

PREFACE

Apart from the short-range interactions mediated by diffusion, long-scale interactions are indispensable for giant plant cells including internodal cells of Characeae because the inefficiency of diffusion for millimeter- and centimeter-scale distances should be counterbalanced by other mechanisms to ensure the integrity of cell metabolism. In this collection, the authors begin by presenting one approach for studying the cyclosis-mediated transmission of regulatory signals along the characean internode by illuminating a cell part with a narrow light beam and to observe the changes of modulated chlorophyll fluorescence occurring in response to this photostimulus at a fixed distance on the downstream side of the light spot.

Following this, the features and characters of various chloroplast genomes that could be retrieved solely from the analysis of triplet composition were studied. Two types of triplet dictionaries were developed: the former lists all the triplets (with overlapping), so that each nucleotide yields a start for a triplet, and the latter is the entity where triplets do not overlap but also have no gaps between them.

The authors go on to describe the effects of cytoplasm on the expression of cytoplasmic male sterility and other agronomically valuable traits in the grain sorghum and sorghum $\times$ Sudan grass hybrids, as well as on the combining ability for these traits. It is hypothesized that the cytoplasm, being a buffer between the external environment and the nuclear genome,

processes environmental signals and thus has a significant effect on the manifestation of nuclear-encoded traits.

A nonlocal strain gradient beam model is developed including the both hardening-stiffness and softening-stiffness size effects in conjunction with the geometrical nonlinearity in the concluding study. Via the variational approach, the governing differential equations are constructed corresponding to each nonlinear mechanical behavior of the lipid micro/nano-tubule surrounded by the cytoplasm biomedium.

Chapter 1 - Apart from the short-range interactions mediated by diffusion, long-scale interactions are indispensable for giant plant cells including internodal cells of Characeae, because the inefficiency of diffusion for millimeter- and centimeter-scale distances should be counterbalanced by other mechanisms to ensure the integrity of cell metabolism. Cytoplasmic streaming plays a crucial role in long-distance interactions between anchored chloroplasts. Translational movement of metabolites is delayed by nonspecific transient binding of the transported substances to intracellular vesicles. The inhibitors of vesicular trafficking may provide the means to affect the number or turnover rate of the vesicles and, consequently, may affect the extent of nonspecific binding that retards the rate of lateral transport. One approach to study the cyclosis-mediated transmission of regulatory signals along the characean internode is to illuminate a cell part with a narrow light beam and to observe the changes of modulated chlorophyll fluorescence occurring in response to this photostimulus at a fixed distance on the downstream side of the light spot. The fluorescence F' response was found to propagate in the downstream direction along the shaded parts of the internode with the velocity comparable to that of the cytoplasmic streaming. Under the constant streaming rate, the transient F' changes have a bell shape and show reproducible time of achieving the F' peak, as counted from the onset of local light application. The treatment of internodal cells with brefeldin A (BFA), an inhibitor of vesicular trafficking had no significant influence on the velocity of cytoplasmic streaming but appreciably accelerated the development of the fluorescence response to local illumination of a distant cell region, which was evident in an earlier achievement of the F' peak. The transmission and perception of the

metabolic signals in untreated and BFA-treated cell was pronounced differently, depending on whether the cell was exposed to continuous weak background light or placed in darkness prior to the onset of the local light. The results indicate that interference of BFA with vesicle trafficking appreciably facilitates the lateral transmission of the regulatory metabolite and that this stimulation cannot be ascribed to acceleration of cytoplasmic streaming.

Chapter 2 - The authors studied the features and characters of various chloroplast genomes that could be retrieved solely from the analysis of triplet composition. To do that, two types of triplet dictionaries were developed: the former lists all the triplets (with overlapping), so that each nucleotide yields a start for a triplet, and the latter is the entity where triplets do not overlap, but also have no gaps between them. Two main cores were studied: the former is the structuredness of a genome that manifests in the statistical properties of small fragments of the genome, each of them converted into a triplet frequency dictionary, and the latter is the relation between the triplet frequencies of a genome, and their phylogeny, when determined over a significant ensemble of genomes. It was found that the great majority of chloroplast genomes exhibit a specific eight-cluster pattern comprising these fragments (converted into triplet frequency dictionaries). The first cluster corresponds to junk fragments, and six more clusters correspond to the fragments corresponding to coding regions, so that each entity corresponds to the specific reading frame shift, and the strand (leading vs. ladder). Finally, the eighth cluster (called the "tail") differs from all those mentioned above, and comprises the fragments with excessive GC-content values. In the observed pattern, two clusters corresponding to the third position of a reading frame but belonging to opposite strands always project one over the other, while the other four clusters do not. Moreover, there is a mirroring symmetry in the orientation of these two coincidental clusters against four others: each genome has either left-hand or right-hand orientation of these six clusters. The cluster structuredness of the chloroplasts found here differs from a similar one observed for bacterial or eukaryotic genomes. The aim of the second core investigation was to establish the relation between the triplet composition of chloroplast genomes

and the taxonomy of their bearers; the latter was determined morphologically, by nuclear genomes. To reveal the relation, all the chloroplast genomes (approx. 900 entries) were converted into triplet frequency dictionaries of the first type, and then they were clustered by K-means, elastic maps and some other clustering techniques into two, three, four, five, six and seven classes, respectively. The composition of the classes was the subject of interest: it was found that the distribution of clades over the classes that developed due to clustering was very non-random, and followed, in general, a natural taxonomy of the bearers. Some further perspectives and problems are discussed.

Chapter 3 - The cytoplasm is an important component of the plant cell, which plays a significant role in the inheritance and realization of genetic information. To date, many examples of the influence of the cytoplasmic background on numerous plant traits, including those of great biological and economic importance, have been documented. In this chapter, the authors describe the effects of cytoplasm on the expression of cytoplasmic male sterility (CMS) and other agronomically valuable traits in the grain sorghum and sorghum $\times$ Sudan grass hybrids, as well as on the combining ability for these traits. Among these traits are plant starting growth, leaf parameters (leaf length, leaf width), tillering, chlorophyll and carotenoid content, biomass yield and grain productivity. In addition, the authors demonstrate examples of heritable changes in the nuclear genome, which occur as a consequence of interaction of nuclear genome with alien cytoplasm. Among them are changes of the character of methylation of the nuclear genes, in particular, of the mobile genetic elements, in the 9E CMS sorghum; emergence of a paramutations in alloplasmic lines of maize obtained by androgenesis *in vivo* (male parthenogenesis). The dependence of expression of cytoplasmic effects on environmental conditions, in particular, on the hydrothermal factors of the growing season, is noted. It is hypothesized that the cytoplasm, being a "buffer" between the external environment and the nuclear genome, "processes" environmental signals and, thus, has a significant effect on the manifestation of nuclear-encoded traits.

Chapter 4 - After discovering lipid micro/nano-tubules made of crystalline bilayer membranes, they have attracted much attention due to

their outstanding physical and mechanical functionalities. In lipid-based micro/nano-tubular drug delivery systems, the micro/nano-tubule is subjected to different loading conditions. Consequently, in order to design more efficient and accurate systems, it is essential to study size dependency in nonlinear mechanical behaviors of lipid micro/nano-tubules embedded in the cytoplasm of a living cell. For this purpose, in the current study, a nonlocal strain gradient beam model is developed including the both hardening-stiffness and softening-stiffness size effects in conjunction with the geometrical nonlinearity. Via the variational approach, the governing differential equations are constructed corresponding to each nonlinear mechanical behavior of the lipid micro/nano-tubule surrounded by the cytoplasm biomedium. After that, an improved perturbation technique together with the Galerkin method is employed to solve the size-dependent nonlinear governing differential equations corresponding to two different loading conditions including axial compression and hydrostatic pressure. Explicit asymptotic solutions are obtained associated with each independent variable of the problems. After that, analytical expressions for the size-dependent stability curves of the lipid micro/nano-tubules embedded in the cytoplasm of a living cell are extracted analytically for the both loading conditions.

ABSTRACT

Apart from the short-range interactions mediated by diffusion, long-range interactions are indispensable for many plant cells including tobacco cells of *Chlamydomonas*—a multicellular organism for millimeter- and centimeter-scale distances, should be experimentally or other mechanisms to ensure the integrity of cell distribution. Cytoplasmic streaming plays a critical role in long-distance intermixing and nutrient exchange in chloroplasts. Translational movement of metabolites is defined by nonspecific transport studies of the transported substances in