



Professor Tatyana Batygina: Scientific Heritage

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Tatyana Borisovna Batygina, a remarkable first-rate scientist in the field of plant embryology and developmental biology was born October 24, 1927 in Leningrad in a family of third-generation intellectuals. October 24, 2017 marks her 90th birth anniversary. She was Professor of the Saint Petersburg State University, corresponding member of Russian Academy of Sciences, Honored Worker of Science of Russian Federation, head of Department of Embryology and Reproductive biology of Komarov Botanical Institute RAS (1983–2015). Unfortunately, she passed away on September 16, 2015 at the age of 87 years.

Tatyana Batygina had matriculated to Leningrad State University in 1946 and graduated in 1951. During her university days she was influenced up to great extent by various talented professors as V. A. Dogel, Yu. I. Polyansky, D. I. Nasonov, M. E. Lobashev, P. M. Zhukovsky, N. L. Gerbilsky and others, whose brilliant lectures inspired her interest to researches. Her first research study was dealing with developmental biology of melons and gourds. Yet in 1950 she published her first article “Influence of paternal principle to the maternal plant (xenia and metaxenia)” done in the context of Ch. Darwin’s ideas.

In 1951 Batygina entered a Ph. D. programme of All-Union Institute of Plant Breeding performing the study of tomatoes distant hybridization supervised by the academician D. D. Brezhnev. At the age of 25 years, she had defended a Ph.D. thesis in 1954, and in September, 1955 she got a permanency in the Department of Anatomy and Morphology of Komarov Botanical Institute of AS USSR hosted by Professor V.G. Aleksandrov. At that time, the embryological field was developed in the department actively under the guidance of Prof. M. S. Yakovlev and that was Batygina’s choice. She understood clearly the close relation of the problem of distant hybridization and plant reproduction. Her supervisor at that time was Prof. E.N. Gerassimova-Navashina, the author of unique works on double fertilization in flowering plants. Under her guidance Batygina performed the first investigations on fertilization, including that upon the distant hybridization in wheat.

Working with remarkable scientists, talented disciples and followers of academician S.G. Navashin : E. N. Gerassimova-Navashina and M.S Navashin developed “higher school of

understanding of science in all its aspects ranging from the “pure” science to organization of scientific work”.

In 1974 Batygina had successfully defended doctoral thesis. Besides the detailed analysis of embryological processes upon the wheat distant hybridization it contained a number of important statements opening the wide perspectives for solving the problem of monocotly. Particularly it was discovery of a new Graminad-type of embryogenesis in wheat and presumption of its presence in other cereals and monocots; the notion on different pace of ontogenetic displacement of shoot point of growth during evolution of embryos of various monocot taxa and the analysis of this process in terms of different theories of monocot embryo origin. After defending doctoral thesis she started working in field of experimental embryology with the main problems of plant developmental biology, the morphogenesis and differentiation of reproductive structures. The result of this intensive work was the elaboration of the original research strategy for the reproductive structures morphogenesis by Batygina with her colleagues. It implied engaging the complex systemic approach, including comparative analysis of generative structures development *in situ*, *in vivo* and *in vitro* in model species possessing different life forms and modes of reproduction, comparison of kinetics of morphological and physiological-biochemical processes, simulation of conditions for different developmental stages considering data on morpho-biochemical investigation of structures *in vivo*.

In 1983 Batygina became a head of the Laboratory of Embryology of Komarov Botanical Institute of AS USSR. Under her guidance the research team of the laboratory had perfectly accomplished the work on ambitious project “Embryology of understudied flowering plant taxa”. The result was a publication of 5-volume edition “Comparative embryology of flowering plants (1981–1990; edited by M. S. Yakovlev and Batygina), that was a reason for awarding the research team of the laboratory with the State Prize of Russian Federation in the sphere of science and technology (1993). Despite the inherently strict subject of this work (plant systematics and phylogeny), Batygina with her general biological view of the problems had given it wider meaning already at that time.

Yet in the middle 1980-ties Batygina had developed her conception of plant reproduction systems, based on brand new, non-traditional approach to evaluation of diversity of reproduction types and modes from viewpoint of both the genetic information transmitted to posterity and morphogenetic modes of its realization. A powerful stimulus for its creation was a discovery of the phenomenon of embryoidogeny, the new category of vegetative propagation which had united a complex of phenomena with uncertain status (cleavage, nucellar, integumentary polyembryony, pseudovivipary) on the base of common mode of new sporophyte formation, the embryoidogenesis, as well as the related phenomenon of polyembryony and genetic heterogeneity of seeds. This discovery allowed creation of new classification of reproduction systems, based on two main criteria: mode of reproduction (sexual and asexual, i.e. involving or not involving both meiosis and fertilization respectively) and mode of new sporophyte formation (embryo-, embryoido- and gemmorhizogenesis). Detailed study of various aspects of these processes allowed Batygina not only to combine into single system the views on modes of reproduction, such as establishing state and relations of types, modes and forms of seed and vegetative propagation (which realization defines reproductive strategy of species and provides flexibility and tolerance of reproduction systems), but also to make a number of other important conclusions. Among them there are: cardinal biological role of embryoidogeny phenomenon as peculiar mode of sporophyte cloning in plant life cycle (beginning with zygote) and as a main cause of genetic heterogeneity of seeds and populations, its advantages as compared with gemmorhizogeny in colonization of new local territories.

The contemporaneity and relevancy of Batygina's ideas was manifested especially brightly upon holding the XI International Symposium "Embryology and Seed Reproduction" (ISER) organized at her initiative in 1990 in Leningrad. On the symposium Batygina had presented explicitly her non-traditional notions on the plant systems of reproduction that immediately attracted the broad attention. These notions also run like a golden thread through all three volumes of fundamental encyclopedic edition "Embryology of flowering plants. Terminology and concepts" (1994–2000), which is the extensive work on complex characterization of multiple phenomena related with plant reproduction and comprehensive revision of notional and conceptual framework of the latter.

It is worth to be noted, that research work in the laboratory at that time was not restricted by pure theoretical investigations, but many problems of applied importance were actively developed in those years, such as study on multiplication of valuable plant genotypes *in vitro*, distant hybridization and usage of mutants, obtaining haploids basing

on theoretical elaborations of Batygina. At her initiative the issues of repatriation of rare orchid species to the natural habitats with usage of plants grown in tissue culture were successfully solved. Namely at that time (1996) the research team of the laboratory under Batygina's guidance got the official status of the Leading Scientific School of Russian Federation ("Development of theoretical basics of flowering plant seed reproduction"), which incorporated large number of her disciples from various regions of Russia and CIS countries. In 2002, the researchers of the laboratory headed by T.B. Batygina were awarded with the Prize of the Government of the Russian Federation in the sphere of science and technology for round of long-term fundamental and applied investigations on plant reproduction, considering social and economical effect from implementation of their results into practice.

In 2003 Batygina was elected to be Corresponding Member of Russian Academy of Science. She initiated publishing the 3-volume edition "Embryology of Flowering Plants. Terminology and Concepts" in USA (2004, 2006, 2009). At the same time several her crucial articles were published, which influenced significantly the subsequent progression of research process in the laboratory. One of them is the joint elaboration by T. B. Batygina and V.E. Vasilyeva of the theory of critical periods in plant ontogenesis. At the same years T.B. Batygina had significantly increased the level of understanding of the problem of identification of embryo and embryoid initial cells under natural and experimental conditions, as well as the role of stem cells in plant morphogenesis and evolution. She had proposed the original conception, which postulated that formation of stem cells (zygote derivatives) is characteristic for all plant organs and life cycle stages, and their functioning depends on their localization and purpose. Following up upon this idea T.B. Batygina had considered for the first time the phenomenon of polyembryony and genetic heterogeneity of seeds from viewpoint of notion on plant stem cells that explains the different genetic nature of embryo upon the various apomixis forms taking into account cloning of maternal and daughter organisms. Further analysis of issues related with stemness and totipotency of cells and the role of critical periods in plant morphogenesis had served as a basis for formulation of statements on universality of the phenomenon of switching over developmental programs, conditioning the transitions between different morphological processes in onto- and phylogeny, as well as the crucial role of stem and somatic cells in the mechanism of this phenomenon as a basis of reproduction systems plasticity.

The important stage in this elaboration was raising the question on role of somatic cell and somatic evolution of plants. Batygina's conceptual elaborations were reflected in her numerous monographs, textbooks and guidelines: "Plant

Propagation” (2002); “Vivipary in Plants and Animals: Invertebrates and Lower Chordates” (2006); “Botany with Bases of Phytocoenology: Anatomy and Morphology of Plants” (2006); “Stem Cells of Plants in Ontogenesis and Evolution” (2010); “Morphogenetic Developmental Programs. Stem cells” (2011). Especial attention in her works was paid as before to elaboration of theoretical basics of cultivation of reproductive biological systems *in vitro* as a basis for developing new biotechnologies. This approach was elucidated most completely in joint monographs “Embryological Bases of Androcliny in Wheat” (2005) and “From Microspore to Variety” (2010).

During the last years Batygina’s aspiration expressed quite brightly to analyze the reproduction systems and ontogenesis regularities from the viewpoint of the problem of integrity and reliability of biological systems, which is the priority problem of developmental biology. Developing the ideas of A.A. Malynovsky on biological objects as systems and relying on her own elaborations in this field, she placed an emphasis on the fundamental principles of organization of biological systems. Among them there are the interaction of elements of biological systems of different organization levels with each other and environment; the hierarchical organization of biological systems illustrating continuity and discretization of development; appearance of unique characteristics in new systems which are absent at previous level; presence of some properties of biological systems which can not be reduced to the sum of the properties of subsystems comprising them.

Batygina was always tending to develop the approach to study ontogenesis as alive integrated biological system. It was used as a basis for her elaboration of the strategy of reproduction research from viewpoint of integrity and system of reliability of plant organism. She began the active discussion of the problem of homology of cell elements of reproductive structures and revealed the especial role of the phenomenon of embryoidogeny in interdisciplinary knowledge synthesis not only in developmental biology, but also in other biological disciplines.

The most outstanding final result of Batygina’s longstanding researches is her unique monograph : Batygina TB 2014. Developmental biology of plants. Symphony of life. Dondua AK, Ermakov IP and Sharova EI (eds.) Saint Petersburg, DEAN. pp. 764. [Bilingual Edition]. The publication can be considered as one of the most significant events in the world biological science during the last years. The monograph actually is the only known review, where not just the main conceptions of modern developmental biology are presented and the basics of the theory of reproduction are stated, but also the crucial directions of further investigations are denoted.

Scientific works of Batygina got the highest appreciation and recognition of the world scientific community and favoured for strengthening the prestige of Russian science. Since 1990 she was a member of the Council of the International Association of Sexual Plant Reproduction Researchers (IASPRR) and up to her last days she kept the status of honorary lifetime member of the association. T. B. Batygina was a member of editorial boards of large international journals: “The International Journal of Plant Reproductive Biology”, “Phytomorphology”, “Acta Biologica Cracoviensia”, a member of a council of journal “Plant physiology” (in Russian), and some other. During many years she participated as organizing committee’s chairman or member in various top-level international congresses and conferences. She was repeatedly invited as a lecturer in different institutions: Institute of Mutagenesis and Differentiation (Pisa, Italy), Indian Institute of Science after J.N. Tata (Bangalore, India), universities of Kyoto (Japan), Delhi, Mysore (India), Ohio (USA) and many others. Besides the State Prize and the Prize of the Government of the Russian Federation her works also awarded by medal after G. Mendel (Czechoslovakia, 1984) and medal of Komarov Botanical Institute of Russian Academy of Sciences “For contribution to botany” (St. Petersburg, 2014). The Society of Plant Reproductive Biologists decorated her “LIFE TIME ACHIEVEMENT AWARD” posthumously during the V International School for Young Scientists «Embryology, Genetics and Biotechnology» dedicated to the memory of the Professor Tatyana Batygina, October, 9-14, 2016. The award was received by the daughter of Prof. Batygina from the Society’s Secretary, Prof. S.V.S. Chauhan.

Batygina made 7 visits to India and she delivered lectures at the international congresses and symposia in various scientific and educational establishments, resulted in a number of cooperative publications. The unforgettable moment in her life was the meeting with Svyatoslav Roerich and his wife Devika. Roerich invited her to all symposia for young people for various aspects of painting. Over many years Batygina was a Professor of Saint-Petersburg State University. She trained more than 30 Ph.D. and 20 Doctors of Biological Sciences for Russia, India, Poland, Mongolia and some other countries. The very warm memories in Batygina pedagogical work were related with Indian Ph.D. student Nityananda Upadhyay (1992). The basis of these relations was established by the Indian-Soviet Symposia on the Embryology of Crop Plants, preceded in New Delhi (1976) and Leningrad (1977). Batygina had established the especially tight contacts with India, with scientists of different universities and institutes of a number of cities. Such outstanding scientists e.g. P. Maheshwari, H.Y. Mohan Ram, R. N. Kapil and N. N. Bhandari and their disciples had

practical study in Komarov Botanical Institute. She stated in her reminiscences, India occurred to be a native country for her. She liked the general scientific problems which Indians were studying, concerning the classical embryology and experimental data, considering the integration of various specializations, particularly questions of symbiosis (Prof. M. R. Viyaraghavan).

Batygina was an expert in organizing the scientific events e.g. it was with regular XI International Symposium

“Embryology and Seed Reproduction” (Leningrad 1990), which due to the big number of participants (more than 400 persons) was officially recognized as a I International Congress on Sexual Plant Reproduction, and its brilliant and original organization is remembered by many participants until now.

The life of T. B. Batygina is an example of selfless service to be beloved science, and her fundamental works comprise the program for farther development of the reproductive biology and related scientific trends.



Fig.1– The young T. B. Batygina working in the laboratory of Embryology or the Komarov Botanical Institute; Fig.2– After her Doctorate; Fig.3–Participating in International conferences; 4: With Prof. Svyatoslav Roerich at Bangalore, India, 1984; Fig.5–Felicitation on her success and birth day and Fig.6 – Life time achievement award of the Society of Plant Reproductive Biology posthumously received by her daughter from MS. Helen N. Batygina, from Prof. S.V.S. Chauhan, Secretary of the Society.