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SCIENCE POPULARIZATION IN THE CONTEXT OF THE HISTORICAL DEVELOPMENT OF THE GLOBAL SCIENTIFIC ENVIRONMENT

PROKHASKO Markiyan,
PhD student,
Lviv Polytechnic National University, Lviv, Ukraine, e-mail: markiyan.t.prokhasko@lpnu.ua
ORCID – https://orcid.org/0009-0000-1671-9261

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Introduction. Science communication remains unevenly distributed. Both practical work in science popularization and academic interest in the dissemination of knowledge have prompted this article.

Relevance of the study. This article examines the popularization of Antarctic research – where information from diverse disciplines and international researchers is woven into a single narrative – as an alternative model for the development of the global scientific environment. Consequently, the research aims to analyze this model of Antarctic science communication against the backdrop of uneven global scientific development and its subsequent impact on the popularization of science as a whole.

Methodology. The research objectives were addressed through a multi-faceted methodological approach: *the historical-genetic method,* used to trace the evolution of science popularization; *comparative analysis,* which enabled the juxtaposition of parallel models of science popularization in various societies with those in Antarctic science; *counterfactual analysis,* applied to identify the underlying causes of uneven development in science and the dissemination of scientific knowledge; *the method of contrast,* employed to propose a more homogeneous model for the popularization of science.

Results. The evolution of science popularization has been shaped by distinct historical contexts. It stems from both the strategic requirements of states to bolster technological advancement and the individual scholarly initiatives, in particular most notably eminent scientists.

Conclusions. The uneven development of global science directly affects the disproportionate process of knowledge popularization. With few exceptions, Antarctica serves as a positive example of scientific integration, fostering collaboration among states, institutions, and scientists in both research and science communication. This new perspective on the popularization of Antarctic research offers a model for a holistic approach to promoting global science.

Keywords: *science popularization, history of science, mass media, audience, content, Antarctica, popularization of Antarctica.*

Introduction. *Problem statement*. Global science is inherently interconnected; its development and current status remain heterogeneous. This disparity stems from the intrinsic links between social phenomena, historical events, and technological shifts [13, p. 75], and the standing of science and its popularization. The popularization of Antarctic research serves as an example of a more homogeneous model.

Relevance of the study. The model for the popularization of Antarctic science represents a unique case where diverse scientific fields, multinational contributions, and past and present research are integrated into a single, cohesive narrative. Consequently, the global implementation of such a model could serve as a benchmark for the future of science communication.

This study is linked to such *scholarly tasks* as examining the historical, political, social, and technological factors that influence the development of science and the dissemination of scientific knowledge. Furthermore, it addresses *practical objectives*, specifically the transition toward a more optimized model for science popularization.

The *theoretical basis* of this research encompasses materials on science and its popularization: the development of science in the USSR (Tkachenko), the history of science popularization (Massarani, de Castro Moreira), the impact of colonialism on science (Starrs, Croke, Muellenbroich), scientometrics (Abramo, D'Angelo, Di Costa), as well as reports from scientific institutions and a European Union (EU) resolution. *Sources include* a collection of media materials on the popularization of Antarctic science in Ukraine: National Antarctic Scientific Center, «Українська правда», Hromadske, «Український Тиждень», Tvoe Misto, Zbruc, «Україна Модерна», BBC News, Deutsche Welle, Open Culture, «Антарктична Україна у дзеркалі преси», and publications by academician V. I. Vernadsky.

The study addresses *previously unresolved issues* concerning the theoretical investigation of Antarctic science popularization and the practical application of the Antarctic research popularization model to the global dissemination of scientific knowledge.

The *novelty* of this research lies in its examination of science popularization within the context of the history of scientific inquiry, alongside a particular interest in Antarctic research.

The *aim* of this paper is to examine the uneven evolution of science popularization as a global phenomenon, focusing on its interplay with shifting public perceptions of the importance of science, its representation in the media, and its societal reception, as influenced by various historical, political, social, and technological factors. Against this background, the study proposes the popularization of Antarctic research as an alternative model.

*Objectives***:** to determine how science popularization depended on the historical processes of scientific development across different epochs; to demonstrate the impact of historical events on the development of Ukrainian science; to consider the consequences of the exclusion of certain scientific areas due to historical processes and the interconnection of such situations with science popularization; to provide examples of the dependence of scientists' work and science popularization processes based on the analysis of Antarctic research.

Research methods. To achieve the research goals and objectives, the following methods were employed: *the historical-genetic method*, which was used to trace the evolution of science popularization as influenced by various historical events, social phenomena, and technological shifts; *comparative analysis*, which enabled the juxtaposition of parallel models of science popularization across different societies, as well as a comparison between global trends and the specific phenomenon of Antarctic science popularization; *counterfactual analysis*, applied to identify historical events and phenomena that serve as distinct causes for the uneven development of societies in general, and of science and its popularization in particular; *the method of contrast*, used to highlight the more homogeneous model of Antarctic science popularization in opposition to the uneven global processes; this also allowed for the outlining of future development prospects for science popularization as a whole.

Results and discussion. Science is a global endeavor; thus, considering the immense scope, scale, and numerous aspects that humanity encompasses within the concept of sci-

ence, it’s challenging to study it as a singular, unified entity [1]. Consequently, defining the concept of science popularization is equally complex, as researchers believe that its intensity worldwide fluctuates due to varying waves of interest in science itself across different historical epochs. As a result, localized popularization processes have emerged globally, reflecting broader trends [13, p. 77]. Factors influencing the homogeneity or heterogeneity of global science include a country’s scientific tradition, its political circumstances and economic capabilities, societal views, and the governing regime [22, p. 109–115].

For instance, the existence of the Soviet Union created a stark division between the open Western societies and the closed Soviet society, including its satellites. In the Soviet Union, the will of the Communist Party deliberately hampered the development of fields like genetics, which are now highly promising and dynamic [8]. In the Union of Soviet Socialist Republics (USSR), information flow was controlled and filtered, which significantly slowed down the exchange of knowledge. Clearly, the atmosphere of restrictions, regulation, surveillance, and censorship prevalent in all spheres of Soviet activity, including science and journalism, similarly imprinted itself on the popularization of science within the USSR. This situation’s repercussions persisted long after Ukraine gained independence. Journalist Volodymyr Bochkaryov aptly described it: «*In our country, with some exceptions, public discussion of even significant scientific issues for the community on the pages of the periodical press is simply not customary*» [5, p. 2].

However, not only significant state interventions like these impact scientific progress. Historical events and processes also serve as prerequisites for science’s state at any given time. Consider, for example, how much more Europeans might have learned if they hadn’t destroyed the civilizations of the Americas [20]. It’s also a well-known fact that much of ancient Greek knowledge was preserved through the mediation of Arab culture and science. After the decline of ancient civilizations, many texts were lost but later rediscovered in Arabic sources. These ancient texts were translated and processed by Arab scholars in their time [11]. We can hypothesize that this knowledge entered Arab culture due to the popularity of Greek texts. Ultimately, ancient texts regained popularity in Europe after their rediscovery in Arabic manuscripts. These historical circumstances lead to the conclusion that the potential for popularizing scientific knowledge directly depends on the status of the scientific community at a specific time and within a particular country or region.

Wars and other turbulent events have occurred throughout human history, influencing and continuing to influence the uneven development of science. Russia’s full-scale invasion of Ukraine has underscored the relevance of research on the impact of such events on various spheres of society. Even at the end of World War I, the naturalist Volodymyr Ivanovych Vernadsky wrote on this very topic, noting that the Russian state – of which he was a subject and which then included Ukrainian lands, thus mentioning Ukraine specifically – was fragmented. He himself was forced to conduct his scientific work during times of great upheaval, the consequences of which could last for months and years. In such circumstances, he sought «points of support». Vernadsky asserted that a scientist’s points of support are not connected to specific events in the lives of people and countries, because from the perspective of scientific inquiry, these are too insignificant compared to eternal and unchanging scientific tasks [17, p. 142].

One might disagree with the scholar, as he claims no upheavals should affect scientists’ work. Incidentally, in 2019, a discussion on this very issue arose at the Ukrainian Antarctic station Academic Vernadsky. One researcher argued that events at the societal, state, political, or economic levels lacked significant importance in the context of studying the Universe. This is quite symbolic, as it was said at a station named after Vernadsky and echoed his own judgment. At the same time, it’s difficult to agree that events, even if not of cosmic scale, have no impact on the research process itself. After all, a country’s economic situation directly influences the level of science funding, among other things. And cataclysms like wars alter the lives of individual scientists, entire institutions, and scientific communities [19].

Nevertheless, in the very article where V. I. Vernadsky advocates for the scientific process, he also states that through science, in the various manifestations of a single phenomenon, one can find the complete truth about it. Vernadsky also essentially engages in science popularization by raising questions about «the moral value of scientific creativity, the necessity of scientific work, and the justification of scientific activity» [17, p. 143–144]. The scholar immediately notes that humanity has answered these questions with three blocks of explanations: religious, philosophical, and scientific, and he asserts that all these lines of inquiry are relevant to the field of science, especially during times of catastrophe [17, p. 143–144]. This can be considered quite obvious science popularization, presented, however, in a manner characteristic of its time.

Researchers studying the history of science popularization assert that it began simultaneously with the very genesis of science itself. However, from the 18th c. onward, science captivated the interest of both the aristocracy and the bourgeoisie. The Enlightenment then leveraged science as a political instrument for civic education. Essentially, due to historical events and the philosophical ideas emerging from them, science became a focal point of broad public interest. A new wave of popularization surged in the 20th c. Firstly, influential and popular figures like Albert Einstein and Marie Curie emerged, who understood the importance of disseminating scientific knowledge among citizens. Secondly, new communication tools such as radio and cinema began to incorporate cultural and scientific themes. Thirdly, an intensified atmosphere of international competition arose, as governments and entrepreneurs recognized the necessity of science for technological application. Nevertheless, the formal boom in international science popularization truly commenced in the 1980s, greatly facilitated by television [13, p. 75–77].

Today, we live in a world with nearly unrestricted access to knowledge. A scientist, if desired, could obtain necessary research information, and a citizen could access self-education resources on virtually any scientific topic. However, this doesn't eliminate factors that still contribute to the heterogeneity of global science. These include, for instance, the presence or absence of equitable access to education for all or most citizens of a given country, the quality of that education, and the development and support of scientific institutions [16]. Furthermore, closed countries still exist. While nations like China broadly invest in the education of their citizens across many fields, despite high technological development, China maintains an extremely closed and censored internet network [6]. A clear example is the «erasure» from the Chinese information space of any facts or mentions of the 1989 Tiananmen Square events [4]. Moreover, as of 2023, governments in over 22 countries were already utilizing technologies such as large language models – so-called artificial intelligence – to detect undesirable online expressions for censorship purposes [25, p. 1–15].

Another factor contributing to the uneven interpenetration of scientific communities is the field of science itself. For example, as Yevhen Dykyi, PhD in Biological Sciences and Head of the National Antarctic Scientific Center, aptly noted, some sciences are more national than global. Ideally, fields like biology or physics function universally and are beneficial to humanity as a whole. However, Ukrainian literary studies, for instance, are primarily relevant to Ukrainians – roughly speaking, to a specific country, society, or ethnicity [9].

Nonetheless, it's crucial to consider that not all knowledge deemed «local» is irrelevant for global study. The history of Ukraine serves as a compelling example. Today, during Russia's war in Ukraine, historians worldwide could be understanding and explaining the ongoing processes, or even predicting the possibility of such events. Yet, the practically absolute exclusion of Ukrainian historiography from the global context, treating Ukraine as part of Russia, and Ukrainian history as part of Russian history, prevented an accurate assessment of the situation. Consequently, a misunderstanding of the significance of Russia's invasion of Crimea and Donbas, coupled with an inadequate assessment of reality, led to the toleration of those events, attempts to reconcile Ukraine with pro-Russian forces and the aggressor itself, and ultimately, to the allowance of the full-scale invasion. However, Russia's war

against Ukraine has impacted not just historical theory but real historical events and the real world [7]: affecting human lives, humanitarian crises, massive economic and environmental consequences, social upheavals in Ukraine, migration to Europe, and the formation of a new «axis of evil» involving Russia, Iran, and North Korea. Therefore, what might at first glance appear to be a) a non-applied science like history, and b) a localized part of it, namely the history of Ukraine, are in fact more real than they might seem. They also hold global, not merely local Ukrainian, significance. Thus, an inadequate consideration of the history unfolding on Ukrainian lands, and a dismissal of the reality linked to centuries of Russian actions, have resulted in truly catastrophic consequences, if not for the entire world, then certainly for Europe and many other involved countries.

It’s crucial to acknowledge the long-standing and deliberate efforts by Russians to exclude Ukraine from global historiography. This began at least with the 1917 revolution, after which many «White» sympathizers emigrated to Western countries and perpetuated a narrative of the Russian Empire’s unity, while omitting any mention of its colonies [12]. This state of affairs can be considered Russian propaganda, juxtaposed against an insufficient popularization of Ukrainian history and culture. Fundamentally, based on rational reasoning, if propaganda is understood as the dissemination of information serving the propagandist’s agenda, then popularization can be seen as conveying information «as it is» – as free as possible from particular biases, and as comprehensively as possible. Ultimately, this aligns with a basic principle in journalism: the author shouldn’t have to explain to the audience, for example, that a thief is a thief. Simply presenting the story and the facts is sufficient; the audience will draw their own conclusions.

However, the prevailing historical circumstances contributed to Western observers at the outset of the invasion not believing Ukraine would remain an independent country, partly due to the misconception that it differed little from Russia. And while history doesn’t operate with «what ifs», one can at least appeal to similar historical experiences, such as when Western countries made increasing concessions to Nazi Germany, leading not to peace but to the largest war of its time. Today, similar sentiments can be heard: if Ukraine had received all necessary assistance immediately, instead of attempts to «understand the aggressor», Ukraine could have achieved greater success [3]. Consequently, the popularization – in this case, of historical science – contributes to the audience’s understanding of certain historical patterns. And understanding a situation impacts the adoption of real-world decisions that have tangible consequences, not merely «theoretical» ones. As an example of the connection between science and real-world events, one can cite Axelrod’s landscape model in sociophysics. The scholar analyzed how coalitions formed between states in Europe before World War II. While we now know what transpired, in the early 1930s, this was not obvious. Axelrod predicted these coalitions, making a mistake with only one country [10]. Thus, it can be confidently stated that applying such models in sciences like history could lead to many interesting breakthroughs and foster closer ties between researchers from different disciplines, thereby making the fabric of science more cohesive.

Furthermore, the fragmentation of the scientific community is also exacerbated by inter-state competition, scientific espionage, the pursuit of citation counts accompanied by academic dishonesty [2], and wars themselves [21]. Russia’s war against Ukraine has, without doubt, erected a barrier between scientists from these countries, and not only between them. Some Western scientific institutions continue to collaborate with Russians, while Ukrainians, for moral reasons, refrain from participating in scientific processes involving Russians. Conversely, there are also situations where Russians are excluded from research and scientific institutions, specifically to support Ukrainians. Russia’s war against Ukraine has also divided scientists in Antarctica, as the Antarctic community largely supports Ukraine, for instance, in its environmental protection initiatives, while these efforts are opposed by countries like Russia and China, which also have a presence in Antarctica [15].

There's at least one more significant consequence of war for the scientific community: the devaluation of science amidst national defense expenditures. A telling example is the rather frequent campaigns aimed at discrediting the National Antarctic Scientific Center. In May 2024, the notorious blogger Anatoliy Shariy attempted to undermine the research conducted by Ukrainians at the Academic Vernadsky station in Antarctica. Manipulating facts, he falsely claimed that scientists were «drinking wine and eating chocolate at taxpayers' expense during the war». This was intended to push society towards believing that funding Antarctic research during wartime is unnecessary [14]. Ultimately, a segment of society reacted to this campaign precisely as intended. Communications expert Nataliia Ulynets explained that there will always be more people unfamiliar with a particular topic, and they are most likely to support a negative information wave. However, the best way for institutions like the National Antarctic Scientific Center to mitigate such attacks is to proactively share information about themselves and their activities [23, 38:08]. In the case of Antarctic researchers, this means actively engaging in the popularization of science and their own work.

Antarctica, according to Ihor Dykyi, PhD in Biological Sciences, zoologist, and participant in four Antarctic expeditions, acts as a litmus test. He notes that processes occurring worldwide are visible there «*as if on a blank sheet of paper*» [18, p. 245]. However, the «blank sheet» concept isn't limited to ecological, climatic, or biological research. One can argue that a similar principle applies to understanding the history of human-world interaction. We witness, as if in a laboratory flask, the unfolding of human history in Antarctica almost from its inception. Ultimately, Antarctica today is the continent where scientific activity is primarily permitted for humans. Indeed, to investigate some of the most crucial phenomena on our planet and in the Universe, Antarctica stands as the best place on Earth [24].

Thus, Antarctic research serves as an example of how the fabric of science can be made more homogeneous. Historically, it has united specialists from diverse fields and scientists from various countries around common tasks, while also connecting researchers across different historical epochs. This is because Antarctica is internationally recognized as a continent dedicated to science, with research being the primary activity for people and nations there. Consequently, this continent brings together state programs, institutions, and scientists of various specializations from many countries worldwide. The Antarctic scientific community is a unique reflection of the global scientific environment, showcasing its best aspects. The icy continent exemplifies the continuity of research conducted by representatives of different countries and professions. Today, Antarctica is the only part of the world formally recognized as a continent of science. Notably, among Ukrainian researchers, scientists from various fields – such as geologists, biologists, and communications specialists – are engaged in studying the history of Ukrainians in Antarctica, as well as the overall exploration of Antarctica over the past two centuries. Furthermore, even more participants from various Antarctic expeditions contribute to preserving this «living history» through involvement in different journalistic programs. This once again demonstrates the potential for the emergence of a homogeneous scientific environment that also actively engages in science popularization.

Conclusions and prospects. Historical processes significantly influence the development of science and the attitudes of both society and scientists towards the necessity of science popularization. Furthermore, political circumstances, available technologies, and other factors impact the global dissemination of information, determining regions where scientific development will flourish more rapidly and others where it will stagnate. This disparity renders both the scientific environment and science popularization inherently heterogeneous. Among the factors contributing to the scientific community's heterogeneity is also the vast diversity of scientific fields and disciplines. However, the example of Antarctic research demonstrates that a seemingly narrow scientific topic can offer a very broad spectrum of potential themes for popularization among a wide audience. For instance, it can appeal to those interested in diverse research as such; to enthusiasts of exploration history and scientific observation; to those curious about the daily lives of scientists and the «behind-the-scenes» aspects

of scientific work; or to those captivated by nature and intriguing corners of the Earth. For each audience segment, scientists can find material to contextualize and generate interest in science. Thus, despite the nonlinear and uneven development of science globally – and, consequently, the parallel development of science popularization – the study and popularization of Antarctica demonstrate that some topics possess the potential to unite representatives of different scientific fields, various countries, and even different historical epochs in popularization efforts. The all-encompassing nature of Antarctic topics within the sphere of science popularization is also a crucial factor. Research related to the Vernadsky Antarctic station, for example, integrates scientific knowledge from diverse fields: natural sciences, technical sciences, and social sciences (history, law). This case study, therefore, specifically highlights the possibilities for scientists to unite around common scientific questions. The mention of V. I. Vernadsky’s figure in this context is particularly symbolic.

Research into science popularization within the framework of historical processes holds significant future prospects. This is especially true given the current relevance of such studies, driven by the rapid development of media technologies and artificial intelligence, the rise of post-truth phenomena and mass fake news generation, the heightened urgency due to disruptions in the scientific environment resulting from Russia’s full-scale invasion, and ongoing public discussions related to the aspects of science funding during wartime.

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ПОПУЛЯРИЗАЦІЯ НАУКИ У КОНТЕКСТІ ІСТОРІЇ РОЗВИТКУ ГЛОБАЛЬНОГО НАУКОВОГО СЕРЕДОВИЩА

ПРОХАСЬКО Маркіян,
аспірант, Національний університет «Львівська Політехніка», Львів, Україна, e-mail: markiyan.t.prokhasko@lpnu.ua.
ORCID – https://orcid.org/0009-0000-1671-9261

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Вступ. Явище популяризації науки поширене нерівномірно. Практична робота у сфері популяризації науки та академічний інтерес до процесу поширення наукових знань спонукали до написання цієї статті.

Актуальність і мета. У статті розглянуто явище популяризації антарктичних досліджень, де інформація з різних галузей та від науковців різних країн укладаються в єдиний наратив, як альтернативну модель розвитку глобального наукового середовища. Тож за мету було взято вивчення моделі популяризації антарктичної науки на тлі розгляду причин нерівномірного розвитку глобального наукового середовища та, як наслідок, явища популяризації науки загалом.

Методи дослідження. Поставлені завдання дослідження були досягнуті за допомогою використання ряду методів: історико-генетичний, за допомогою якого представлено еволюцію популяризації науки; метод компаративістського аналізу дозволив зіставити паралельні моделі процесів популяризації науки в різних суспільствах з популяризацією антарктичної науки; за допомогою методу контрфактичного аналізу виокремлено причини нерівномірності розвитку науки та популяризації наукових знань; методом протиставлення запропоновано модель одноріднішої популяризації науки.

Результати. Еволюція популяризації науки відбувалася у різних історичних контекстах. Вона випливає як зі стратегічних потреб держав у підтримці технологічного прогресу, так і з окремих наукових ініціатив, зокрема, видатних вчених.

Висновки. Нерівномірний розвиток науки у світі впливає і на нерівномірний процес популяризації знань. Позитивним прикладом об’єднання наукового середовища виступає – за деякими винятками – Антарктида, яка сприяє об’єднанню держав, інституцій та науковців у процесі досліджень та популяризації науки. Новий погляд на явище популяризації антарктичних досліджень пропонує приклад цілісної моделі популяризації глобальної науки.

Ключові слова: *популяризація науки, історія науки, медія, ЗМК, аудиторія, контент, Антарктида, популяризація Антарктиди.*

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