For 125 years
N.G. Kholodny devoted:

N.G. KHOLODNY'S IDEAS AS A TRIGGER OF THE PHYTOHORMONOLOGY DEVELOPMENT

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«About a quarter of a century ago… there were laid foundations of a new science of plant endocrinology, or, in other words, the science of plant hormones (phytohormones). Within a short time span this young science achieved much and succeeded in studying the chemical nature and physiological role of those substances. Some plant hormones have been isolated and produced as pure chemicals. That enabled synthesizing chemical compounds similar in their activity to natural phytohormones; however, these new substances have never been found in plants. Those were so-called synthetic plant growth substances."

Those words were written in 1949 by Academician M.G. Kholodny, a great naturalist and thinker of the 20th century, one of the founders of phytohormone science and creators of the hormonal theory of tropisms. On June 22, 2007, the scientific community of Ukraine celebrated the 125th Anniversary of this outstanding naturalist, known for his profound and pioneering studies in the fields of plant physiology, microbiology, ecology, philosophy, and general biology (natural sciences), who not only established the modern plant endocrinology but also predicted the main trends of development of this science.

In view of the aforesaid, I would like to remind you that already in 1933 Kholodny formulated the concept of «hormone»: "A plant hormone should be regarded as a substance that is produced in a plant organ, is able to get into growing tissues, and control, that is to increase or decrease, the rate of cell growth, acting in trace quantities". Phytohormones are substances-inductors, organizers of growth processes and morphogenesis, which "…with some combination of internal and external conditions, despite their minute content in the organism, acquire an ability to change the rate and direction of physiological processes occurring there".

It should be emphasized that Kholodny established fundamentals of the science of phytohormones at the time when only one plant hormone, auxin, was known. But even in that time he already spoke about polyvalent functions of the plant hormone, came up with an idea of a great variety of hormones in the plant world. He wrote: «We should bear in mind that, in addition to auxin, the plant organism contains some other substances of hormonal types». In view that he foresaw that «…various morphogenetic processes, and plant development in general, must be related to the action of phytohormones appropriately distributed in the plant organism».

As a result of M.G. Kholodny research, there was established a physiological polyfunctionality of auxin (as he wrote, «auxin polyvalency»), its ability to cause various effects depending on its concentrations and nature of a substrate on which that substance acts.

He experimentally demonstrated that a growth substance «plays an important role in the mechanism of geotropic responses in general. Plant organs whose upper tips do not perform any specific physiological functions, "irritants" are not exceptions in this respect».

In 1918 M.G. Kholodny expressed new ideas on the localization of synthesis of phytohormones and their transport: «The root tip is an internal-secretion organ that exudates into the growth zone some substances of a hormonal type». Later that suggestion was proved by classical experiments on sections of roots, hypocotyls and coleoptiles of corn, oats, and lupine. Experimental studies carried out by M.G. in the 1920s-1930s to investigate the effects of hormones on the root growth enabled him to show for the first time that phytohormones can not only stimulate but also inhibit plant growth: "a substance diffused from the corn coleoptile contributes to the coleoptile growth and at the same time quite evidently inhibits the root growth".

Through his experiments M.G. Kholodny discovered one more significant scientific fact concerning the speculative «irritant» itself – the substance that was produced by corn coleoptile apical cells and that was classified as a plant hormone. That was the phenomenon of non-specificity of hormonal action: "…substances that are produced by cells in upper tips of *Zea mays* coleoptiles are by no means specific".

While continuing those experiments, M.G. paid attention to the fact that "a disruption of the hormonal balance may cause development of tumors (swellings) in plants" followed by development of lateral, auxiliary roots. Thus, it was the first demonstration of the morphogenetic effect of plant hormones.

Analyzing the results of his experiments that showed some morphogenesis disruptions in roots resulting from auxin effects, M.G. expressed hope that the introduction of "phytohormones into the plant organism at the specific stages of its development may in the future be a very effective method to increase the production of plant mass and to control development of agricultural plants". Observing a high physiological and biochemical activity of phytohormones, M.G. concluded that "that peculiarity … makes them the most suitable means for changing the course of various life processes".

We are all witnesses that these visionary views of M.G. have not only been proven but become commonly accepted, widespread ideas. It should also be added here that in 1948 M.G. put forward a new concept of parahormones, the substances that are not typical of plants but are obtained synthetically and characterized by a high physiological activity. And only much later it has became clear that it was an outline for a new direction in studies of plant growth and development: using synthetic analogues of phytohormones for scientific and practical purposes. Thereby, the foundation was established for the advent of a unified concept of regulators of plant growth and development.

One of the most significant problems of phytohormonology is the role of phytohormones in plant transition from the vegetative stage to the generative one. M.G. was not directly involved in such research; however, already in 1938 he published an article entitled "Does the flowering hormone exist?" in which he assumed that "not some specific substance but the whole complex, compounds of known metabolites, possibly including hormones, cause the setting and development of buds". Fifty years later, in 1988, this idea proposed by M.G. was formulated by the Belgian scientist Bernye in his multifactor theory of flowering control, according to which the floral stimulus is a combination of assimilates and complex of known hormones.

It is very much to the point to conclude this brief description of Kholodny's ideas and previsions, which have become not only the beginning of modern phytohormonology (phytoendocrinology) but also have determined for many years the directions of further development of this science, by his words from the conclusions of his famous worldwide (but presently rare) book "Phytohormones. Essays on Physiology of Hormonal Phenomena in a Plant Organism".

The significance of «"infinitesimals", both in the scope of problems concerning the structure of «living matter» and regarding biochemical and physical processes occurring in plant and animal organisms, increases in modern biology every year. In the last field this basic trend in modern natural science is expressed in an intense interest in various oligo-dynamic phenomena, that is, in the processes involving nearly imperceptible minute quantities of substance and energy. It becomes more and more clear that just those phenomena form a typical feature of the organized nature, and that without a complete and precise knowledge of them, the final aim of biological science can not be achieved. This aim is "getting control" of living nature in theory and in practice, that is, an ability to predict events that will occur in it and control them in conformity with our interests and knowledge.

I would like to stress the fact that all the above-mentioned citations were written before the year of 1939; that is, long before the mankind could use nuclear power, before the advent of molecular biology and modern nanophysics, before clear understanding of the structure of

living matter at all levels of its organization. It is a direct evidence of the scientist's genius, the scope of his scientific interests, understanding of the basic tendencies in development of science, and richness of his erudition.

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