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IN HONOR OF THE 300TH ANNIVERSARY OF THE BIRTH OF M V LOMONOSOV

Mikhail Vasil'evich Lomonosov, our first university

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Abstract. Mikhail Vasil'evich Lomonosov, an outstanding figure in Russian culture, lived and worked at a time of radical changes, both globally and in Russia. Lomonosov was highly instrumental in the development of national science and education, as symbolized by the Academy of Sciences and Moscow University, and his influence has since been felt throughout the history of the country.

This year marks the 300th anniversary of the birth of Mikhail Vasil'evich Lomonosov (1711–1765), the outstanding Russian polymath scientist.

The life of M V Lomonosov coincided with the epoch of the implementation of Peter the Great's reforms in Russia [1, 2], which were of vital importance for the country as it sought to strengthen its position in the world. The world had changed dramatically by the time Peter came to the throne. Major changes took place throughout the 17th century in the mode of production in the most developed nations. New knowledge acquired in natural sciences began to be applied in various production processes [3, 4], and this tendency can be traced to contemporary philosophical treatises [5, 6]. The most farsighted statesmen started to patronize the natural sciences, and such encouragement gave rise to new forms of science organization. Academies of sciences appeared in several European countries.

The Royal Society of London originated in 1660, and the Paris Academy of Sciences was founded in 1666. The number of academies continued to increase thereafter. During his tour of Europe (April 1698), Peter the Great thrice visited the Royal Mint in London where Sir Isaac Newton was the warden [7]. In 1717, Peter was named an honorary member of the Paris Academy of Sciences; he later founded the Saint Petersburg Academy of Sciences, in imitation of the Academie Francais.

Newton published his *Mathematical Principles of Natural Philosophy* in 1687. This book marked a new era in science and is considered to be the most important work in the transformation of early natural philosophy into modern physics. The first three editions appeared in England in the Latin language (second in 1713, third in 1726) during the author's lifetime. The English version was published in 1729, and the French one in 1756, when Latin began to lose its dominant position as the main language of scholarship. The fate of one copy of the first edition of Newton's book turned out to be deeply intertwined with the history of the Royal Society of London, the Saint Petersburg Academy of Sciences, and Moscow University. M V Lomonosov more than once cited this book.

Briefly, the story runs as follows. In 1943, the scientific community celebrated the 300th anniversary of the birth of Sir Isaac Newton. The Royal Society donated a copy of the first edition of his book to the USSR Academy of Sciences, which did not have it in its library at that time [8]. In 1984, V S Kirsanov discovered another copy of the first edition at an exhibition held at M V Lomonosov Moscow State University [9]. Further surveys showed that the book had found its way to Russia in Newton's lifetime. It was bought by R Erskin (Areskin), a personal physician to Peter the Great, for the library of A Pitkarn in 1718. This library and other private collections constituted the core of the library of the Saint Petersburg Academy of Sciences. The Moscow University library suffered severe losses in the fire during Napoleon's invasion of 1812. To replenish its stock, the Saint Petersburg Academy donated some of its books in 1814 to the library damaged by fire, including the copy of the first edition of Newton's *Principia*.

In other words, the library of Saint Petersburg Academy of Sciences from the very beginning possessed the copy of the first edition of this book with numerous notes and corrections in the margins and the text. It is mentioned in all early catalogues of this library.

In his doctorate thesis [10], V S Kirsanov provided conclusive evidence that the copy of *Principia* found in the Moscow University library had been owned by David Gregory, admitted into Newton's close circle from the early 1690s [11]. Notes in the book date to the time when Newton was preparing the second edition. The formerly unknown facts revealed in Ref. [10] suggest the existence of contacts between English scientists and their Russian counterparts in that period. In 1713, the Royal Society of London set up a 'Russian' Commission comprising 16 members, including Isaac Newton and Edmund Halley. The Commission made a list of 'Questions' concerning Russia. A copy of the list was also sent to R Areskin.

The second half of the 17th century witnessed the appearance of scientific journals. Before that, scholars used correspondence to report on their research and exchange data. In the first half of the 1600s, M Mersenne, a French physicist and theorist known for acoustic research and applications, organized an exchange of information between the then most renowned scientists [12]. However, correspondence was unreliable as a mode of scientific communication,

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nor could it encompass all fields of growing human knowledge. Proceedings of the Royal Society appeared in 1665; thereupon, the French Academy began to publish the works of its members. Little by little, periodicals became the main source of scientific information.

A few state-governed schools were created in Russia in the second half of the 17th century. In 1648, Meletii Smotritskii published his *Grammatika* (*Grammar*), which became popular among schoolchildren; it contained rules of written and spoken speech, together with a concise instruction for writing verses. In 1687, Simeon Polotskii initiated the idea of creating the first higher educational establishment based on the school at the Bogoyavlenskii Monastery, Moscow. Established as the Ellino-grecheskaya akademiya (Hellenic Greek Academy), it was renamed Slavyano-latinskaya akademiya (Slavic–Latin Academy) in 1701 and thereafter (1775) Slavyano-greko-latinskaya akademiya (Slavic–Greek–Latin Academy). It was the institution where M V Lomonosov got his education. It was redesignated as Moscow Ecclesiastical Academy in 1814.

In the 17th century, the students of the academy were taught Greek, Latin, and Slavic languages, 'the seven liberal arts', and theology. When the curriculum was expanded in the early 1700s, the priority was given to studying Latin.

L F Magnitskii (1669–1739), teaching at the School of Mathematics and Navigation in Moscow, founded by Peter the Great (1701), published the *Arifmetika* (*Arithmetic*) in 1703. It was the first guide to mathematics and natural sciences at large written in Russia by a Russian and remained the basic Russian mathematics textbook till the mid-1700s [13]. Lomonosov called *Grammar* by Smotritskii and *Arithmetic* by Magnitskii 'the gates of learning'.

In 1708, Peter introduced the new civil print type instead of that employed by the Old Slavonic tongue of the Church and substituted Arabic numerals for letter ones. This greatly promoted the development of general education and secular schools [14].

The idea of creating the Academy of Sciences in Russia emerged at the turn of the 18th century. In Europe at this time, scientific institutions were organized in a variety of ways, being either privately-owned or state-run establishments [15]. Another dilemma Russian organizers faced was whether the Academy should only be a research center or an educational one. In the end, Peter the Great decided to set up the academy as a research institution with auxiliary educational establishments, such as the university and gymnasium.

L L Blumentrost, his physician-in-ordinary, was charged in January 1724 with drawing up a draft charter of the Academy in written form; Peter looked through it and introduced amendments on 22 January [16]. The document was discussed at a meeting of the Senate and incorporated into the decree establishing the Academy of Sciences on January 28/February 8, 1724 [17].

The official statute of the Academy was approved in 1747 to replace the provisional charter playing the part of regulations for the Academy. The draft charter ran roughly as follows: "Since the foundation of this institution relies on the model of the Parisian Academy (that apart from everything else functions as a University or Collegium), I believe it would most properly be called the Academy." The draft charter just as well substantiated the structure of the Academy-affiliated University: "As mentioned, the University will have 4 Faculties offering courses in (1) theology, (2) law, (3) medicine, and (4) philosophy. The theological faculty will only be managed by the Synod, while the remaining three, (1) law faculty, (2) medical faculty, and (3) philosophical faculty, will be governed by the University." The shortage of "direct schools, colleges, and seminaries" in Russia necessitated the establishment of the gymnasium. Clearly, there is much in common between this draft charter of the Academy and Lomonosov's project for Moscow University.

In 1728, *Commentaries of the Saint Petersburg Academy of Sciences* (*Commentarii* in Latin) began to be published and soon became widely known [18, 19].

The Physical Cabinet of the Academy with its 400 scientific instruments (as per the 1741 catalogue) greatly contributed to the development of physics in Russia.

The formative years of the Academy fell in the period of political instability in Russia that influenced all aspects of its activity, especially that of educational institutions. The academic gymnasium had no premises of its own and occupied a building unsuitable for the purpose of effective teaching. The lessons were poorly organized, while the students endured cold and hunger, since they were given a very small stipend with which to feed and clothe themselves. At the same time, up to 1747, admission was open to children of all estates.

Education at the university was organized differently from what had been planned in the initial charter; in fact, its structure reproduced the format accepted by the Academy. The students, whose number was small, attended mathematical, physical, and art 'classes'. Interpretation of various book texts was the main form of teaching.

M V Lomonosov had great influence on the work of the Academy of Sciences, with which he was associated from his studentship till he won renown as a leading scientist both at home and abroad. Lomonosov was elected a honorary member of the Swedish Academy of Sciences and the Academy of Bologna.

M V Lomonosov entered the Saint Petersburg Academy of Sciences as a student in early 1736. Such reputed scientists as professors G W Krafft (physics), I G Leitman (mechanics and optics), and J-N Delille (astronomy) were among his first teachers. The rare intellectual abilities and brilliant memory of the young man were immediately recognized and appreciated; he happened to be one of the best students sent to the Marburg University to study under Ch Wolff. Lomonosov always highly respected his teacher and remained on good terms with him through most of his career. The theoretical course of chemistry was taught at Marburg by professor J G Duising.

Lomonosov was greatly influenced by Wolff's style of teaching, which accorded primacy to the mathematical method. At Marburg, he attended lectures in different disciplines, read books about Galileo Galilei, Isaac Newton, Robert Boyle, Rene Descartes, G W Leibniz, and other European scientists. Even in those early years, Lomonosov was highly regarded by his teachers, not only for his extraordinary abilities but also for his ingenuity in solving various scientific problems; the latter was attested by favorable reports from Ch Wolff [20].

Lomonosov made the acquaintance with mining engineering at Freiburg, a center of the mining industry in Lower Saxony, where, apart from everything else, he did practical work in the laboratory. However, he found his new teacher J F Henckel a much less sympathetic character than Wolff. In May 1740, Lomonosov left Freiburg. Later on, he explained his decision as follows: "I have completed

studies of the art of assaying and chemistry, but inspector Kern was reluctant to continue because Henckel had skimmed too much money from the sums allocated to him by the Academy of Sciences'' [21]. Nevertheless, J F Henckel was among those who reported positively on the results of Lomonosov's studies [20].

On June 8, 1741, M V Lomonosov rejoined the Academy of Sciences, which already had a staff of 400 members [18] and was soon (January 8, 1742) appointed adjunct professor in the physical class. By that time, the Russian throne had been taken (November 25, 1741) by Elizaveta Petrovna, daughter of Peter the Great, who proclaimed her aim of returning to the orders established by her farther. This idea appealed greatly to Lomonosov's notion of ideals, and the reign of Elizabeth I proved the most fruitful period in his life.

During the five-year stay abroad, Lomonosov considerably extended his knowledge of natural sciences, methods of teaching, and organization of research in Europe. He came back to the Academy of Sciences with ambitious plans, but immediately encountered violent opposition from a number of persons whose goals were far from the interests in developing research and education in Russia. Lomonosov wrote later: ''I had an unwavering purpose and unshakeable conviction to sacrifice if necessary my own provisional well being for the development of sciences in Russia...'' [21].

In 1745, Lomonosov was appointed professor of chemistry, i.e., academician [22]. From that time on, he was in a better position to continue building a chemical laboratory at the Academy of Sciences, which he considered ''indispensable for studying natural phenomena ...without which a professor of chemistry cannot make himself useful, just as a professor of astronomy cannot without an observatory and proper instruments'' [23, 24]. The construction of this laboratory took 7 years and was successfully completed in 1749. Lomonosov worked in the laboratory till 1757, when he consigned it to U Ch Salchow.

In 1747, the of the Imperial Academy of Sciences and Arts in Saint Petersburg was approved. The Reglament (Regulations) substantially enlarged the powers of the President and his chancellery, which acted on the president's behalf in the event of his absence. Also, the Reglament separated the university from the Academy and distinguished between members of the Academy and professors attached to the university for giving lectures.

For many years, much of Lomonosov's time and energy were taken up by efforts to shut down the bureaucratic chancellery and transfer a leadership to the Academy sessions. He alluded to the experience of European academies: ''There, sessions of the Academy members are free to make decisions by themselves... . Clearly, the Academy does not need a chancellery like ours that interferes with its functioning and must therefore be expelled from the true House of Science'' [21]. Russia of that time faced an acute problem of manpower training. M V Lomonosov wrote that ''our motherland is apt to give birth to children not only glorious in armed struggle and other important affairs but also capable of acquiring much knowledge in various domains.''

The new Reglament imposed restrictions discriminating against representatives of the lower classes in admission to the academic gymnasium and university. Lomonosov was in a constant struggle for the right of access to scientific knowledge for ''people of any estate''. He wrote in the draft ''Memo on the necessity to reform the Academy of Sciences'' dated 1758–1759: ''...the more a student knows the more he is respected, no matter whose son he is'' [21].

Lomonosov's efforts aimed at establishing Moscow University are worthy of special mention. His ideas laid the foundation of the university education program and continued to influence the development of the university throughout its long history.

In 1753, Lomonosov departed for Moscow to start practical preparative work [15]. In a letter sent to Count I I Shuvalov in summer 1754, Lomonosov outlined a plan for the university structure and formulated the main principles of its organization [25–27]. On July 19, the Senate approved ''The report on the establishment of the University and two gymnasiums in Moscow'', presented by I I Shuvalov, together with the Project for their organization [27, 28]. This decision set in motion a chain of activities that eventually led to the foundation of Moscow University. The decree by Empress Elizaveta Petrovna signed in August granted the university the Aptekarsky (Apothecary) house near Voskresenskie (Kuryatnye) Gates at Red Square to be the seat for its staff and students. By this edict ''Her Imperial Majesty orders the former drugstore house located near Kuryatnye Gates to be repaired and made suitable to accommodate the University being first established in Moscow'' [28, 29]. The offices that occupied the Aptekarsky house were removed and its refurbishment completed for the most part in December.

On January 12, 1755, the Empress approved a project stipulating that Moscow University and its gymnasiums be set up [30]. The university was supposed to have three major departments (Departments of Law, Philosophy, and Medicine) with a total of 10 chairs. This structure matched that of the Academy's university projected in 1724 [17] and of the university described by Lomonosov in his letter to V K Trediakovskii cited below: ''My Sir, Vasily Kirillovich! You informed me that I am expected to voice my opinion about the University Reglament. To be brief, I tend to believe that the University must necessarily have Departments of Law, Medicine and Philosophy (Department of Theology is left with synodal academies) to train students wishing to earn a magister, licentiate or doctor degree... .'' [21, 23].

The decree establishing the university and its two gymnasiums was published on January 24, 1755. It appointed I I Shuvalov and L L Blumentrost curators of the university, and A M Argamakov its director [31].

In March 1755, magisters N N Popovskii, A A Barsov, and F Ya Yaremskii (pupils and disciples of M V Lomonosov) were moved from the University of Saint Petersburg Academy of Sciences to Moscow University. The Senate allocated 5,000 rubles ''to buy books and other necessities'' for the university [26]. At two meetings of the Academy conference held on March 16 and 20, University Director Argamakov initiated discussions in an attempt to raise additional funds for the library's collection and purchasing equipment for the Physical Cabinet [31]. The Academy of Sciences provided the requested support [32].

The University inauguration ceremony took place on April 26, 1755. N N Popovskii and A A Barsov, teachers of German and French, made inaugural speeches at the opening of the University gymnasium. A A Barsov entitled his speech, ''On the benefits of the creation of Moscow University''. The first six students were enrolled on May 25. The studies began already in June with a lecture on philosophy delivered by N N Popovskii. This event marked the beginning of teaching at the university [27].

The opening of Moscow University greatly influenced not only the development of education in Russia but also public life at large. The printing-office and the bookstore attached to the university began operating already in 1756. The *Moskovskie Vedomosti* (*Moscow Bulletin*) newspaper was established by Moscow University and issued also in the same year. At about the same time, the university-based public library was opened. The first volume of Lomonosov's collected works was published in August 1758 (the front page shows 1757). It contained both poetry and scientific and popular scientific writings, polemics, and criticism. *Moskovskie Vedomosti* of October 9, 1758 announced publication of "the book by Mr. Lomonosov, collegiate councilor, professor of chemistry, and member of the Saint Petersburg Imperial Academy of Sciences, as printed recently and offered for sale at the Imperial Moscow University." Volume 2 was issued in 1765.

M V Lomonosov continually devoted much attention to the work of the academy's university and gymnasium. The first Russian teachers of Moscow University were trained at these institutions, where Lomonosov read lectures in Russian. With Moscow University founded, Lomonosov began in essence taking action to convert the academic university into the independent Saint Petersburg University [26]. Heading both of academic institutions, Lomonosov undertook a major reform of their teaching systems; as a result, the university for the first time was able to recruit students mainly among graduates from the gymnasium rather than from the outside.

He was perfectly aware of the importance of attending to formalities for the strengthening of the university position. Therefore, his next step was to elaborate the university statute and prerogatives, staff schedule, and budget. He had to constantly substantiate the necessity to increase the number of specialists trained at the university. In the draft speech to be delivered at the university inauguration ceremony, Lomonosov listed the following spheres in which university graduates could be employed: "1. Development of Siberia, 2. Mining industry, 3. Factories, 4. Development of the Northern Sea Route, 5. Demographic policy, 6. Architecture and weather forecast, 7. Administration of justice, 8. Improvement of public morals, 9. Merchantry and relations with the orient, 10. Strengthening religious unity and faith, 11. Agriculture and weather forecast, 12. Military science" [18]. Lomonosov's continuous hard struggle was not completely very successful, yet his efforts were not in vain.

First, dozens of specialists graduated from the academy's university. Second, long discussions proved instrumental in the formation of public opinion on the ways and means to develop science and education. Third, a wealth of factual materials was left and continually used to reconstruct the true picture of the evolution of education in Russia. Fourth, Lomonosov set concrete goals for the further improvement of education in the country

M V Lomonosov's role in the history of Moscow University is not limited to his decisive contribution to its foundation. His works became an object of thorough attention and further development by later authors.

In 1810, the university printing-office published the textbook *Kratkoe Nachertanie Fiziki* (*A Concise Description of Physics*) by P I Strakhov, corresponding member of the Saint Petersburg Academy of Sciences, that summarized the experience with teaching this discipline at Moscow University over many years. The style of this book had much in common with *Volfianskaya Eksperimental'naya Fizika* (a brief exposition of *Wolff's Experimental Physics* translated and published by Lomonosov under this title). This is not surprising, bearing in mind that Lomonosov was the first to develop Russian scientific terminology in physics, as was noted in a review of Strakhov's textbook published in the *Russian Vestnik* (*Russian Messenger*) journal in 1810 [22].

In 1820, I A Dvigubskii, Professor at Moscow University, began issuing a new scientific journal, *Novyi Magazin Estestvennoi Istorii, Fiziki, Khimii i Svedenii Ekonomicheskikh* (*The New Magazine of Natural History, Physics, Chemistry, and Economic Information*). A few of Lomonosov's works translated from Latin into Russian were published in this journal. One of them, translated by N E Zernov, appeared in 1828 under the heading "O prichine tepla i kholoda" ("On the cause of heat and cold"). The same article, translated by B N Menshutkin, is included in the second volume of Lomonosov's *Complete Collected Works* under the title "Razmyshleniya o prichine teploty i kholoda" ("Reflections on the cause of heat and cold").

Somewhat earlier (1824), I A Dvigubskii called Lomonosov one of the outstanding physicists in the third edition of his *Fizika* (*Physics*) textbook [33].

In the 1820s–1830s, M G Pavlov published a series of polemic articles containing references to Lomonosov' works. He wrote in one of them: "Why do we repeat in our textbooks without any examination, not knowing Lomonosov's arguments, the words of foreign scientists asserting that Rumford was the first to consider heat as a form of internal motion in bodies?" [32].

D M Perevoshchikov more than once cited the works of Lomonosov on atmospheric electricity, optics, and the kinetic theory of heat (see, for example, his *Rukovodstvo k Opytnoi Fizike* (*The Guide to Experimental Physics*) [34].

M F Spasskii many times referred to the studies of M V Lomonosov in the 1840s–1850s [35]. In his lectures in physics, he frequently alluded to Lomonosov's molecular-kinetic theory of heat and applied his theory of origin of atmospheric electricity.

From 1859 to 1882, the Department of Physics at Moscow University was headed by N A Lyubimov, who had a reputation as a brilliant lecturer and was highly respected by contemporaries, including N A Umov [36]. As early as 1855, N A Lyubimov published the booklet *Lomonosov Kak Fizik* (*Lomonosov As a Physicist*) [37] containing what can be regarded as the first critical analysis in our literature of a few of Lomonosov's physical works, such as "Reflections on the cause of heat and cold" (1747). However, it was a formal logical analysis showing that the author was unfamiliar with the molecular-kinetic theory of gases being developed at that time [38]. P L Kapitza wrote an unfavorable comment on Lyubimov's article [39].

In 1872, N A Lyubimov published the first part of his book *Zhizn' i Trudy Lomonosova* (*The Life and Works of Lomonosov*) [40] intended as an aid for studying the history of Lomonosov's epoch at senior classes at Tsesarevich (Prince) Nikolai Lyceum. The book contains the detailed biography of M V Lomonosov and characteristic of his organizational activities in the Academy of Sciences. As for the analysis of his scientific work, it is based on a small number of publications. The closing chapter offers a psychological portrait of Lomonosov and the following assessment of his activities: "Nothing is as much at variance with the character of Lomonosov's work and the very spirit of Peter the Great's reforms as the attempts to contradistinguish between

'Russian' and 'European'... As far as Lomonosov is concerned, these attempts are as false as the attempts to picture him as misjudged, underrated, and beaten out in his struggle for truth... The true meaning of Lomonosov as a scientist is in that he was the first Russian scholar in the European sense, a living embodiment of the success of Peter's project to introduce Russia into the family of European nations as a full-fledged member... The outstanding services Lomonosov rendered to the implementation of this plan need neither exaggeration nor deliberate belittling.'' And a few lines below: ''The true value of Lomonosov's works should be estimated not so much from the standpoint of their contribution to the world science at large as in terms of the benefits they brought to the development of education in Russia; in fact, they make brilliant pages in its history.''

N A Lyubimov continually was a recognized expert in the sphere of education. His analysis and assessment of Lomonosov's activities in this domain are of value even now. In contrast, the analysis of Lomonosov's scientific work is formal and fragmentary, its major drawback being disregard of the fact that science develops continuously and the value of the contribution of individual researchers to its progress is subject to reappraisal. Opinions prevailing at one time are not always regarded as just at another.

The consistent physical theory, i.e., the kinetic theory of matter and statistical physics, was developed only in the 19th century based on the fundamental ideas of L Boltzmann [41, 42]. Boltzmann himself was a member of major academies of the Old and New Worlds, but at the end of his life his views were regarded as anti-scientific. Only in 1908 did W Ostwald recognize the existence of atoms and molecules, as confirmed in direct experiments [43]. M Smoluchowski later wrote in this connection: ''It is highly instructive to follow the mutable fates of scientific theories. They are even more interesting than the changeable fates of people since each of them contains something immortal, at least a small part of eternal truth'' [44].

In light of the aforesaid, due respect should be given to B N Menshutkin for his work in unearthing, translating, and publishing M V Lomonosov's writings. It was not a simple task in 1911 (the year marking Lomonosov's 200th birthday) by which time the views of the molecular-kinetic theory had changed and physics itself was undergoing radical transformation. On the other hand, that period witnessed the revival of interest in the general approach to the solution to many problems offered by M V Lomonosov. The first edition of *Zhizneopisanie Mikhaila Vasil'evicha Lomonosova* (*The Biography of Mikhail Vasil'evich Lomonosov*) by B N Menshutkin sold a total of 80,000 copies [45]. Thereafter, O D Khvol'son mentioned Lomonosov in his *Kurs Fiziki* (*Physics Course*) [39]. In the 20th century, Lomonosov's studies were included and considered in many textbooks [46–49].

In the later half of 1890s, V I Vernadsky began to study M V Lomonosov's scientific heritage in the field of geology and mineralogy. He was one of the first to point out that Lomonosov had pioneered the creation of the methodological basis of modern natural science. He also emphasized that the works of Lomonosov had not only important scientific but also social implications [50]. Those proved to be prophetic words. Scientific developments in the 20th century revealed the true value of Lomonosov's studies and confirmed their great importance.

At a grand meeting at Moscow University held on November 27, 1936 to celebrate the 225th anniversary of the birth of M V Lomonosov, N D Zelinskii suggested that Moscow University be named after him [27]. Since the May 7, 1940, it has been known as M V Lomonosov Moscow State University.

Extensive studies of Lomonosov's scientific legacy were undertaken in the 20th century. His complete collected works were published. New materials thought to have been irretrievably lost emerge from time to time. The interest in Lomonosov's life and works has never waned during these 300 years; on the contrary, it has grown considerably. It is an indisputable indication of his great influence on the development of science and education in Russia.

The works of M V Lomonosov predetermined many aspects of this development. These sources were sought whenever help was needed in periods of radical changes in science and society. This tendency is fairly well illustrated by the situation in the early 20th century, when the mode of teaching physics at Moscow University underwent modification and a solid experimental base started to be created, despite serious difficulties [51]. A similar situation took place in the midtwentieth century when the number of physics students increased by a factor of 15 in comparison with the early 1930s and new physical disciplines emerged at the junction of different sciences [3, 4].

A new discipline (known as the science of science) came into being in the 1960s. It started as the history of science but eventually transformed into a self-contained discipline under the influence of sociological research, including studies of scientific activities in the period of tremendous growth in science in the 1940s–1960s. At that time, the first indicators of scientific activity began to be widely applied, such as the number of journal publications, the number of researchers, and the amount of funds allocated to support them. These parameters grew so rapidly at this period that their extrapolation from the end of 1960s to the near future suggested that, if the tendency persisted, all people on Earth would be engaged in research activity by the early 21st century. This gave reason to expect that the further development of science would soon change considerably [52]. Indeed, the pace at which science progressed (in terms of the above parameters) decreased in the 1970s throughout the world. Soon after that fall, however, new electronic devices appeared that significantly increased calculation speeds and high-capacity information carriers were created.

Under those conditions, the development of science in Russia was greatly influenced by internal factors [53]; discussions of this topic continue today. Recent decisions and plans will determine the development of our science and education for many years to come. In this context, it is worthwhile recalling the prophecy of M V Lomonosov that ''an ill-conceived and narrow plan'' designed to satisfy immediate needs rather than the logic of scientific development will soon have to be revised and modified.

When dealing with problems pertinent to the organization of research and education, M V Lomonosov relied on the most advanced strategies available at his time and chose the highly efficient ones. Lomonosov's method, prompted by his holistic view of life and science coupled to irreproachable honesty with himself and other people, appears to be of paramount importance at the present time of rapid changes in science and education that require solving many complex scientific and social problems [54, 55].

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