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Alexandr Nikolaevich Bazhanov's Contribution to the Development of Tissue Biology and Evolutionary Morphology

Nikolai N. Shevlyuk

Orenburg state medical university, Orenburg, Russia

ABSTRACT

The aim of this article is to analyze the contribution of Alexandr Nikolaevich Bazhanov, a prominent Soviet histologist and representative of the Orenburg scientific histological school, to the development of fundamental problems in tissue biology and evolutionary morphology. Bazhanov was engaged in scientific research during the 1960s to 1990s. Bazhanov's primary scientific research was devoted to the problems of embryonic histogenesis of the esophageal epithelium, the morphofunctional characteristics of esophageal mucosal structures, the study of evolutionary tissue changes, and tissue cultivation. His comparative histological studies and work on tissue culture led to the hypothesis that the esophageal epithelium originates from the prechordal plate. The findings obtained by Bazhanov served as the basis for the assertion that the prechordal plate is of endodermal origin. The results of his work made a substantial contribution to the development of the evolutionary direction in histology and promoted the advancement of research on debated problems in tissue biology. Bazhanov's scientific legacy includes nearly one hundred articles and three monographs, two of which were co-authored. The importance of his work for the advancement of modern tissue biology was widely recognized during his lifetime. These studies have remained relevant even several decades after they were completed.

Keywords: Alexandr N. Bazhanov; history of histology; morphogenesis; esophagus; histogenesis; epithelium; tissue cultures; evolutionary morphology.

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Вклад Александра Николаевича Бажанова в развитие проблем биологии тканей и эволюционной морфологии

Н.Н. Шевлюк

Оренбургский государственный медицинский университет, Оренбург, Россия

АННОТАЦИЯ

Целью статьи является анализ вклада видного советского гистолога, представителя Оренбургской научной гистологической школы, Александра Николаевича Бажанова, в развитие фундаментальных проблем биологии тканей и эволюционной морфологии. Александр Николаевич Бажанов занимался научно-исследовательской деятельностью в 60–90-х годах XX века. Основные научные исследования А.Н. Бажанова посвящены проблемам эмбрионального гистогенеза эпителия пищевода, вопросам морфофункциональной характеристики структур слизистой оболочки пищевода, изучению эволюционной динамики тканей и их культивированию. Его сравнительно-гистологические исследования и работы по культивированию тканей позволили выдвинуть предположение о том, что эпителий пищевода происходит из прехордальной пластинки. Полученные Александром Николаевичем факты послужили основанием для утверждения об энтодермальном происхождении прехордальной пластинки. Результаты его работ внесли весомый вклад в развитие эволюционного направления в гистологии и способствовали активизации разработки дискуссионных проблем биологии тканей. Научное наследие А.Н. Бажанова включает около сотни статей и три монографии, две из которых написаны им в соавторстве. Значимость исследований Александра Николаевича Бажанова для прогресса современной биологии тканей была высоко оценена ещё при его жизни. Не потеряли эти работы своей актуальности и по прошествии нескольких десятков лет.

Ключевые слова: Александр Николаевич Бажанов; история гистологии; морфогенез; пищевод; гистогенез; эпителий; культуры тканей; эволюционная морфология.

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Alexandr Nikolaevich Bazhanov在组织生物学与进化形态学发展中的贡献

Nikolai N. Shevlyuk

Orenburg state medical university, Orenburg, Russia

摘要

本文旨在分析苏联著名组织学家、Orenburg组织学学派代表人物Alexandr Nikolaevich Bazhanov在组织生物学与进化形态学基础问题研究中的学术贡献。Bazhanov于20世纪60至90年代从事科研工作。Bazhanov的主要科研工作致力于探讨食管上皮的胚胎期组织发生、食管黏膜结构的形态与功能特性、组织的进化动态及其培养方法。他的比较组织学研究及组织培养实验促使其提出了食管上皮源自脊索前板的假说。Bazhanov所获得的研究事实为确认脊索前板具有内胚层起源提供了依据。他的研究成果为组织学中进化方向的拓展做出了重要贡献，并推动了组织生物学若干争议性课题的进一步探讨。Bazhanov的学术遗产包括近百篇学术论文和三部专著，其中两部为合著。Bazhanov的研究对于现代组织生物学进展的重要意义在其生前就已受到高度评价。这些研究成果即使在几十年后的今天，也依然保持其学术的时效性。

关键词：Alexandr Nikolaevich Bazhanov；组织学史；形态发生；食管；组织发生；上皮；组织培养；进化形态学。

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INTRODUCTION

Alexander Nikolayevich Bazhanov (1934–2019), Doctor of Medical Sciences and Professor, was one of the scientists who worked throughout his entire research career to solve basic issues of histology. He was one of the most prominent representatives of the Orenburg Scientific Histological School. The year 2024 marks the 90th anniversary of his birth and the 5th anniversary of his death.

LIFE MILESTONES OF ALEXANDER BAZHANOV

Alexander Bazhanov was born on January 28, 1934, in Samarskoye village, Yekaterinovskiy District, Orenburg Region, to a family of collective farmers. He graduated from the Medical Department of the Orenburg Medical Institute in 1958. From 1955 to 1957, while he was a student, Alexander served as a deputy of the Orenburg City Council of Workers' Deputies. He was also a member of the city council's permanent committee on healthcare. After graduating from the institute, Alexander Bazhanov became the chief physician at the Ponomarevskiy State Farm Hospital in the Ponomarevskiy District of the Orenburg Region. He trained as a histologist at the Orenburg Medical Institute (Fig. 1 and 2) [1–4]. From 1962 to 1965, Alexander Bazhanov was a full-time postgraduate student in the Department of Histology at the Orenburg Medical Institute. He studied under the supervision of Professor Zoya Sergeevna Khlystova. Alexander Bazhanov was offered a position as an assistant professor in the department after completing his postgraduate studies in September of 1965. From February 1 to June 3, 1968, he served as acting head of the Department of Histology while Professor Khlystova was working in Moscow. In 1968, Alexander Bazhanov was elected associate professor in the Department of Histology at the Tselinograd Medical Institute [1–4]. Professor Bazhanov worked in this department from 1968 to 1997. He first served as an associate professor, then as head of the department. The only exception was from December 1986 to October 1987, when he was the head of the Department of Histology at the Stavropol Medical Institute. Professor Bazhanov had a bright start to his scientific research career and continued it until the mid-1990s. He stopped publishing almost entirely due to illness and retirement in the late 1990s. He then moved to the Stepanovsky farm in the Orenburg District of the Orenburg Region, where he lived for about twenty years until his death.

However, Professor Bazhanov remained interested in morphological issues even after retirement. His students, coworkers, and colleagues from different cities often sought his advice.

Bazhanov's scientific legacy includes nearly 100 articles and 3 monographs, two of which were co-authored (Fig. 3) [5–7].



Fig. 1. Alexandr Nikolaevich Bazhanov (1967) (photo from the archive of the Department of Histology, Orenburg State Medical University).

This study aimed to describe Professor Bazhanov's contributions to the development of fundamental issues in tissue biology.

STUDY OF MORPHOLOGY AND FUNCTION OF THE EPITHELIUM OF THE MUCOSA OF THE HUMAN AND ANIMAL ESOPHAGEAL MEMBRANES

Bazhanov's research focused on the esophagus of humans and animals. His Candidate of Sciences thesis, titled *Histological and Histochemical Characteristics of the Esophageal Mucosa in Ontogenesis and in Experimentation* [8], which he defended on March 11, 1966, and several articles, were devoted to various aspects of the esophageal mucosa's structure [9–12]. He was an author of several articles and a monograph [6] devoted to the comparative morphological and functional characteristics of the esophageal epithelium. This work is based on his Doctor of Science thesis titled *Properties and Distinguishing Features of the Esophageal Epithelium* [13], which he presented on October 8, 1980, at the meeting of Specialty Council D 074.42.01 (Д 074.42.01) at the Novosibirsk State Medical Institute.

Professor Bazhanov obtained new data and resolved disputed issues regarding the esophageal epithelium, including its origin in phylogenesis, transformation



Fig. 2. The staff of the Department of Histology of the Orenburg Medical Institute (1964): top row — graduate student Bazhanov Alexander Nikolaevich, assistant Abdrashitova Emina Hamidovna; bottom row — assistant Savitskaya Lyudmila Andreevna, associate Professor Volodina Evgeniya Petrovna, Professor, head of the Department Zoya Sergeevna Khlystova, graduate student Semchenko Yuri Petrovich. Photo from the archive of the Department of Histology Orenburg Medical University.

patterns in human and animal ontogenesis, morphology, and function of integumentary and glandular epithelia, and *in vivo* differentiation using Lazarenko's technique. He also investigated the reactive and adaptive restructuring of the epithelium under various destabilizing factors.

Professor Bazhanov studied the origins of the esophageal epithelium and initially proposed that it evolved from the prechordal plate [5, 8]. However, Professor Bazhanov later changed his opinion based on new data he had obtained and began considering the endoderm to be the source of the esophageal epithelium [6, 13]. Professor Bazhanov compared the epithelium of the human esophagus with epithelia of ectodermal and endodermal origin. He noted the following differences: a smoothed basal membrane, a significantly thickened cambium, secretory activity in the intermediate layer, an endocrine function in the glandular component, and a special protective barrier that prevents the epithelium from keratinizing under normal conditions. The main difference between the esophageal epithelium and the intestinal epithelium is the multilayer structure of the latter [8, 13]. The origin of the esophageal epithelium is still debated. Most researchers believe it is endodermal.

Professor Bazhanov discovered that during the embryonic development of humans and other vertebrates, the epithelial lining of organs that originate from the foregut, such as the esophagus, undergoes normal changes. In the early

embryogenesis, the esophagus epithelium is single-layered (simple). Then, it is replaced by a multi-row (pseudostratified) epithelium, which is then replaced by a multi-layered (stratified) squamous epithelium. In humans, this occurs during the middle of the fetal period [14–26].

Professor Bazhanov characterized the features of synthetic processes in the epithelial cells of human and animal esophagi at various stages of ontogenesis and in

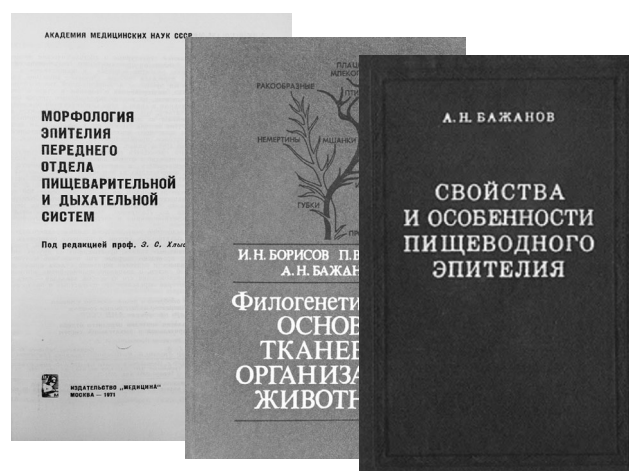


Fig. 3. Monographs, which were prepared by Alexander Nikolaevich Bazhanov (books from the library of the Department of Histology of Orenburg Medical University).

experimental settings based on his analysis of histochemical reactions. He was focused on the integumentary and glandular epithelia of the esophagus. Using histochemical techniques, he studied the exocrine and endocrine cells of the cardiac glands of the human esophagus and identified several types of endocrine cells in these glands [27–30]. Professor Bazhanov concluded that the identified cells may have similar tinctorial properties to those of the A-, B-, and D-cells of the pancreatic islets [29].

At that time, the Department of Histology of the Orenburg Medical Institute used the technique of culturing organs and tissues in the body, which was developed by Fedor Lazarenko [31]. Alexander Bazhanov mastered this technique during his postgraduate studies and used it as the primary technique in his subsequent research. While working in the histology departments at the Orenburg and Tselinograd Medical Institutes, Professor Bazhanov tracked the development of esophageal structures over different time periods (from 1 to 20 days). Epithelial structures were no longer detected in the implants when they were cultivated for more than 20 days, because all implanted tissue components died [5, 6, 8, 13, 32, 33].

Professor Bazhanov discovered that only the youngest cells in the lower layers of the epithelium enter a state of proliferation. Under culture conditions, epithelial growth can manifest in two forms: integumentary layers or submerged strands. In most cases, the integumentary layers are multilayered. The esophageal epithelium rarely grows as a single layer. These single layers were found to differentiate into single-layer structures, such as squamous, cuboidal, and columnar epithelia. Less frequently, they differentiated into pseudostratified epithelia. The epithelium of the newly formed integumentary layers can grow into the underlying connective tissue as submerged strands. Professor Bazhanov demonstrated that newly formed undifferentiated layers and submerged strands differentiate during cultivation. In some cases, differentiation occurs up to the point of keratinization of the epithelial layer [6, 8, 13, 32, 33].

Professor Bazhanov described how the esophageal mucosa epithelium reacts and adapts to chronic exposure to various negative factors. When negative factors are not very intense, the epithelium responds by increasing its synthetic activity and mild thickening of the layer. Strong, irritating stimuli cause a sharp increase in mitotic activity in cambial cells, leading to asynchronous reactive manifestations in the epithelium and connective tissue. This is primarily due to a delay in the epithelium's reactive potential [8, 13, 34].

The sources of origin, main mechanisms, and differentiation patterns of the esophageal epithelium in human ontogenesis were identified through tissue cultivation using Lazarenko's technique. For example, under implantation conditions, the esophageal epithelium was found to demonstrate polymorphism of strands, which was reflected by the development of stratified and simple, as well as pseudostratified, epithelia under the same conditions [5,

6, 8, 13, 32, 33]. The growth of the esophageal epithelium in cultures differs significantly from that of ectodermal and endodermal derivatives. Based on the evidence obtained, Professor Bazhanov hypothesized that the esophageal epithelium may originate from the prechordal plate, which demonstrates properties of both the ectoderm and endoderm [5, 8]. This led Professor Bazhanov to reevaluate the origin of the prechordal plate and how its derivatives differentiate.

Professor Bazhanov published several dozen articles on morphology and function of the integumentary and glandular esophageal epithelium and two monographs "Morphology of the Cranial Sections of the Digestive and Respiratory Systems" [5] and "Properties and Distinguishing Features of the Esophageal Epithelium" [6].

DEVELOPMENT OF FUNDAMENTAL ISSUES OF MORPHOGENESIS AND EVOLUTION OF TISSUES

Professor Bazhanov made fundamental contributions to tissue biology by comparing the histological characteristics of the esophageal epithelium in vertebrates. His research focused on the comparative histological analysis of histogenesis and tissue differentiation, using a histogenetic approach in most of his published works.

Professor Bazhanov discovered that the epithelial lining of the esophagus undergoes regular transformations during vertebrate evolution. For example, the simple epithelium typical of the esophagus of many lower vertebrates transforms into a pseudostratified epithelium that produces mucus. This transformation can be observed in some fish, all amphibians, and most reptiles. From this pseudostratified epithelium, stratified mucous epithelium is formed, which is found in some reptiles. During the evolution of vertebrates, this stratified epithelium evolved into a stratified squamous epithelium in all birds and mammals [6, 13].

In addition, Professor Bazhanov demonstrated that the divergent nature of esophageal epithelial differentiation is evident in embryonic histogenesis and at various stages of organism evolution. He proposed that this divergence causes the epithelium to combine its original endodermal properties with its newly acquired, convergent features as a stratified epithelial cover [6, 13].

It should be noted that, as a researcher, Professor Bazhanov was not afraid to abandon his own ideas when new facts refuted them. This can be traced through his evolving views on the nature of the prechordal plate and its derivatives. In the early 1960s, Professor Bazhanov believed that the esophageal epithelium originates from a special primordial tissue that is distinct from both the ectoderm and the endoderm and may originate from the prechordal plate [5, 8]. Professor Bazhanov considered the results of culturing the esophageal epithelium *in vivo* using the Lazarenko's technique as the most compelling evidence

supporting the theory that the esophageal epithelium originates from the prechordal plate. However, based on new data he obtained in the 1970s and 1980s, Professor Bazhanov suggested that the prechordal plate has an endodermal origin. In addition, he challenged the suggestion that the prechordal plate is responsible for the epithelial histogenesis in the pharynx, esophagus, air-bearing structures of the lungs, and branchiogenic glands [6, 13]. Professor Bazhanov based his conclusion on the characteristic location of the prechordal plate and the structure and volume of its derivatives.

Among Professor Bazhanov's works on comparative and evolutionary morphology [5–7, 35–41], the monograph "Phylogenetic Foundations of Animal Tissue Organization" [7] should be particularly mentioned, which was co-authored with Igor Borisov and Pavel Dunaev. The monograph discusses the origin of multicellular organisms, the emergence and transformation of tissues throughout evolution and ontogenesis, and the classification of tissues. Phylogenetic reconstructions of the evolutionary changes in tissues of various organs of humans and vertebrates are especially interesting.

Many of the ideas presented in this monograph are still discussed. For example, the authors stated that Mechnikov's theory of parenchymella (phagocytella) was not well-substantiated. According to Bazhanov and his co-authors, the endothelium should not be classified as an epithelial tissue because it most likely shares a common stem cell with the hematopoietic lineage. Regarding the levels of organization of organisms, the authors stated that morphological and functional criteria are used to classify tissues and that genetic criteria are used to classify histogenetic units. Based on cell differentiation and evolutionary changes, lineages can be identified. These subunits play an equal role in the organization of organisms and can be classified by three groups of criteria [7, 40].

APPLIED RESEARCH IN HISTOLOGY, CYTOLOGY, AND EMBRYOLOGY

Professor Bazhanov primarily focused on fundamental issues of histology, but he also constantly investigated applied issues in medicine and biology. For example, his first published work discusses reactive changes in the skin caused by antiseptic agents, such as iodine solution and formalin [42]. Several of his works explored the morphological and functional characteristics of the esophagus, testes, and pancreas in various pathological conditions such as Barrett esophagus, hypoxia, clinical death, and post-resuscitation period [43–46]. Professor Bazhanov demonstrated that hypoxia negatively affects the spermatogenic epithelium during the final stages of the post-resuscitation period, resulting in the formation of abnormal germ cells and disruption of their differentiation. During the degeneration and death of germ cells, the spermatogenic epithelium of convoluted seminiferous tubules contains spermatocytes

and spermatids with large nuclei, as well as multinucleated forms of developing germ cells. The article by Professor Bazhanov should also be mentioned [47], which described patterns of insulin content changes in rats at different post-resuscitation stages.

SIGNIFICANCE OF ALEXANDER BAZHANOV'S RESEARCH BY PROMINENT RUSSIAN MORPHOLOGISTS

As previously mentioned, Professor Bazhanov frequently addressed controversial histology issues in his publications. His work inspired active discussions in journals such as the Archives of Anatomy, Histology, and Embryology (*Arkhiv anatomii, gistologii i embriologii*). From 1978 to 1988, five reviews of Bazhanov's work were published by prominent Soviet morphologists, including Alexey Knorre, Georgiy Schmidt, Nikolay Kochetov, and Moisey Shubich [48–52]. Alexey Knorre, editor-in-chief of the Archives of Anatomy, Histology, and Embryology journal and corresponding member of the USSR Academy of Medical Sciences, published an extensive review of the joint monograph co-authored by Alexander Bazhanov [5]. The review thoroughly discussed all of its chapters. Knorre wrote, "This small yet significant joint monograph is completely devoted to clarifying the histogenetic specificity of foregut derivatives. The authors selected Lazarenko's implantation technique as the primary method for resolving this controversial issue in histology <...>. The authors of the monograph gathered substantial information on the behavior of foregut derivatives under implantation conditions (Lasarenko's term for "cultivation in the body") <...>. The Orenburg histological school is renowned for its preparation and microphotography techniques. During a visit to the department, the reviewer saw excellent demonstrations of these techniques, including preparations and color slides of the studies presented in the monograph." Knorre concluded that "it is important to emphasize the clear value and interest of the factual material obtained through many years of dedicated work by a large group of authors."

In 1978, Knorre published a positive review [50] on Bazhanov's monograph, "Properties and Distinguishing Features of the Esophageal Epithelium" [6]. On page 160 of that review, Knorre wrote, "This implies that the publication of this book is urgent and will contribute positively to the ongoing debate about controversial but not pointless issues on the origin and nature of foregut epithelia. This issue is not purely academic. The author correctly emphasizes that the problem involves their medical aspects related with dangerous blastomatous developmental anomalies." For this reason, discussions surrounding the issue cannot be pointless."

Professor Schmidt [51] wrote another review of this monograph. He wrote that "Properties and Distinguishing

Features of the Esophageal Epithelium” by Bazhanov is a serious monograph “based on a large body of comparative embryological and histological data on various vertebrate groups that Bazhanov investigated personally. The author’s research is clearly thorough and honest.”

The monograph “Phylogenetic Foundations of Animal Tissue Organization” by Bazhanov, Borisov, and Dunaev received controversial reviews [7]. After the monograph was published, Kochetov reviewed it negatively in Archives of Anatomy, Histology, and Embryology [48]. Kochetov concluded that, “by suggesting new ‘basic concepts of histology,’ the authors had appropriately challenged the validity of these ideas. Therefore, it appears that they did not accomplish the task they set out to do.”

Some time later, Shubich published a more balanced review, highly appreciative of the authors’ work [52]. He concluded that “in general, the reviewed monograph deserves a high appraisal. It synthesized a large body of evidence from various fields of biology and developed novel theories regarding the origins of multicellular organisms and the evolution of tissues. In addition, it introduced new theoretical concepts to general histology. Given the difficulty and extraordinary nature of the task, it is unreasonable to expect a clear approach to determining the limits of factual data extrapolation or all statements being completely persuasive. Though the monograph is challenging to read, morphologists who master its content will deepen their understanding of evolution and greatly expand their theoretical knowledge.”

CONCLUSION

Professor Bazhanov primarily focused his research on developing fundamental histology. His research on embryonic morphogenesis, focusing on the esophagus, helped determine the origins and progression of digestive organ alterations during embryonic development, and also advanced the

study of controversial issues in tissue biology. Comparative histological papers made significant contributions to the development of evolutionary issues in histology. Professor Bazhanov’s research was widely recognized during his lifetime as being important to advancing modern tissue biology. These studies have remained relevant even several decades after they were completed.

ADDITIONAL INFORMATION

Author contributions: The author confirms that his authorship complies with the ICMJE criteria (he developed the article’s design, collected and processed the material, prepared the text and illustrations, and reviewed and approved the final version prior to publication). The author agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад автора. Автор разработал дизайн статьи, собрал и обработал материал, подготовил текст и иллюстрации, одобрил рукопись (версию для публикации), а также согласился нести ответственность за все аспекты работы, гарантируя надлежащее рассмотрение и решение вопросов, связанных с точностью и добросовестностью любой её части.

Источники финансирования. Автор заявляет об отсутствии внешнего финансирования при проведении поисково-аналитической работы.

Раскрытие интересов. Автор заявляет об отсутствии отношений, деятельности и интересов за последние три года, связанных с третьими лицами (коммерческими и некоммерческими), интересы которых могут быть затронуты содержанием статьи.

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AUTHOR'S INFO

Nicolai N. Shevlyuk, Dr. Sci. (Biology), Professor;
address: 6 Sovetskaya st, Orenburg, Russia, 460000;
ORCID: 0000-0001-9299-0571;
eLibrary SPIN: 6952-0466;
e-mail: k_histology@orgma.ru

ОБ АВТОРЕ

Шевлюк Николай Николаевич, д-р биол. наук, профессор;
адрес: Россия, 460000, Оренбург, ул. Советская, д. 6;
ORCID: 0000-0001-9299-0571;
eLibrary SPIN: 6952-0466;
e-mail: k_histology@orgma.ru