PRIMARY AND SECONDARY METABOLISM OF PLANT CELL CULTURES II C pdf

1: Primary and secondary metabolism of plant cell cultures II.

At the end of the initial meeting on Primary and Secondary Metabolism of Plant Cell Cultures at Schloss Rauischholzhausen, it was decided to convene similar events on a regular basis midway between the International Congress for Plant Tissue and Cell CulÂ- ture.

Int J Mol Sci. Published online Nov 4. This article is an open access article distributed under the terms and conditions of the Creative Commons by Attribution CC-BY license http: This article has been cited by other articles in PMC. Abstract Higher plants synthesize an amazing diversity of phenolic secondary metabolites. Phenolics are defined secondary metabolites or natural products because, originally, they were considered not essential for plant growth and development. Plant phenolics, like other natural compounds, provide the plant with specific adaptations to changing environmental conditions and, therefore, they are essential for plant defense mechanisms. Plant defensive traits are costly for plants due to the energy drain from growth toward defensive metabolite production. Being limited with environmental resources, plants have to decide how allocate these resources to various competing functions. This decision brings about trade-offs, i. Many studies have been carried out in order to link an evaluation of plant performance in terms of growth rate with levels of defense-related metabolites. Available results suggest that environmental stresses and stress-induced phenolics could be linked by a transduction pathway that involves: Plant Phenolic Secondary Metabolites Higher plants produce a bewildering number of chemical compounds more than , different structures. These compounds can be classified as belonging to primary or secondary metabolites, also called natural products. Primary metabolites are ubiquitous in plants and fulfill essential metabolic roles. Natural products refer to compounds that are differentially distributed in the plant kingdom and fulfill a very broad range of physiological roles that are considered essential for their adaptive significance in protection against environmental constraints. Nowadays, it is widely recognized that natural products play a role in plant growth, reproduction, and the continued survival of land plants [1 , 2 , 3]. Plants exhibit a variable qualitative and quantitative distribution of natural products in different tissues and organs. This variability is also observed between different physiological stages, between individuals, and between populations [4 , 5 , 6 , 7 , 8]. Plants synthesize amounts of natural products under genetic control upon environmental stimuli. These natural products are synthesized in plants through metabolic pathways, which are an integral part of the whole plant developmental program, as a response to stress conditions induced by biotic and abiotic agents. A strict genetic and epigenetic control of these pathways guarantees the proper production profile of different secondary metabolites. Their transport represents an additional level of regulation [9 , 10 , 11 , 12 , 13 , 14 , 15]. Plant phenolics are the most widely distributed natural products. In leaf extracts of vascular plants several classes of phenolic compounds such as esters, amides, and glycosides of hydroxycinnamic acids, flavonoids, proanthocyanidins, and their relatives can be found. In addition, polymeric phenolics, such as lignin, suberin, and melanins, can be commonly found in these plants [16 , 17 , 18 , 19]. Poly phenolic compounds are produced in plants by the sequential action of five biosynthetic pathways. The glycolytic and pentose phosphate pathways provide precursors phosphoenolpyruvate and erythrosephosphate, respectively to the shikimate pathway. Phenylalanine, produced by the shikimate route, is the precursor of phenylpropanoid metabolism which, in turn, feeds the diverse specific flavonoid pathways Figure 1 [20 , 21 , 22 , 23 , 24 , 25 , 26].

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2: W. G. W. Kurz (Author of Primary And Secondary Metabolism Of Plant Cell Cultures Ii)

This book comprises 36 papers presented at the symposium entitled "Regulation of Primary and Secondary Metabolism in Plant Cells" held at the Plant Biotechnology Institute of the National Research Council of Canada in Saskatoon in

This article has been cited by other articles in PMC. Abstract Plants are the tremendous source for the discovery of new products with medicinal importance in drug development. Today several distinct chemicals derived from plants are important drugs, which are currently used in one or more countries in the world. Secondary metabolites are economically important as drugs, flavor and fragrances, dye and pigments, pesticides, and food additives. Many of the drugs sold today are simple synthetic modifications or copies of the naturally obtained substances. The evolving commercial importance of secondary metabolites has in recent years resulted in a great interest in secondary metabolism, particularly in the possibility of altering the production of bioactive plant metabolites by means of tissue culture technology. Plant cell and tissue culture technologies can be established routinely under sterile conditions from explants, such as plant leaves, stems, roots, and meristems for both the ways for multiplication and extraction of secondary metabolites. In vitro production of secondary metabolite in plant cell suspension cultures has been reported from various medicinal plants, and bioreactors are the key step for their commercial production. Based on this lime light, the present review is aimed to cover phytotherapeutic application and recent advancement for the production of some important plant pharmaceuticals. The utilization of plant cells for the production of natural or recombinant compounds of commercial interest has gained increasing attention over past decades. Primary metabolic pathways converge too few end products, while secondary metabolic pathways diverge too many products. Primary requires the cell to use nutrients in its surroundings such as low-molecular weight compounds for cellular activity. There are three potential pathways for primary metabolism: The EMP produces two molecules of pyruvate via triose phosphate intermediates. This pathway occurs most widely in animal, plant, fungal, yeast, and bacterial cells. Many microorganisms, however, use this pathway solely for glucose utilization. During primary metabolism, hexoses such as glucose are converted to single cell protein by yeasts and fungi. Plants produce a vast and diverse assortment of organic compounds, the great majority of which do not appear to participate directly in growth and development. These substances, traditionally referred to as secondary metabolites, often are differentially distributed among limited taxonomic groups within the plant kingdom. Their functions, many of which remain unknown, are being elucidated with increasing frequency. The primary metabolites, in contrast, such as phytosterols, acyl lipids, nucleotides, amino acids, and organic acids, are found in all plants and perform metabolic roles that are essential and usually evident. Although noted for the complexity of their chemical structures and biosynthetic pathways, natural products have been widely perceived as biologically insignificant and have historically received little attention from most plant biologists. Pharmaceutical organic chemists, however, have long been interested in these novel phytochemicals and have investigated their chemical properties extensively since the s. Studies of natural products stimulated development of the separation techniques, spectroscopic approaches to structure elucidation, and synthetic methodologies that now constitute the foundation of contemporary organic chemistry. Interest in natural products was not purely academic but rather was prompted by their great utility as dyes, polymers, fibers, glues, oils, waxes, flavoring agents, perfumes, and drugs. Recognition of the biological properties of myriad natural products has fueled the current focus of this field, namely, the search for new drugs, antibiotics, insecticides, and herbicides. Based on their biosynthetic origins, plant natural products can be divided into three major groups: All terpenoids, including both primary metabolites and more than 25, secondary compounds, are derived from the five-carbon precursor isopentenyl diphosphate IPP. The 12, or so known alkaloids, which contain one or more nitrogen atoms, are biosynthesized principally from amino acids. Rationale of the Study The objectives of this study were to get an overview of various works that have been done and could be done in the field of metabolic engineering of plant secondary metabolites by using yeast and to search the possibility of using methods and mechanisms for the production of various human health promoting plant secondary metabolites in the coming future. The principle advantage of recent technologies is that it may provide continuous, reliable source of plant pharmaceuticals and could be used for the large-scale culture of plant cells from which these metabolite can be extracted. Plant cell and tissue cultures hold great promise for controlled production of myriad of useful secondary metabolites on demand. The current yield and productivity cannot fulfill the commercial goal of plant cell-based bioprocess for the production of most secondary metabolites. In order to stretch the boundary, recent advances, new directions, and opportunities in plant cell-based processes are being critically examined. However, most often trials with plant cell cultures fail to produce the desired products. In such cases, strategies to improve the production of secondary metabolites must be considered. One of the main problems encountered is the lack of basic knowledge of the biosynthetic routes and mechanisms responsible for the production of plant metabolites. Where the productivity of the desired metabolites is limited by the lack of particular precursors, biotransformation using an exogenous supply of biosynthetic precursors, genetic manipulation, and metabolic engineering may improve the accumulation of compounds. Elicitors, compounds triggering the formation of secondary metabolites, can be abiotic or biotic. Natural elicitors include polysaccharides such as pectin and chitosan, which are also used in the immobilization and permeabilization of plant cells. Immobilization with suitable bioreactor system provides several advantages, such as continuous process operation, but for the development of an immobilized plant cell culture process, natural or artificially induced secretion of the accumulated product into the surrounding medium is necessary. Advancements in the Production of Secondary Metabolites Plant cell and tissue cultures hold great promise for controlled production of myriad of useful secondary metabolites on demand. Discoveries of cell cultures capable of producing specific medicinal compounds at a rate similar or superior to that of intact plants have accelerated in the last few years has been summarized in Table 1. They are unique in their genetic and biosynthetic stability, faster in growth, and more easily maintained. Using this methodology, a wide range of chemical compounds has been synthesized. Useful compounds can be produced under controlled conditions independent of climatic changes or soil conditions. Cultured cells would be free of microbes and insects. The cells of any plants, tropical or alpine, could easily be multiplied to yield their specific metabolites. Automated control of cell growth and rational regulation of metabolite processes would reduce labor costs and improve productivity. Organic substances are extractable from callus cultures. Trends in Production of Secondary Plant Metabolites from Higher Plants Plant cell and tissue cultures can be established routinely under sterile conditions from explants, such as plant leaves, stems, roots, and meristems for multiplication and extraction of secondary metabolites. Strain improvement, methods for the selection of high-producing cell lines, and medium optimizations can lead to an enhancement in secondary metabolite production. The capacity for plant cell, tissue, and organ cultures to produce and accumulate many of the same valuable chemical compounds as the parent plant in nature has been recognized almost since the inception of in vitro technology. These include the following: Production can be more reliable, simpler, and more predictable. Isolation of the phytochemical can be rapid and efficient, when compared with extraction from complex whole plants. Compounds produced in vitro can directly parallel compounds in the whole plant. Interfering compounds that occur in the field-grown plant can be avoided in cell cultures. Tissue and cell cultures can yield a source of defined standard phytochemicals in large volumes. Tissue and cell cultures are a potential model to test elicitation. Cell cultures can be radiolabeled, such that the accumulated secondary products, when provided as feed to laboratory animals, can be traced metabolically. While research to date has succeeded in producing a wide range of valuable secondary phytochemicals in unorganized callus or suspension cultures, in other cases production requires more differentiated micro plant or organ cultures. A prime example is ginseng Panax ginseng. Because saponin and other valuable metabolites are specifically produced in ginseng roots, root culture is required in vitro. Similarly, herbal plants such as Hypericum perforatum St. Callus and shoot cultures of tobacco can produce only trace amounts of nicotine because they lack the organ-specific compound anabasine. In other cases, at least some degree of differentiation in a cell culture must occur before a product can be synthesized e. Reliance of a plant on a specialized structure for production of a secondary metabolite, in some cases, is a mechanism for keeping a potentially toxic compound sequestered. Intensive activities have been centered on production of natural drugs or chemoprotective compounds from plant cell culture by one or more of the following strategies: Organ Cultures for Secondary Metabolite Production Fritillaria unibracteata can be rapidly propagated, directly from small cuttings of the bulb by the technique of organ culture. The cultured bulb can be harvested after a day culture period in MS media supplemented with 4. The growth rate was about 30â€”50 times higher than that under natural wild growth conditions. The content of alkaloid and beneficial microelements in the cultured bulbs was higher than found in the wild bulb. MJ, a proven signal compound, is the most effective elicitor of taxol production in Taxus chinensis Roxb. Valine and isoleucine, upon administration to the shoot cultures, were incorporated into acyl side chain of hyperforin and adhyperforin, respectively. Feeding the shoot cultures with unlabelled lisoleucine at a concentration of 2 mM induced a fold increase in the production of a hyperforin. In the callus culture, manifold increase of asiaticoside accumulation was reported with the addition of leucine. Tannic acid profoundly inhibited the hairy root growth during growth period. The production of secondary metabolites in callus, cell suspension, and hairy roots of Ammi majus L. Chitosan was the biotic elicitor polysaccharide and it is eliciting the manifold increase of anthraquinone production in Rubia akane cell culture. The secondary metabolites produced by hairy roots arising from the infection of plant material by A. During the infection process, A. Two sets of pRi genes are involved in the root induction process: Genetic Manipulation in Hairy Root Culture for Secondary Metabolite Production Transformed roots provide a promising alternative for the biotechnological exploitation of plant cells. These foreign DNA sequences are stably inherited in a Mendelian manner. An example of a gene of interest with regard to secondary metabolism that was introduced into hairy roots is the 6-hydroxylase gene of Hyoscyamus muticus which was introduced to hyocyamin-rich Atropa belladonna by a binary vector system using A. Role of Endophytes in In vitro Production of Secondary Metabolites There are three schools of thought on the origins of secondary metabolism in plants. Another thought is that an ancient horizontal gene transfer took place between plants and microbes. The third suggests that either plants or endophytic fungi produce these secondary metabolites and transfer them to the other symbiont. Biosynthetic pathway studies using radiolabeled precursor amino acids reveal that plants and endophytic fungi have similar but distinct metabolic pathways for production of secondary metabolites. The fact that a combination of inducing factors from both plants and endophytic fungi increased the accumulation of secondary metabolites in plants and fungi, respectively,[33 , 34] suggest that the fungal endophyte may play important roles in the biosynthesis of secondary metabolites. Therefore, the symbiotic association and effects of plants and endophytes on each other during the production of other important pharmacological bioactive natural products such as camptothecin, vinblastine, and podophyllotoxin need to be explored. This could provide the framework for future natural product production through genetic and metabolic engineering. Plant cells in liquid suspension offer a unique combination of physical and chemical environments that must be accommodated in large-scale bioreactor process. Immobilization Scaling up of Secondary Metabolite Accumulation Advances in scale-up approaches and immobilization techniques contribute to a considerable increase in the number of applications of plant cell cultures for the production of compounds with a high added value. Plant-derived compounds with cancer chemotherapeutic or antioxidant properties use rosmarinic acid and taxol as representative examples. Immobilization in calcium alginate enhanced the production of plumbagin by three-, two-, and one-folds compared with that of control, un-crosslinked alginate and $CaCl_2$ -treated cells, respectively. Tissue Cultures Producing Pharmaceutical Products of Interest Research in the area of plant tissue culture technology has resulted in the production of many pharmaceutical substances for new therapeutics. Advances in the area of cell cultures for the production of medicinal compounds have made possible the production of a wide variety of pharmaceuticals such as alkaloids, terpenoids, steroids, saponins, phenolics, flavanoids, and amino acids.

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3: Plant Interactions: Secondary Metabolism

At the end of the initial meeting on Primary and Secondary Metabolism of Plant Cell Cultures at Schloss Rauischholzhausen, it was decided to convene similar events on a regular basis midway between the International Congress for Plant Tissue and Cell CulÂ- ture. We felt it was necessary to bring.

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4: Current approaches toward production of secondary plant metabolites

from book Primary and Secondary Metabolism of Plant Cell Cultures II (pp) Primary and Secondary Metabolism of Plant Cell Cultures II Chapter Â· January with 14 Reads.

Atropine[edit] Atropine is a type of secondary metabolite called a tropane alkaloid. Alkaloids contain nitrogens, frequently in a ring structure, and are derived from amino acids. Tropane is an organic compound containing nitrogen and it is from tropane that atropine is derived. Atropine is synthesized by a reaction between tropine and tropate, catalyzed by atropinase. Within Atropa belladonna atropine synthesis has been found to take place primarily in the root of the plant. Typically, secondary metabolites are not necessary for normal functioning of cells within the organism meaning the synthetic sites are not required throughout the organism. As atropine is not a primary metabolite , it does not interact specifically with any part of the organism, allowing it to travel throughout the plant. Flavonoids[edit] Flavonoids are one class of secondary plant metabolites that are also known as Vitamin P or citrin. These metabolites are mostly used in plants to produce yellow and other pigments which play a big role in coloring the plants. In addition, Flavonoids are readily ingested by humans and they seem to display important anti-inflammatory, anti-allergic and anti-cancer activities. Flavonoids are also found to be powerful anti-oxidants and researchers are looking into their ability to prevent cancer and cardiovascular diseases. Flavonoids help prevent cancer by inducing certain mechanisms that may help to kill cancer cells, and researches believe that when the body processes extra flavonoid compounds, it triggers specific enzymes that fight carcinogens. Good dietary sources of Flavonoids are all citrus fruits, which contain the specific flavanoids hesperidins, quercitrin ,and rutin , berries, tea, dark chocolate and red wine and many of the health benefits attributed to these foods come from the Flavonoids they contain. Flavonoids are synthesized by the phenylpropanoid metabolic pathway where the amino acid phenylalanine is used to produce 4-coumaryol-CoA, and this is then combined with malonyl-CoA to produce chalcones which are backbones of Flavonoids [6] Chalcones are aromatic ketones with two phenyl rings that are important in many biological compounds. The closure of chalcones causes the formation of the flavonoid structure. Flavonoids are also closely related to flavones which are actually a sub class of flavonoids, and are the yellow pigments in plants. In addition to flavones, 11 other subclasses of Flavonoids including, isoflavones, flavans, flavanones, flavanols, flavanolols, anthocyanidins, catechins including proanthocyanidins , leukoanthocyanidins, dihydrochalcones, and aurones. Cyanogenic glycoside[edit] Many plants have adapted to iodine-deficient terrestrial environment by removing iodine from their metabolism, in fact iodine is essential only for animal cells. Many plant pesticides are cyanogenic glycoside which liberate cyanide , which, blocking cytochrome c oxidase and NIS, is poisonous only for a large part of parasites and herbivores and not for the plant cells in which it seems useful in seed dormancy phase. The compounds of these secondary metabolites As seen in Figure 1 are found in over plant species. Its structure allows the release of cyanide , a poison produced by certain bacteria, fungi, and algae that is found in numerous plants. Animals and humans possess the ability to detoxify cyanide from their systems naturally. Therefore, cyanogenic glycosides can be used for positive benefits in animal systems always. For example, the larvae of the southern armyworm consumes plants that contain this certain metabolite and have shown a better growth rate with this metabolite in their diet, as opposed to other secondary metabolite-containing plants. Although this example shows cyanogenic glycosides being beneficial to the larvae many still argue that this metabolite can do harm. To help in determining whether cyanogenic glycosides are harmful or helpful researchers look closer at its biosynthetic pathway Figure 2. Past research suggests that cyanogenic glucosides stored in the seed of the plant are metabolized during germination to release nitrogen for seedling to grow. With this, it can be inferred that cyanogenic glycosides play various roles in plant metabolism. Though subject to change with future research, there is no evidence showing that cyanogenic glycosides are responsible for infections in plants. Phytic acid[edit] Phytic acid is the main method of phosphorus storage in plant seeds, but is not readily absorbed by many animals only absorbed by ruminant animals. Not only is phytic acid a phosphorus storage unit, but it also is a source of energy and cations , a natural antioxidant for plants, and can be a source of myoinositol which is one of the preliminary pieces for cell walls. Phytic acid is also known to bond with many different minerals, and by doing so prevents those minerals from being absorbed; making phytic acid an anti-nutrient. In preparing foods with high phytic acid concentrations, it is recommended they be soaked in after being ground to increase the surface area. Cooking can also reduce the amount of phytic acid in food but soaking is much more effective. Phytic acid is an antioxidant found in plant cells that most likely serves the purpose of preservation. This preservation is removed when soaked, reducing the phytic acid and allowing the germination and growth of the seed. When added to foods it can help prevent discoloration by inhibiting lipid peroxidation. It can exist in three forms: All of these forms have very similar biological properties. Gossypol is a type of aldehyde, meaning that it has a formyl group. The formation of gossypol occurs through an isoprenoid pathway. Isoprenoid pathways are common among secondary metabolites. Extensive studies have shown that gossypol has other functions. Many of the more popular studies on gossypol discuss how it can act as a male contraceptive. Gossypol has also been linked to causing hypokalemic paralysis. Hypokalemic paralysis is a disease characterized by muscle weakness or paralysis with a matching fall in potassium levels in the blood. Hypokalemic paralysis associated with gossypol in-take usually occurs in March, when vegetables are in short supply, and in September, when people are sweating a lot. This side effect of gossypol in-take is very rare however. Gossypol induced hypokalemic paralysis is easily treatable with potassium repletion. One such group of metabolites is phytoestrogens , found in nuts, oilseeds, soy, and other foods. This has a negative result, because there are various abilities of the phytoestrogen which estrogen does not do. Its effects the communication pathways between cells and has effects on other parts of the body where estrogen normally does not play a role. But, one role of estrogens which phytoestrogens mimic is its protective behavior for the heart. So, an intake of phytoestrogens has also been seen to reduce the risk of cardiovascular disease. Resveratrol , a phytoestrogen found in grapes is responsible for this. For example, the French suffer relatively little heart disease despite the average French diet being relatively high in fat. One proposed reason for this is the resveratrol found in red wine, which has been linked to decreased risk of cardiovascular disease. They are also found in some organisms such as algae, fungi, some bacteria, and certain species of aphids. There are over known carotenoids. They are split into two classes, xanthophylls and carotenes. Xanthophylls are carotenoids with molecules containing oxygen, such as lutein and zeaxanthin. Carotenoids have two important functions in plants. First, they can contribute to photosynthesis. They do this by transferring some of the light energy they absorb to chlorophylls , which then uses this energy for photosynthesis. Second, they can protect plants which are over-exposed to sunlight. They do this by harmlessly dissipating excess light energy which they absorb as heat. In the absence of carotenoids, this excess light energy could destroy proteins, membranes, and other molecules. Some plant physiologists believe that carotenoids may have an additional function as regulators of certain developmental responses in plants. Carotenoids involved in photosynthesis are formed in chloroplasts; Others are formed in plastids. 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5: Plant secondary metabolism - Wikipedia

Via specialized pathways plant cells are able to produce a variety of compounds. Plant cell cultures are ideal tools for studying these pathways of secondary metabolisms and can be exploited to accumulate and produce natural products in a defined and handable way.

References Abstract Plants synthesise an extraordinary array of natural products that usually do not play a role in their growth and development, and thus are traditionally referred to as secondary metabolites. However, recent advances in plant sciences have revealed that these compounds not only function in response to environmental stimuli, but also play more basic roles in plant growth. Secondary metabolites have several important roles in plants: Many secondary metabolites are also useful for mankind as dyes, essential oils, flavouring agents, pesticides, pharmaceuticals, tanning agents and so on. Rapid advances in the metabolic engineering and synthetic biology of secondary metabolites have revealed novel physiological roles of these secondary metabolites in plants. Plants synthesise a vast array of natural products secondary metabolites in response to environmental stimuli. Secondary metabolites have several important roles: Secondary metabolites are synthesised from primary metabolites such as acetate, pyruvate, and amino acids, and are mainly classified into three major groups; the terpenoids, the phenolics mainly phenylpropanoids and alkaloids. Some terpenoid compounds from plants. Tetrahydrocannabinol is synthesised from two building units. Some plant alkaloids; biosynthetic origins shown in parentheses. Miscellaneous classes of plant secondary metabolites â€" polyacetylenes, polyenes, cyanogenic glycosides, glucosinolates, nonprotein amino acids â€" and their biosynthetic precursors. Ac, acetyl; Bz, benzoyl; Ph, phenyl. Plant secondary metabolites that act as hormones and signalling agents. Plant secondary metabolites in defence and allelopathy. Plant and Cell Physiology Journal of Plant Growth Regulation American Society of Plant Biologists. Hartmann T From waste products to ecochemicals: Journal of Biological Chemistry Molecular Biology and Evolution 22 Current Opinion in Plant Biology 8 3: Natural Product Reports Archives of Biochemistry and Biophysics 1: Ortiz de Montellano P ed. Structure, Mechanism, and Biochemistry, pp. Sato F and Yamada Y Engineering formation of medicinal compounds in cell cultures. Stahl E Pflanzen und Schnecken. Biologische Studie uber die Schutzmittel der Pflanzen gegen Schneckenfraas. Jenaische Zeitschrift fuer Naturwissenschaften und Medizin Current Opinion in Plant Biology 8: Waterman PG Roles for secondary metabolites in plants. Their Evolution and Function. Ciba Foundation Symposium , pp. Winkel BSJ Metabolic channeling in plants. Annual Review of Plant Biology Yamada Y and Sato F Transcription factors in alkaloid biosynthesis. International Review of Cell and Molecular Biology Prospects for the 21st Century. Mann J Murder, Magic and Medicine.

6: Plant Secondary Metabolism

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7: Carbon Fluxes between Primary Metabolism and Phenolic Pathway in Plant Tissues under Stress

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