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TEACHING CYTOGERONTOLOGY IN RUSSIA AND CHINA

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Approaches to teaching the cell biology of aging (cytogerontology), within the appropriate agreements by scientists of the School of Biology of Moscow State University and at the Department of Life Science and Engineering of Harbin Institute of Technology (China), are described. The authors draw attention to certain differences in teaching biology between the two institutions and emphasize the significance of a system approach to teaching cytogerontology. This approach makes it absolutely necessary to introduce the course on the basics of biology of aging. It is concluded that full perception of the data from modern molecular cell cytogerontological research, by the students from both institutions, is impossible without understanding the fundamental notions and definitions used in both theoretical and experimental gerontology.

Key words: cytogerontology, aging, cell biology, teaching, system approach

The Harbin Institute of Technology (HIT) has grown out of the Harbin Sino-Russian School for Industry established by Russian engineers in 1920 to educate personnel in the field of construction and maintenance of the Chinese Eastern Railway (CER). In 1928, the school was renamed the Harbin Institute of Technology. In 1950, the administration of HIT was taken over by the Chinese government and later the institute became a university. Since its establishment, increased attention has been paid to this institution by the Chinese government. In the 1950s, HIT was acknowledged by the Chinese government to be one of the two institutes of higher education in the country adopting the advanced experience of the Soviet Union in education. Since then, HIT has more than once been found among the top ten leading institutes of higher education in China, which received special financial support from the government. HIT comprises eight technical laboratories of national significance, which have integrated the results of modern research worldwide. The state's decade-long funding of the development of high technologies in the institutions of higher education has helped HIT achieve recognition as the second best university in China.

The Department of Life Science and Engineering (DLSE) of HIT was established in 1995. DLSE gives both bachelor and master degrees to students in the fields of molecular biology, cell biology, developmental biology, bioengineering, and microbiology.

In 2005, Moscow State University (MSU) and HIT entered into an agreement on scientific and educational collaboration, involving an exchange of teachers, students, and PhD students. A delegation of DLSE staff visited Moscow State University in October 2007. Another collaboration agreement (between the School of Biology of MSU and DLSE) was signed in 2008 based on the results of this visit. The parties agreed to:

1. Assist in exchanges of researchers, administrative staff, PhD and undergraduate students.
2. Assist in the establishment of scientific collaboration in the fields of mutual interest.
3. Provide mutual assistance in professional training of the researchers and teachers.
4. Exchange of experience in the development of the advanced teaching methods.
5. Assist in exchanging of publications and materials on the ongoing research.
6. Mutually organize two- and multi-way symposiums, workshops, and conferences.
7. Implement joint research projects and programs (given that there are opportunities and mutual interest).

To apply the goals of the approved working program, the School of Biology of MSU and DLSE of HIT agreed upon educational and scientific collaboration in the following major subjects: cell biology, genetics, molecular biology, bioengineering, biophysics, biochemistry, and neurobiology. This working program also assumed exchanging of teachers to give lectures on the subjects mentioned above.

As a result of these agreements, in 2008, teachers of the School of Biology of MSU started giving lectures devoted to various aspects of molecular cell biology to master's students at DLSE of HIT. In particular, the Head of the Evolutionary Cytogerontology Sector, School of Biology of MSU, A. N. Khokhlov, was commissioned to teach the cell biology of aging. It was assumed initially that this would focus only on specific results of cytogerontological research (cytogerontology being the science that studies mechanisms of aging in experiments on cultured cells [6, 9, 10, 12–14]). However, the scope of the lectures was significantly broadened on the initiative of A. N. Khokhlov, and based on the lecture series «Basics of Biology of Aging» developed by him in 1999 [8, 12, 15, 16]. Since then, this course has been permanently offered at the Department of Embryology of the School of Biology (MSU). The scope of this course embraces almost all the aspects of both theoretical and experimental gerontology:

1. Gerontology and its role in biology and medicine. The history of its establishment and development as a science.

2. The current state of gerontological studies in Russia and abroad.

3. Definitions of the following terms: aging, mortality, life span (average life span, maximum life span, life expectancy, species life span). What is the rate of aging? Accelerated and premature aging. Progeroid syndromes.

4. Survival curves, mortality tables. The Gompertz–Makeham formula.

5. Longitudinal and cross-sectional studies. Sex differences in life expectancy. Evolution and aging.

6. Longevity and long-livers. Aging and non-aging organisms. Age-specific diseases. Is aging a norm or a pathology? Geriatrics and biology of aging. Social and psychological aspects of gerontology.

7. Various concepts of aging (free radical theory, error catastrophe theory, «cholesterol» concept, the concept of cell proliferation restriction as the reason for the accumulation of damaged macromolecules during aging, etc.). Methodology of gerontological research. The requirements for new theories of aging.

8. Biological age — definition, assessment methods, application in gerontological and geriatric studies. The requirements of the biological age markers.

9. Physiology, molecular biology, and biochemistry of aging. Genetics and aging.

10. The possible role of changes in DNA, proteins, lipids, structure and functions of membranes in aging. DNA repair and aging. Cholesterol and aging.

11. Age-related changes in various physiological systems (blood, cardiovascular system, respiratory system, digestive system, urinary system, neurohumoral system, and immune system).

12. Germ cells and aging. The problem of «immortality» of the germ line. The maternal age effect. Stem cells and aging.

13. In vitro aging (the Hayflick phenomenon) — the history of the question, application in modern gerontology. The theory of marginotomy. Telomeres and telomerase. The commitment theory. The «stationary phase aging» model. Other gerontological models using cultured cells (e.g., the cell kinetics model for testing geroprotectors and geropromoters).

14. «Gist» and «correlative» models in gerontological studies.

15. Experimental prolongation of life. Geroprotectors and geropromoters, various approaches to the testing thereof. Diet restriction. Physical activity. Antioxidants. Latirogens. Complexons. Ionizing radiation. Possible consequences of increase of species life span.

16. Aging in protozoa. The notions about aging of bacteria, fungi, plants, micoplasmas, etc.

The subject matter of the lectures was broadened because of the following considerations. Students of the School of Biology of MSU are SYSTEMICALLY taught biology, as well as chemistry, physics, mathematics, and other subjects. This means that, by their last years of study, students have adequate notions on many FUNDAMENTAL concepts of natural science, including origin of life, evolution, development, aging, and higher nervous activity. When students gain deeper knowledge in various specialty courses, they automatically embed this new information into the earlier acquired general knowledge of biology. Nevertheless, all lecturers who offer specialty courses at MSU still face the necessity of reviewing the above-mentioned fundamental problems and concepts, since without that, the meaning of specific biochemical, molecular biological or cytological data is not properly understood.

At DLSE, students with a bachelor's degree have good but narrow knowledge in the corresponding areas. This makes the above-mentioned problems with the mastery of fundamental biological knowledge even more critical than at the School of Biology of MSU. This became evident as a lecture course on cell biology of aging was delivered at HIT in recent years.

The telomere concept of aging provides a classical example of this. The concept was formulated back in the early 1970s by Russian scientist A. M. Olovnikov [17]. He assumed that shortening, with each division, telomeres are the «counter» that limits the number of divisions that normal animal and human cells are capable of (the Hayflick phenomen). Olovnikov's prediction has been subsequently supported by a large amount of experimental data. In particular, the enzyme (telomerase) was discovered later and it recovered the telomere length in the transformed cells after each cell division, thus making the cells «immortal,» i.e., having an unlimited proliferative potential. This discovery caused a new wave of theories of aging, which would explain this phenomenon by shortening of telomeres in the dividing cells. Surprisingly, the overwhelming majority of researchers neglected the fact that the most essential organs of highly developed animals consist of postmitotic or very slowly dividing cells; therefore, the mere idea of proliferative potential makes no sense for these cells. As for the cells that are capable of proliferation, they almost never use the entire potential during the lifetime of an organism. This fact was convincingly demonstrated by comparing this index for fibroblasts obtained from children and practically healthy long-livers [3]. It should be noted that, in this connection, the attempts of some gerontologists to present the mechanism of telomere shortening as the way to implement the aging program are now considered unreasonable. There is actually no need for the aging program. Our lecture series thoroughly explains that aging is likely to be a «by-product» of the development program [11]. Of course, students cannot grasp this without at least a brief summary of the fundamental principles of developmental biology.

Thus, despite the fact that the idea of «telomeric counter», as the major mechanism of aging of living organisms, did not correspond to the FUNDAMENTAL notions of the developmental biology and biology of aging, the telomere theory of aging persisted for many years. Moreover, it is still supported by some gerontologists. Although many researchers, including L. Hayflick and A. M. Olovnikov, repeatedly placed emphasis on the above-mentioned inconsistency in their publications, the situation is changing very slowly.

Another methodological problem is connected with the fact that many researchers studying the molecular cell mechanisms of the effect that various geroprotectors and geropromoters have on the aging process neglect the classical definition of aging as a combination of age-related changes resulting in increasing probability of death. Data on factors that increase or decrease life span are often interpreted in the studies as a modification of the aging process. However, aging and life span are not necessarily interrelated. If people did not age at all, they would not live eternally anyway. People would die because of random reasons, and the life expectancy would be increased only up to 700—800 years. It is impossible to adequately interpret the data obtained even in the most virtuosic experiments using the best modern equipment, without understanding this premise. We feel this must be surely explained to students who intend to study experimental gerontology. We would like to emphasize that this approach can be seen in all of the best monographs devoted to the biology of aging written by distinguished gerontologists [1, 2, 4, 5, 7].

Of course, it is much easier for MSU students to understand the lectures, since they are delivered in Russian, language that is natural for them. The lectures for Chinese students are given in English; Chinese students also use English to take their examinations. However, the knowledge of English is absolutely necessary for either group of students, since almost the entire world literature on the biology of aging is published in English. In this connection, it should be emphasized that the fact that all the presentation slides are made in English makes the comprehension of the material much simpler, and enhances the efficiency of studying, both in MSU and HIT. Therefore, later work with scientific publications is not a problem for students. Chinese colleagues record all lectures as video files containing both the presentation and the lecturer's comments. These have proven useful also at the School of Biology of MSU. Students receive these files to prepare for examinations.

Thus, there is an impression that, despite certain differences in the approaches to teaching biological subjects in MSU and HIT, the major problems with the «proper» organization of the course on cell biology of aging are similar. The SYSTEM APPROACH to teaching cytogerontology, which assumes the presentation of an introductory lecture series on the basics of biology of aging, is essential. We believe that students of both institutes of higher education cannot demonstrate adequate comprehension of the results of the modern molecular cell cytogerontological studies without understanding the fundamental definitions and terms used both in theoretical and experimental gerontology.

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О ПРЕПОДАВАНИИ ЦИТОГЕРОНТОЛОГИИ В РОССИИ И КИТАЕ

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Излагаются подходы к преподаванию, в рамках соответствующих соглашений, клеточной биологии старения (цитогеронтологии) специалистами биологического факультета Московского государственного университета им. М. В. Ломоносова в Центре инженерно-медицинских и биологических наук Харбинского политехнического университета (Китай). Отмечая имеющиеся определенные различия между двумя вузами в преподавании биологических дисциплин, авторы подчеркивают важность системного похода к изучению цитогеронтологии, делающего совершенно необходимым чтение вводного курса лекций по основам биологии старения. В заключении говорится о том, что адекватное восприятие студентами обоих вузов результатов современных молекулярно-клеточных цитогеронтологических исследований невозможно без понимания основных фундаментальных определений и понятий, используемых как в теоретической, так и в экспериментальной геронтологии.

Ключевые слова: *цитогеронтология, старение, клеточная биология, преподавание, системный подход*