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# Experimental Botany: Anatomical and Morphological Approaches for Biotechnology and Nature Protection

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## 1. Introduction

As photosynthetic systems, plants are fundamental elements of the Earth's biosphere, playing key roles in providing energy and resources. Here, an equilibrium is established between obtaining, storing and consuming energy, which, if changed, can cause global consequences, affecting the gas composition of the atmosphere, temperature balance and ecological homeostasis. Changes in the natural landscapes and plant communities due to the expansion of agricultural practices and urban modifications across large areas of the planet have led to a situation of unpredictable stress on a global scale, often associated with so-called global warming [1,2]. As a result, many communities and their constituent species are threatened by extinction, unable to pass the this "natural selection" bottleneck. The disappearance of biodiversity in plant communities endangers the existence of other species, provoking a domino effect, which raises serious concerns among scientists and has become a real threat to the existence of life on Earth as we imagine it. Examples of this are well known and being actively studied; they are at the frontier of attention of scientific researchers and the public [3]. In this regard, new generations are faced with the task of not only studying the "nature of things" in order to clarify the details of physiological processes, interactions between cells, organs and tissues, genetic regulation of the tolerance of domesticated and natural forms and the stability of individual systems but also studying the possibilities of preserving and recreating individual species and components of communities that may be lost. This task at a new stage of development can be achieved through the use of technologies such as cryopreservation, clonal micropropagation and other related technologies used to collect and recreate territories disturbed as a result of irrational human activity.

Equally important is the conservation of local species and cultivated varieties, natural plant communities, the preservation of plant gene pools and the controlled expansion of invasive species, posing a significant threat concerning the spread of dangerous plant pathogens and pests and the expansion of their habitats and potential targets. These destructive consequences due to rash decisions also have significant economic consequences, disrupting the activities of entire agricultural production sectors, increasing the cost of chemical plant protection and creating environmentally dangerous precedents associated with increased pesticide loads [4]. Thus, large-scale introductions and difficulties in ensuring quarantine during the transportation of goods can cause damage not only to nature or agriculture [5] but also to cultural and historical landscapes [5,6], as was the case with the boxwood moth, when planting material was imported for urban landscaping and sports facilities to a region where this pest was absent [7]. All of these are on the agenda of daily environmental monitoring and at the forefront of research at the global level carried out by regional and international organizations, such as the FAO [8]. The study and protection of plants, as well as the preservation of their diversity, require modern approaches to

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morphological and anatomical research supported by biochemical and molecular methods [9], as well as digital support using the predictive capabilities of phenotyping and 3D modeling [10].

This work plays an important role in preserving resource potential, traditional organic farming and developing a responsible approach to agriculture while ensuring the protection and biodiversity in the environment. The studies proposed by the authors (contributions 1–13) in the fields of applied and structural botany, bioinformatics and bioengineering can contribute to the expansion of scientific knowledge in the field of experimental botany and allow for the popularization of knowledge related to this important aspect of environmental responsibility, one way or another affecting different spheres of human life.

## 2. An Overview of Published Articles

### *2.1. Natural Populations*

The ecology of natural communities requires good expeditionary practice and careful analysis. Of particular interest are rare species that grow in hard-to-reach places and provide stable natural landscapes (contributions 1, 4 and 12). An example of such a plant is *Zygophyllum pinnatum*, which is common in certain regions of Kazakhstan and Bashkortostan. Studying the diversity of such species and considering the subspecies characteristics of individual habitats supports our knowledge and allows us to monitor changes in regions where anthropogenic impacts are indirect. Research (contribution 1) has confirmed the stability of half of the studied populations and the need for protective measures for those where degradation processes have been identified.

In a study of natural populations of *Iris pumila* L. (contribution 4), it was found that difficulties in the stable maintenance of the vegetative propagation characteristics of this species are of particular importance; for this reason, grazing, fires and habitat disturbances pose a particularly high risk. Therefore, the preservation of these natural populations requires constant monitoring and special conditions for exploitation.

A number of species can only be effectively preserved if anthropogenic pressure is almost completely eliminated. Thus, *Pyrola chlorantha* Sw. being a very rare species for a number of regions, turned out to stably preserve populations in *Pinus sylvestris* L. plantations precisely under such conditions. At the same time, the authors found that this species, which is an indicator of the stability of phytocenoses, had differences in terms of age in the studied territories and persisted precisely in the absence of anthropogenic load (contribution 12). This is likely due to the recreational impact on vegetation cover of arid areas dominated by pine, which is influenced by changes in ecological and coenotic conditions reported in different regions [11].

### *2.2. Crops*

The physiological aspects concerning the selection, growing and storage of agricultural plants create enhanced opportunities for forecasting market developments, changes in costs and the expansion of assortment, which are important in terms of enabling a more expensive but more environmentally friendly and responsible method of agricultural practice. The use of Methanesulphonate makes it possible to obtain valuable genotypes with different shapes and colors of eggplant fruit. The results obtained by the authors (contribution 2) may be in demand when expanding the range of varieties of this valuable and popular vegetable, with a possible change in the properties of the antioxidant system [12].

Umbrella plants are important green, vegetable and herb crops, widespread in the food practices of different peoples. Only relatively recently has it been possible to identify the role of oxalates in the formation of a number of the tissues and organs of these plants (contribution 6). It has been established that crystal structures may be important in the formation of the special structure of fruits in these species, which makes it possible to confidently identify the botanical relationship of many species and simplifies their identification.

Abiotic factors, such as drought, acidic soils and high osmotic pressure, have a significant impact on the quality and yield of crops. In some cases, they can cause such a strong

drop in yield that the cultivation of traditional crops such as wheat and barley becomes impractical. Researchers (contribution 9) have proposed that regions with severe drought and other unfavorable edaphic factors should grow the more stable and equally valuable crop, *Sorghum bicolor* (L.), making it possible to obtain high grain yields that are not inferior in nutritional value to other cereals. Salinization is a significant limiter even due to the effects of secondary salinization, even in those areas where there is no shortage of water. For this reason, choosing the wrong variety can lead to significant yield losses. The physiological basis of salt tolerance is very complex, and diagnosed tolerance often differs at different stages of ontogenesis [13]. An evaluation of simple diagnostic techniques was carried out on one of the most popular plants of the *Solanaceae* family, the tomato. It was revealed (contribution 10) that an important factor relating to the sustainability of traditional cultures is origin. Thus, varieties obtained in the Astrakhan region demonstrated higher resistance to salinity for any evaluation criterion used, as expected. This suggests that the use of local genotypes may still be appropriate for breeding for salt tolerance.

One of the most important parameters in ensuring high-quality and varied nutrition is proper and qualitative storage of the yield. Researchers have suggested (contribution 5) that these goals require evaluation of the packaging materials used, optimal temperature conditions and the establishment and implementation of clear protocols to ensure quality and safety [14]. Researchers have confirmed the importance of these parameters for valuable green crops such as onions. The results allow us to propose clear storage criteria.

Modern biotechnological approaches and genomic technologies for obtaining new valuable mutant, transgenic and modified forms require high-quality work and an understanding of the botanical aspects to obtain morphogenic calli and develop regeneration and cryopreservation protocols that can be used for cereal, fruit and ornamental plants (contribution 3, 11, 13). Structural botany and cytological analysis methods are strategically important bases for creating technology [15].

### *2.3. Ornamental Plants*

The study of ornamental plant species often leads to the establishment of new interdependencies and can clarify the individual details of evolutionary processes important for understanding biological regularities. The research presented in this issue demonstrates new advances in the study of the characteristics of valuable orchids (contributions 7 and 8). Clarification of the characteristics of microsporogenesis is an important aspect concerning the propagation of these popular ornamental plants.

## 3. Conclusions

These various methodological approaches, including careful randomized studies of populations, the search for new analytical approaches to assess resistance and the refinement of ontogenetic details at the cellular, tissue and organismal levels are key strategies in modern plant physiology. Searching for new correlations based on a clear experimental basis using phenotyping [16], bioinformatics and molecular approaches [17], supported by reliable methods of analysis of morphology, physiology and biochemistry, enables the use of both established routine methods and modern technologies and methodological solutions to obtain new knowledge [18].

Digital technologies, which can be used to obtain new correlation relationships and new qualitative repetitions of previously obtained data, will collectively help solve problems relating to the influence of the growing environment on the stability and flexibility of evolutionary systems at the level of cells, tissues, organs, plants and plant communities, as well as the ability to regulate these important processes.

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