyl ester bonds on the phospholipids, thereby releasing a fatty acid from the second carbon of glycerol and a lysophospholipid.
- Phospholipase C (PLC)** An enzyme which hydrolyzes the glycerophosphate bond of a phospholipid molecule to yield diacylglycerol and a phosphorylated head group, such as inositol triphosphate (IP₃).

- Phospholipase D (PLD)** An enzyme of phospholipase superfamily which hydrolyzes phosphatidyl choline to produce signal molecules of phosphatidic acid (PA) and soluble choline. Different phospholipase D isoforms are expressed in different cellular locations in plant tissues at various stages of development.
- Phosphorylation potential** A measure of the energy state of a cell in terms of actual free energy of ATP hydrolysis under intracellular conditions. It is the ratio of concentration of ATP to that of ADP and P_i in the cytosol of a cell.
- Photoblastic seeds** Seeds in which germination is sensitive to light. They are of two types: positively photoblastic seeds (stimulated to germinate in the presence of light), for example, lettuce, and negatively photoblastic seeds (unable to germinate in presence of light), for example, *Phlox*.
- Photochemical reaction center** A part of the photosystem where the first charge separation event occurs and electron of the donor excited molecule is accepted by the primary electron acceptor.
- Photoinhibition** Damage to the photosynthetic capacity of leaves when exposed to excessive light.
- Photomorphogenesis** The developmental response of an organism to the information in light, such as quantity, quality (i.e., the wavelength), and direction, and the relative length of day and night (photoperiod).
- Photon fluence** Total number of photons incident on unit surface area (units = mol. m^{-2}).
- Photonastic response** A type of movement induced by light, such as opening and closing of flowers during day and night, respectively.
- Photonasty** A nastic movement representing the response of a plant organ upon providing light stimulus or changing light intensity.
- Photoperiodism** A biological phenomenon of flowering at specific times of the year in response to changing day length.
- Photophosphorylation** A reaction resulting in synthesis of ATP from ADP and P_i in chloroplasts of photosynthetic cells using the light energy.
- Photoreceptors** Chromophore-containing biomolecules which absorb photons of a given wavelength and use this energy as a signal to initiate a photoresponse.
- Photosynthate or photoassimilate** The transportable forms of sugars or sugar derivatives that are formed during the process of photosynthesis.
- Photosynthetic induction period** Time interval required for the photosynthetic process to establish at constant velocity after the plant has been exposed to light.
- Photosynthetic photon flux density (PPFD)** The flux of light ($\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) of the photosynthetically active radiation (PAR) range, i.e., 400–700 nm incident on unit surface area for a specified amount of time.
- Photosystem I (PS I)** A specialized pigment-protein system that contains chlorophyll 700 in the reaction center and is involved in transfer of electrons from plastocyanin and reduction of ferredoxin. It absorbs maximally in the far-red region of light spectrum. It is also known as plastocyanin-ferredoxin oxidoreductase.

- Photosystem II (PS II)** A specialized pigment-protein system that contains chlorophyll 680 in the reaction center and is involved in capturing of photons and transfer of electrons from water to plastoquinone, with the release of oxygen. It absorbs poorly in the far-red region of light spectrum. It is also known as water-plastoquinone oxidoreductase.
- Phototaxis** Movement of unicellular organisms, like *Chlamydomonas reinhardtii*, toward or away from the direction of light. It is controlled by two rhodopsin-like molecules known as channel rhodopsins (ChR1 and ChR2) located in the eye spot.
- Phototropins** A class of blue light-sensitive flavoprotein photoreceptors containing two LOV (light, oxygen, and voltage) domains in the N-terminus that bind FAD and a serine/threonine kinase domain in the C-terminus. They are primarily associated with blue light responses, like phototropic bending response of shoots. They also modulate stomatal opening, ion transport, chloroplast movement, cotyledon, and hypocotyl growth.
- Phototropism** The process of directional movement of a light-responsive organ or an organism in response to unilateral light, either toward the source of light (positive phototropism) or away from it (negative phototropism), for example, bending of shoots in the direction of light.
- PHT 1** A family of high-affinity H⁺-coupled phosphate symporters.
- Phycobilisomes** Protein complexes containing light-absorbing pigments called phycobilins. They are found in photosynthetic apparatus of cyanobacteria, red algae, and glaucophytes.
- Phyllosphere** The area surrounding plants where microorganisms proliferate.
- Physiology** A study of the activities and functions of cells, tissues, organs, or the whole organism.
- Phytic acid or phytate** A saturated cyclic acid, also known as inositol polyphosphate or hexakisphosphate, which may be found in conjugation with a salt. It is the main storage form of phosphorus in many plant tissues, especially in bran and seeds.
- Phytoalexins** A group of low molecular mass lipophilic compounds produced by higher plants in response to different types of stress factors that act antimicrobial agents, for example, capsidiol.
- Phytochelatins** Oligomers of glutathione found in plants, fungi, and nematodes, which act as chelators. They play an essential role in heavy metal detoxification.
- Phytoferritins** A superfamily of iron-storage and detoxification proteins present in plastids which play important roles in controlling cellular iron homeostasis.
- Phytoliths** Minute silica particles found in the epidermis of many plants, such as *Ficus* and *Artocarpus*.
- Phytosiderophores** Small iron chelators released by members of Poaceae family under iron and zinc deficiency. They chelate iron found in the rhizosphere and make it available to the roots for absorption.
- Phytosulfokines** A group of disulfated pentapeptide growth regulators that are involved in promotion of proliferation of cells.

- Phytotropins** Noncompetitive inhibitors of polar auxin transport, for example, TIBA (2,3,5-triiodobenzoic acid), morphactin (9-hydroxyfluorene-9-carboxylic acid), PBA (pyrenoyl benzoic acid), and NPA (N-1-naphthylphthalamic acid).
- Pigment** A molecule capable of interacting with photons from the visible range of the electromagnetic spectrum and absorbing light of certain wavelength, for example, chlorophyll which gives plants their green color.
- PIN proteins** Transmembrane proteins principally responsible for efflux of IAA across plasma membrane. They are mainly located in the basal region of IAA-transporting cells, mainly xylem parenchyma in both root and shoot, and, thus, cause directional and localized auxin transport.
- Plagiotropy** The orientation of long axis of roots or branches such that they are inclined away from the vertical line.
- Plant growth regulators (PGRs)** Naturally occurring or synthetic compounds which affect metabolic and developmental processes in higher plants, mostly at low concentrations. PGRs include plant hormones, their synthetic analogs, inhibitors of hormone biosynthesis, and blockers of hormone receptors.
- Plant hormones** A group of endogenous organic substances which influence various physiological and developmental processes in plants at low concentrations, for example, auxins, cytokinins, abscisic acid, gibberellins, etc.
- Plasmodesmata** Membrane-lined channels that connect adjacent cells through the cell wall and form a continuity of cytoplasm and a central rod (desmotubule) derived from ER. They allow movement of molecules from cell to cell through symplasm and exhibit size exclusion limit depending on the physiological state.
- Plasmolysis** The process of shrinkage of protoplast of a cell as it pulls away from the cell wall as a result of loss of water.
- Polyamines** A group of low molecular weight nitrogenous compounds which exist in positively charged state at physiological pH and bind to biological molecules bearing negative charge. They are involved in modulating various growth and developmental processes including regulation of organogenesis, embryogenesis, development of flowers and fruits, and senescence.
- Polycomb group proteins** A family of proteins discovered in *Drosophila* that mediate chromatin remodeling which leads to epigenetic gene silencing.
- Polygalacturonase** A hydrolase enzyme that catalyzes the hydrolysis of α -1,4 glycosidic bonds between galacturonic acid residues.
- Polygalacturonase-inhibiting proteins (PGIPs)** Extracellular, defense-related proteins having a leucine-rich repeat (LRR) motif. They are secreted by plants and have the ability to inhibit the pectin-hydrolyzing activity of the pathogen secreted polygalacturonase enzyme.
- Polymer-trapping model** A model that explains the formation and symplastic accumulation of tri-, tetra-, and pentasaccharides in the sieve elements which is commonly observed in the members of Cucurbitaceae and Rosaceae.
- Porphyrin** A complex heterocyclic nitrogenous compound containing four substituted pyrroles covalently joined into a ring, often complexed with a central

metal atom. It forms important constituent of many enzymes and molecules, for example, hemoglobin in human blood.

POT (proton-dependent oligopeptide transporter) A family of transporter proteins which are mainly involved in energy-dependent uptake of small peptides with the concomitant uptake of a proton. It is also known as peptide transporter (PTR) family.

Potometer A device to measure the rate of transpiration by a plant in terms of the rate at which water is drawn by the shoot of a plant.

P-proteins A set of proteins abundant in sieve elements of all dicots and many monocots. Their form (tubular, spheroidal, fibrillar, and granular) is dependent upon the species and maturity of the sieve-tube elements. They are involved in short-term sealing of damaged sieve elements via formation of filaments that plug the pores of the damaged sieve element and block translocation.

Pressure potential (ψ_p) A component of water potential expressed as the hydrostatic pressure of the solution.

Pressure flow model A model explaining translocation of solutes in the sieve elements driven by pressure gradient between source and sink. The pressure gradient is osmotically generated and results from photoassimilate loading at the source and unloading at the sink.

Primary dormancy A type of dormancy in which seeds are viable but are unable to germinate immediately after they are released from the parent plant.

Primary response genes A set of genes whose expression is rapidly upregulated independent of de novo protein synthesis as a part of early response to a stimulus.

Programmed cell death (PCD) The process of activating senescence program in cells, which brings about morphological and biochemical changes leading to cell death.

Prolamins A group of storage proteins having high proline and glutamine content typically found in cereals. In wheat, it is commonly known as gluten which is a complex mixture of 71–78 proteins.

Prosthetic group Inorganic or organic cofactor which is covalently bound to the enzyme protein.

Prosystemin The precursor molecule of 200 residues from which systemin is synthesized at the wounding site by cleavage of the C-terminus.

Protease An enzyme which hydrolyzes protein into smaller chains (peptides) or amino acids. It is also known as peptidase or proteinase.

Protein bodies (or aleurone grains) Highly specialized structures representing dry vacuoles which store proteins and hydrolytic enzymes in the storage tissues of seeds. The storage proteins are synthesized in ER and are co-translationally transported in ER lumen from where they are released into protein bodies after modifications.

Proteinase inhibitors Synthetic drugs which inhibit the activity of various protease enzymes. Proteinase inhibitors produced in some legumes and tomato block the activity of herbivore proteolytic enzymes such as trypsin and chemotrypsin.

- Protoderm** A single-layered meristematic tissue region that gives rise to the epidermis.
- Protonophores or proton translocators** Compounds which facilitate transport of protons across the lipid bilayer of membrane, for example, 2,4-dinitrophenol.
- PUFA (polyunsaturated fatty acid)** A type of fatty acid which has more than one double bond in its hydrocarbon backbone. Different types of PUFA are identified by the position of the last double bond in their structure.
- Pullulanase** A debranching enzyme which hydrolyzes the α -1,6 glycosidic linkages in pullulan (a polymer of maltotriose units) and amylopectin (a polymer of α -glucose units).
- Pulvinus** An enlargement at the base of the petiole of a leaf or petiolule of a leaflet. It has a role in the movement of leaf or leaflet.
- Pumps** Integral membrane proteins which actively transport solutes against their electrochemical gradient using ATP or pyrophosphate hydrolysis as a source of energy. The rate of solute transport by pumps is much faster than that by transporters.
- Pyrethroids** Monoterpene esters having high toxicity against insects. They form components of many insecticides.
- Pyridoxal 5'-phosphate** The active form of vitamin B₆ which serves as a coenzyme for several enzymes primarily involved in amino acid metabolism.
- Quanta (sing. quantum)** Discrete packets of energy contained in photons.
- Quantum flux or photon flux density (PED)** The number of photons of light striking the leaf per unit area per second. It is expressed in $\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, where moles refer to the number of photons (1 mole of light = 6.02×10^{23} photons; Avogadro's number).
- Quiescent center** A region in the apical meristem that has reached a state of relative metabolic inactivity and is capable of resuming meristematic activity upon damage of surrounding cells. It is common in roots.
- Quiescent stage** Suspended growth state of embryo or resting state of seed. Once favorable conditions arrive, seeds are able to germinate.
- Quorum sensing** A mechanism which is a characteristic feature of bacteria involving cell-to-cell communication by release of certain chemical signals which allows them to monitor density of their own strain as well as that of the other bacterial strains in the host tissue.
- Radial micellation** The radial arrangement of microfibrils in guard cells of stomata that facilitates opening and closing of stomatal pore.
- Radicle** The embryonic root which forms the basal continuation of the hypocotyl in an embryo and gives rise to root.
- Raffinose Family Oligosaccharides (RFOs)** A class of water-soluble polysaccharides which are alpha-galactosyl derivatives of sucrose, for example, raffinose (a trisaccharide), stachyose (tetrasaccharide), and verbascose (pentasaccharide). These are formed as a result of sequential addition of galactose units by the action of a set of galactosyltransferases.

- Raphides** Tiny needlelike crystals of calcium oxalate that are found in clusters in specialized cells called idioblasts within the tissues of plants mainly belonging to family Araceae and Commelinaceae.
- Reactive nitrogen species (RNS)** Various nitric oxide-derived products produced during metabolic events in cells. Peroxynitrite (ONOO^-) and peroxynitrous acid are two major reactive nitrogen species.
- Reactive oxygen species (ROS)** Oxygen containing chemically reactive molecules with free electrons, produced as a byproduct of normal metabolism. Incomplete reduction of molecular oxygen forms superoxide anion ($\text{O}_2^{\cdot-}$), which acts as a major precursor for all other ROS, such as peroxides (ROOR), hydroxyl radical (HO^\cdot), and singlet oxygen. ROS can act as signaling molecules at lower concentrations but cause damage to cellular components upon excessive accumulation.
- Recalcitrant seeds** Seeds with relatively high water content and active metabolism at the time of maturity. They lose viability rather rapidly and fail to survive storage, for example, avocado, cacao, coconut, mango, and lychee.
- Receptors** Specialized sensor proteins localized either on the membrane or in cytoplasm which perceive signals, leading to amplification of the cellular response. They play important parts in plant growth, development, and immunity.
- Receptor kinases** A family of protein receptors found in animals which are part of signaling pathways in response to various ligands (e.g., a hormone) and participate in eliciting cellular response by phosphorylating themselves or another target protein majorly at tyrosine residues.
- Receptor-like kinases (RLKs)** A family of putative transmembrane protein receptors in plants which have N-terminal extracellular domain and intracellular C-terminal with kinase activity. They are involved in signaling cascades leading to cellular responses to a variety of ligands in plant cells via phosphorylation of target proteins at serine and threonine residues.
- Rectifying channels** Ion channels which allow flow of ionic current only in one direction, either inward or outward, for example, potassium inward rectifiers and potassium outward rectifiers present in guard cells and a wide variety of other plant cells.
- Red drop phenomenon** A phenomenon characterized by decline in the quantum yield of photosynthesis when light of wavelength beyond 700 nm is absorbed by chlorophyll molecules.
- Reducing sugars** Sugars capable of reducing other compounds due to availability of an aldehyde or ketone groups for oxidation, for example, glucose and fructose.
- Reductive amination** The process by which ammonia is condensed with aldehydes or ketones to form imines, which are subsequently reduced to amines.
- Resistance genes (R-genes)** Genes responsible for regulation of gene expression, thereby providing resistance to a specific group of pathogens in plants. They encode proteins that play key roles in recognizing pathogen effectors (Avirulent proteins).

- Respirasomes** A supramolecular structural-functional complex formed by assembly of two or more different electron-transferring enzyme complexes of respiratory chain.
- Respiratory burst** The rapid and transient release of reactive oxygen species (superoxide radical and hydrogen peroxide) from different types of cells as one of the earliest feature of plant defense strategy against pathogens.
- Response** Biochemical, physiological, or developmental impact of one or more signals perceived and transduced by the sensing cells or tissues.
- Resurrection plants** Plants which can tolerate extreme desiccation and revive quickly under wet conditions in mature state, for example, *Selaginella lepidophylla*.
- Retrotranslocation** The reverse process of translocation.
- Reverse osmosis (RO)** A process by which a solvent moves into the direction opposite to that of natural osmosis through a membrane under the influence of pressure applied. It is used to demineralize or deionize water for making it potable. Pressure is applied on the water containing high amount of salts which forces it to move against the gradient across the semipermeable RO membrane, leaving behind dissolved salts. The water collected by this process has less salt and is safe for drinking.
- Revertants** Seeds produced by mutagenized plants that regain the previously lost ability to germinate after further mutation.
- Rhizosheath** A structure composed of mucilage secreted from plants and adherent soil particles which forms a cylindrical sheath around the root.
- Rhizosphere** The region of the soil around the roots which is influenced by the secretions of the plant roots and by the microorganisms associated with roots.
- Rhizotron** A specially designed camera to monitor the growth of root and its interaction with soil particles in vivo.
- Rieske Fe-S center** A type of protein having two Fe-S clusters in which one of the Fe ion is coordinated by two conserved cysteine residues while the other Fe ion is coordinated by two conserved histidine residues. It acts in many electron transfer reactions including photophosphorylation and oxidative phosphorylation. It is one of the components of cyt bc_1 and cyt b_6f .
- RNA interference** A posttranscriptional process triggered by the introduction of dsRNA in the cell cytoplasm. It is controlled by RNA-induced silencing complex (RISC) leading to gene silencing in a sequence-specific manner.
- Root pressure** The positive hydrostatic pressure (1–2 bars) developed within the roots due to the difference in solute potential between the soil solution and xylem sap. It drives the xylem sap upward into the xylem elements through the plant body.
- ROP (Rho-like GTPases of plants)** A group of plant-specific Rho GTPases that participate in a variety of processes, such as control of the cytoskeleton, vesicle trafficking, and cell growth.

- ROP-interactive CRIB motif-containing proteins (RICs)** Proteins that interact with ROP1 to regulate pollen tube growth and polarity.
- Rubisco (ribulose biphosphate carboxylase/oxygenase)** An enzyme which, in the presence of carbon dioxide, utilizes ribulose 1,5-bisphosphate to produce two molecules of 3-phosphoglycerate and, in the presence of oxygen, produces one molecule each of 3-phosphoglycerate and phosphoglycolate.
- Russetting** A disorder of the fruit skin characterized by microscopic cracks in the cuticle, leading to periderm formation. It is observed in apples and pears.
- S-adenosylmethionine (SAM)** A common co-substrate involved in reactions including methyl group transfers, transsulfuration and aminopropylation. It is an intermediate in ethylene biosynthesis and plays an essential role in production of higher forms of polyamines from diamines like putrescine.
- Scarification** The process of mechanically removing or damaging the hard seed coat around the seeds of plants, such as morning glories, lupine, and sweet pea, to facilitate seed germination.
- Second messengers** A class of intracellular, diffusible small molecules and ions which are rapidly synthesized or released transiently as a concentrated pulse following signal perception by the receptors and modify the activity of target signaling proteins, for example, ROS and Ca^{2+} .
- Secondary active transporters (cotransporters)** Transmembrane proteins which utilize ion gradients established by primary active transport (facilitated by ATP hydrolysis) to move another solute against its electrochemical gradient. Thus, secondary active transporters facilitate the movement of two solutes simultaneously. One solute moves down its electrochemical gradient, whereas the second one moves up its electrochemical gradient. They include symporters and antiporters.
- Secondary dormancy** A type of dormancy which develops once seed is detached from the plant due to change in environmental conditions.
- Secondary metabolism** Metabolism, not directly related with maintaining the life. Products formed during secondary metabolism are called secondary metabolites.
- Secondary metabolites** Compounds which are generally not essential for basic growth or development of plants but are required for their survival in the environment by functioning as defenses against herbivores and microbial infection by microbial pathogens, attractants for pollinators, and seed-dispersing animals and as agents of plant-plant competition.
- Secondary response genes** Genes which bring about delayed response to a stimulus through de novo protein synthesis.
- Seismonastic response (or thigmonastic response)** A nastic response to a stimulus, especially mechanical stimulus, like touch and vibration irrespective of the direction of the stimulus, for example, drooping of leaflets in *Mimosa pudica* in response to touch stimulus and the shutting of Venus flytrap when an insect lands on it.

Self-incompatibility (SI) The inability of the pollen grain to effect fertilization in the pistil of the same flower. It is often induced in plant species to promote outcrossing.

Senescence A sequential process during which cells enter a state of growth arrest along with autocatalysis controlled by environment and genetic constitution of an organism. It is characterized by metabolic changes, such as hydrolysis of macromolecules and pigments.

Senescence-associated genes (SAGs) Genes which are upregulated with onset of senescence.

Senescence-downregulated genes (SDGs) Genes that exhibit decreased expression during senescence.

Serotonin A multifunctional tryptophan-derived indoleamine known to modulate various plant physiological processes including shoot morphogenesis, plant defense responses, and gene expression associated with auxin response pathways.

Short-day plants Plants which flower only when the day length does not exceed the critical day length, for example, chrysanthemum, poinsettias, rice, soybean, tobacco, and *Xanthium*.

Short-distance transport The transport of biomolecules over a distance of two or three cells, for example, the movement of sugars from mesophyll cells to the cells in the vicinity of the veins of the source leaf during the process of phloem loading.

Sieve cells Sieve elements of primitive type which are relatively unspecialized and characterized by narrow pores and absence of sieve plates.

Sieve elements The cells of phloem which transport sugars and other organic compounds throughout the plant body. They refer to both sieve-tube elements in angiosperms and sieve cells in gymnosperms.

Sieve plates Areas generally found in end walls of sieve-tube elements of angiosperms that have larger pores than other sieve areas.

Sieve pores The pores present on sieve elements.

Sieve tube Tubular strands formed by the joining together of individual sieve-tube elements at their end walls.

Sieve-tube elements Sieve elements of advanced type present in angiosperms which are highly differentiated and are characterized by presence of large pores and sieve plates at their end walls.

Signal Any environmental or intracellular input which initiates one or more responses in the cell/plant.

Signal transduction pathway A sequence of biochemical events that involves binding of a ligand (e.g., light or hormone) to a receptor protein, triggering changes in the downstream signaling molecules in the cell, thereby leading to a cellular response.

Singlet state The excited state of a molecule attained on absorption of a photon wherein all the electrons with opposite spins are paired. It has a natural life time of 10^{-9} seconds. Electron spin is zero because both the electrons in an orbital are spinning antiparallel to each other.

- Sink** Any tissue/organ which imports photoassimilates, for example, tubers, bulbs, and roots.
- Sink activity** The rate of uptake of photoassimilates per unit weight of the sink tissue.
- Sink size** The total weight of the sink tissue.
- Sink strength** The competitive ability of a sink to mobilize sugars toward it from other parts of the plant body.
- Siroheme** A heme-like prosthetic group found in many sulfite and nitrite reductases (enzymes that catalyze electron transfer in the process of reduction of nitrite and sulfite to ammonia and sulfide, respectively).
- Size exclusion limit** The molecular mass of the smallest solute that is excluded from movement through symplast across the plasmodesmic channels.
- Skotomorphogenesis** The development of a plant in dark.
- Skotonastic response** A type of movement that is synchronized by light to dark transition, for example, folding of leaves in dark.
- S-locus cysteine-rich protein (SCR)** A cysteine-rich protein located in the pollen coat that represents the male S-determinant in the members of Brassicaceae.
- S-locus receptor kinase (SRK)** A serine/threonine receptor kinase located in the plasma membrane of stigmatic cells that represents the female S-determinant in the members of Brassicaceae.
- Source** The plant organs which are capable of producing photosynthates and transporting them to other parts of the plant, for example, leaves. Storage areas such as roots and tubers also become sources under certain conditions.
- Sphingosine** An 18-carbon amino alcohol which is a primary component of sphingolipids (a class of phospholipids containing sphingomyelin).
- Sporophytic self-incompatibility (SSI)** A type of self-incompatibility where the incompatibility response or rejection of pollen is determined by the diploid genotype of the plant (sporophyte) that produces pollen. The pollen does not germinate on the stigma of flowers that contain either of the two alleles in the male sporophyte parent.
- Sporopollenin** Chemically inert biological polymer which consists of covalently linked phenolic acid and fatty acid-derived constituents. It forms the tough outer wall of pollen grains and provides protection from a variety of external agents.
- Standard free energy** The free energy associated with a reaction that occurs at physiological pH (7.0) at 25 °C and 100 kPa, when both reactants and products are at unit concentrations (1 M).
- Static solution culture** A hydroponic technique to culture plants in containers filled with nutrient solution which is aerated using a pump.
- Statocytes** A group of cells found in the root cap that contain statoliths. They are responsible for the gravitropic response exhibited by roots.
- Statoliths** Starch-containing plastids located in specialized cells known as statocytes found in the roots. They sediment to the bottom of the cells under the influence of gravity and, thus, regulate the gravitropic response in roots.

- Sterols** A group of lipids consisting of a steroid (comprising four hydrocarbon rings) with an attached hydroxyl group. They may exist as free sterols or with many modifications (acetylation, alkylation, and glycosylation), for example, campesterol and stigmasterol produced by plants.
- Stigma/style cysteine-rich adhesion (SCA) protein** A protein secreted by the transmitting tract of style in the members of Liliaceae that is involved in the growth and adhesion of pollen tubes.
- Stigmasterol** An unsaturated plant sterol which is similar to animal cholesterol. It is characterized by the presence of –OH group at C-3 of steroid skeleton and unsaturated bond at 5–6 position of ring B. It is found in fats and oils of soybean and many other legumes and vegetables.
- Stomatal frequency** The number of stomata per unit area of leaf. It plays an important role in determining the rate of exchange of gases and water vapor through a leaf surface.
- Stratification** The process of subjecting seeds to low temperature prior to sowing in order to simulate natural winter conditions.
- Stress** A condition which prevents plants from attaining their full genetic potential, thereby affecting plant growth, development, and productivity. It may be induced by abiotic or biotic factors.
- Stress response regulon** The transcriptional regulatory gene network generated in response to specific abiotic stresses by the action of different transcription factors that can cause activation of some genes and suppression of others.
- Strigolactones (SLs)** A class of plant growth regulators that are derived from carotenoids. They are involved in modulating plant development processes such branching and promoting symbiotic interactions between plants and microbes.
- Stroma** The fluidlike content of chloroplasts that surrounds photosynthetic membranes.
- Strophiole** An outgrowth of hilum region which restricts the movement of water in and out of the seeds with hard seed coat, for example, leguminous seeds.
- Substrate channeling** The movement of chemical intermediates in a series of enzyme-catalyzed reactions from the active site of an enzyme to that of the next enzyme in a pathway without dissociating from the surface of the protein complex.
- Substrate-level phosphorylation** A reaction resulting in the synthesis of ATP and GTP by direct transfer of phosphoryl group to ADP and GDP, respectively, from another phosphorylated compound. It is independent of electron transport.
- Succinoglycan** An extracellular acidic polysaccharide produced by microbes, which is composed of repeated units of an octasaccharide. The octasaccharide consists of galactose and glucose units in a ratio of 1:7, respectively, which are modified with acetyl, succinyl, and pyruvyl moieties.
- Suicide inactivators** Compounds which, instead of being converted to products in an enzyme-catalyzed reaction, are converted to highly reactive molecules that

combine irreversibly with enzyme and inhibit its activity. For example, hydrogen peroxide is a suicide inactivator of peroxidases.

Sunflecks Patches of sunlight passing through small gaps in the canopy of trees in dense forests.

Superoxide dismutase (SOD) An enzyme that catalyzes the dismutation of the superoxide ($O_2^{\cdot-}$) radical into either molecular oxygen (O_2) or hydrogen peroxide (H_2O_2).

Surface tension The tension created on the surface of a liquid as a result of high cohesive forces among the liquid molecules. It pulls the surface layer of the liquid such that it appears stretched and tends to minimize the surface area.

SUT1 (sucrose transporter 1) A sucrose- H^+ symporter found in the plasma membrane of sieve elements that transports sucrose into the cell coupled with an uptake of proton.

Symbiosis A close and long-term association between two biological species for mutual benefit, for example, mycorrhiza which represents a relationship between certain fungi and roots of plants.

Symplast The continuous system formed by interconnection of the cytoplasm of one cell with that of the neighboring cells through plasmodesmatal connections. It plays an important role in transport of water, minerals, and other low molecular weight solutes.

Symplastic pathway The pathway by which water and other molecules travel from one cell to another through plasmodesmata.

Symport A type of secondary active transport of solutes involving the movement of two solutes in the same direction across a membrane. One species moves down its electrochemical gradient and drives the transport of the other against its gradient.

Symporters Integral membrane proteins which facilitate cotransport of two solutes across the membrane in the same direction. One molecule moves down the electrochemical gradient, while the other moves against the gradient, for example, sucrose- H^+ symporter.

SymRK (symbiosis receptor-like kinase) A membrane-bound kinase protein which consists of an extracellular leucine-rich repeat (LRR) domain, a transmembrane segment, and a functional intracellular kinase domain. It is required at the early stage of symbiosis between the host plant and the microsymbiont.

Syncytium A multinucleate cell resulting from the fusion of multiple uninucleate cells.

Systemic acquired resistance (SAR) A type of resistance occurring at whole plant level following pathogen attack due to induction of pathogenesis related genes by salicylic acid. It confers a long-term protection to a broad range of pathogens and pests.

Systemic defense A network of signal transduction and amplification that result in activation of defense genes and establish systemic resistance in the entire plant.

Systemin A small peptide signaling molecule biosynthesized concomitant to JA accumulation in some plants and plays important roles in short range intercellular

communications. It is capable of inducing the synthesis of proteinase inhibitors and defense-related genes in response to insect attack.

Tannins Complex phenolic compounds involved in plant defense that have the ability to bind and denature proteins. They are exploited for tanning of hides in leather industry.

Tricarboxylic acid (TCA) cycle TCA cycle is also known as citric acid cycle or Krebs cycle during which acetyl-CoA is completely oxidized with simultaneous reduction of cofactors such as NAD^+ and FAD to NADH and FADH_2 , respectively.

Thermal death point The temperature at which an organism is killed depending upon the time of exposure.

Thermogenesis The metabolic process in which heat is produced as a result of expenditure of energy. During thermogenesis, most of the electron flow in mitochondria gets diverted from cytochrome respiration pathway to cyanide-insensitive non-phosphorylating electron transport pathway which is unique to plant mitochondria. The energy released by electron flow through this alternative respiratory pathway is not conserved as chemical energy but is released as heat.

Thermogenic plants The plants which are capable of producing heat in order to raise their internal temperature above that of the environment, for example, lotus and arum. The heat is produced via the action of alternative oxidase in an alternate respiratory pathway.

Thermonasty A type of plant movement such as opening and closure of petals, due to differential growth in response to fluctuating temperature.

Thigmotropism A response of plant in the form of directional growth or movement toward the contact stimulus. For example, tendrils of a climbing plant twine around any support they touch.

Thioredoxin A small ubiquitous thiol-active protein that has a pair of active site cys-thiols which upon oxidation form a disulfide bond.

Thylakoids Flattened saclike membranes present in the stroma of plastids where photosynthetic pigments are localized. These may be present in stacked or unstacked form.

Tonoplast intrinsic protein (TIP) Intrinsic proteins of the tonoplast which are responsible for high permeability to water and various other molecules, including ammonium and urea.

Totipotency The potential of a single plant cell to divide and differentiate into various cell types and give rise to a whole plant.

Toxicity Accumulation of high levels of micronutrients in plants leading to deleterious effects.

Trans fat (trans-unsaturated fatty acid) A type of unsaturated fatty acid that contains one or more double bonds in trans geometric configuration. These are not commonly found in nature but produced from vegetable oil due to partial hydrogenation.

Transaldolase An enzyme of pentose phosphate pathway, which catalyzes reversible transfer of a three-carbon fragment from sedoheptulose 7-phosphate to

glyceraldehyde 3-phosphate resulting in the formation of fructose 6-phosphate and erythrose 4-phosphate. The reaction provides a link between pentose phosphate pathway and glycolysis.

Transcellular Transport of water and solutes through a cell whereby they enter the cell from one side and exit from the other. The molecules to be transported by this mode have to cross the membrane twice.

Transduction (of signals) Conversion of a signal perceived by the receptor into another form so as to amplify the signal.

Transition state An intermediate, short-lived unstable state of a substrate molecule before being converted to the product in a chemical reaction.

Transitory starch Starch stored in chloroplasts during daytime and mobilized out of chloroplasts during night.

Transketolase An enzyme of both pentose phosphate pathway and Calvin cycle, which catalyzes transfer of a two-carbon fragment from a five-carbon ketose donor to an aldose acceptor.

Translocation The transport of photosynthates from source to sink tissue in the phloem.

Transpiration The evaporation of water in the form of water vapor from the aboveground parts of the plant, mainly through stomata.

Transpiration pull The pressure exerted on the xylem sap by transpirational force in the xylem tissue.

Transpiration ratio It is the ratio between the amount of water transpired to the mass of dry matter produced by a plant. It determines the efficiency of a plant to fix carbon dioxide at the expense of the amount of loss water by transpiration.

Transpiration stream The upward translocation of water in the form of continuous stream in xylem from root to leaves under the pressure of transpiration.

Transporters Specific transmembrane proteins present in the plasma membrane which facilitate transport of ions or molecules across the membrane.

Triose phosphate pool The intracellular pool of triose phosphates, i.e., 3-phosphoglyceraldehyde and dihydroxyacetone phosphate, from which either of the triose phosphates can be removed according to the need in cell metabolism.

Triple response Concentration-dependent morphological changes shown by dark-grown seedlings exposed to ethylene, characterized by the inhibition of hypocotyl and root elongation, a pronounced radial swelling of the hypocotyl and exaggerated curvature of the plumular hook.

Triplet state The excited state of a molecule attained when the molecule in singlet state loses some energy to environment as heat which is accompanied with the reversal of spinning of electron. The resulting electron spin resonance value is 1. This is the lowest energy state of the molecule having longer natural life time, i.e., 10^{-2} – 10^{-4} s.

Tritrophic interactions Interactions that describe plant defense system against herbivores having impact across three trophic levels, i.e., the plant, the herbivore, and its natural enemies (parasitoids). In such an interaction, a plant upon being

damaged by a particular herbivore releases volatile chemicals which, in turn, attract the parasitoids of the herbivore.

Tryptophan decarboxylase The key regulatory enzyme for mobilizing tryptophan in the biosynthesis of indole-3-acetic acid or serotonin/melatonin.

Tunica The peripheral layer in the shoot apical meristem consisting of cells that divide in anticlinal plane and contribute to the growth of the surface.

Turgor pressure The pressure exerted by water inside the cell per unit area of the plant cell wall. It pushes the plasma membrane outward and helps in maintaining the shape of the cell and provides force for cell expansion.

Turnover number (K_{cat}) The maximum number of chemical conversions of substrate molecules per second carried out by a single catalytic site of an enzyme at a given concentration.

Type III secretion system (T3SS) A type of secretory system present in gram-negative bacteria to deliver effector molecules into the host cell via the pilus (a hairlike appendage).

Ubiquitination The addition of ubiquitin to a protein targeted for degradation via the 26S proteasome pathway.

Uncouplers Compounds that uncouple ATP synthesis from electron transport, for example, 2,4-dinitrophenol.

Uniporters Integral membrane proteins facilitating transmembrane migration of specific solutes according to concentration gradient by binding one molecule at a time and transporting it in either direction across the membrane depending upon its concentration gradient.

Ureides Nitrogenous organic compounds which are acyl derivatives of urea. They are produced as a result of purine catabolism and contribute in translocation of nitrogen within the plant. Ureides include uric acid, allantoin, and allantoic acid.

UVR8 Photoreceptor for sensing UV-B (280–315 nm) radiation in plants. It is a seven-bladed β -propeller protein without a prosthetic group.

Vacuolar iron transporter (VIT) A protein responsible for the transfer of iron from cytosol to vacuole for intracellular iron storage.

Valinomycin An antibiotic which functions as K^+ -specific translocator and facilitates movement of potassium through lipid bilayer down the electrochemical gradient.

Vapor density Concentration of water molecules in vapor phase relative to that of hydrogen at the same conditions of temperature and pressure and is expressed as vapor mass per unit volume (unit = $\text{g}\cdot\text{m}^{-3}$).

Vapor pressure The pressure exerted by vapors on the walls of the stomatal chamber.

Variation potential (or slow-wave potential) A temporary change in the membrane consisting of propagating electrical signals generated exclusively in plants cells in response to a change in hydraulic pressure wave or ligand transmitted in xylem. It can be generated by wounding, excision, or flame. In contrast with action potential, variation potential exhibits longer phase of repolarization, following depolarization.

- Vernalin** A hypothetical plant hormone produced in the shoot apex as a result of cold temperature treatment and is responsible for induction of flowering.
- Vernalization** A treatment of cold temperature required by the plant for the competence to photoperiodic stimulus for flowering.
- Vertical resistance** Specific resistance acquired by the host against a particular race of pathogen which is heritable and is passed down to the next generation. It is also called single-gene resistance as it is governed by a single gene.
- Virulent** Pathogens that have the ability to cause disease in host and induce drastic effects.
- Vivipary** A condition in which the seed germinates and embryo grows and develops while still attached to the parent plant. This phenomenon is observed in mangroves such as *Rhizophora* sp.
- Wall pressure** The pressure exerted by cell wall on the contents of a cell. It is equal and opposite to the force exerted by turgor pressure.
- Water potential (ψ)** A measure of the free energy of water per unit volume expressed as the difference between the chemical potential of water at any point in a system and that of pure water under standard conditions. It is a function of solute potential (ψ_s), pressure potential (ψ_p), matric potential (ψ_m), and gravitational potential (ψ_g).
- Wax synthases** A group of long-chain-alcohol o-fatty-acyltransferases that catalyzes the formation of wax esters.
- Whiptail** A deficiency symptom of molybdenum commonly seen in cauliflower which is characterized by poorly developed leaf blades with green and yellow margins.
- Wilting** A condition of a plant that arises when the plant body loses more water by evaporation than it is able to absorb from the soil, causing the cells to lose their turgidity and leading to the loss of rigidity of non-woody parts of the plants.
- WRKY proteins** A large class of WRKY domain-containing sequence-specific, DNA-binding transcription factors found in plants. They regulate many responses like biotic and abiotic stress, senescence, seed germination, seed dormancy, and some developmental processes.
- Xanthoxin** A natural growth inhibitor that has physiological properties similar to ABA. It leads to the formation of ABA via oxidative steps involving the intermediates ABA-aldehyde or xanthoxic acid in the cytoplasm.
- Xenobiotic** A chemical compound, generally synthetic, which is extrinsic to normal metabolism of an organism or to an ecological system. These include synthetic drugs or drug metabolites in the body or pollutants in environment such as synthetic pesticides, herbicides, industrial pollutants, etc.
- Xenogamy** The process of transfer of pollen onto the surface of stigma of a flower present on a different plant.
- Xylogenesis** The process of differentiation of xylem elements.
- Yang's cycle** The cycle responsible for prevention of methionine depletion and its regeneration in plants during ethylene production.

Yellow stripe-like 1 (YSL1) A member of oligopeptide transporter family predicted to be integral membrane proteins regulated in response to iron status in plants. It is involved in transport of iron (Fe^{3+}) complexed with phytosiderophores.

Zeitgeber An environmental cue that synchronizes the biological clock of an organism with the 24-hour diurnal and annual cycle.

Zeitlupe (ZTL/ADO) Photoreceptors involved in the targeted proteolysis of signaling components which control flowering time and circadian clock.