Introduction

THE main theme of this book is the shaping of science and scientific institutions in Russia and the Soviet Union by social, economic, and political factors. If it is true, as many modern historians of science believe, that such factors are major influences on science and its development, surely those influences will manifest themselves in the case of Russia and the Soviet Union. No one will deny that Russian society and culture have in the thousand years of Russian history differed from society and culture in Western Europe, where modern science was born. Russia has followed a different economic path from that of Western Europe, and it has religious, political, and cultural traditions quite unlike those of its Western neighbors.

The most fruitful comparisons are made, however, not between entities that are totally different, but between those that are similar enough for some common elements to be found but diverge sufficiently that the variations can be studied. Russian science fits these criteria well. Imported initially from Western Europe, it took root and developed in distinct ways. One of the theses of this book is that the variations that arose were not only organizational and economic, but cognitive. The intellectual pathways of many areas of Russian and Soviet science are dissimilar from those in Western Europe and America.

Studying how those differences arose can reveal a great deal about the ways in which science develops in distinct environments. Why, for example, did most biologists in nineteenth-century Russia accept Darwin's theory of evolution enthusiastically yet reject his term "struggle for existence"? Why has Russia had such a strong tradition in mathematics and astronomy, but weak ones in experimental science? Why did Soviet physicists for thirty years refuse to use Niels Bohr's term "complementarity"? Why did Soviet scientists lag in the development of plate tectonics in geology but lead in the promotion of magnetohydrodynamics? Why have Soviet astrophysicists been enthusiastic pioneers in developing "inflationary theories" of the development of the universe and critics of "big bang" theories? What factors account for the Soviet

Union being the first country in the world to build an atomic power station and the first to launch an artificial satellite?

And then there are the differences that are rooted in the authoritarian and ideologically troubled history of Russian and Soviet science. Why did so many Russian scientists get into political difficulties, both before and after the 1917 Revolution? Why did Lysenkoism, a biological doctrine that denied the achievements of modern genetics being pursued elsewhere in the world, reign in the Soviet Union for several decades? Why did Soviet authorities purge thousands of its best scientists and engineers exactly at the moment when it needed them most? And how did Soviet science not only survive these terrible losses but even, in some instances, flourish under conditions of tyranny? How do we explain the fact that Russian and Soviet science seemed to do best when the political situation was worst, and, with the emergence of democratic reforms in the nineties, seemed to go into decline?

These questions point to some of the ways in which Russia and the Soviet Union offer a unique opportunity for the study of science under conditions different from those in the industrialized West. In the chapters that follow, I have tried to answer these questions while, at the same time, giving an overview history of Russian and Soviet science.

The history offered here is not, of course, a comprehensive coverage of Russian and Soviet science; such a treatment would occupy many volumes. I have tried to analyze the most essential points. Where I have thought that more detail is necessary even though all readers may not be equally interested, I have placed that material in the appendix chapters under the individual scientific disciplines discussed there.

The main text of the book analyzes different aspects of the shaping of science in Russia by the social environment. The first chapter contains an analysis of the receptivity of early Russian culture to science, and the importation of science by Peter the Great in the early eighteenth century. In this first stage of the history of Russian science some issues emerge that remain constant in the later history: the authoritarian method of promoting science, the effort by Russia's leaders to catch up with Western science and technology without losing their own cultural and political identities, and the greater success of Russia in mounting large centralized projects such as explorations of the Arctic and Siberia than in fostering scientific creativity in a broad spectrum of official and unofficial organizations.

The next chapter, concentrating on the nineteenth century, describes the remarkable appearance of two scientists in Russia who left permanent marks on the history of world science, the mathematician Nikolai Lobachevskii and the chemist Dmitrii Mendeleev. Their improbable social origins and remarkable achievements are consonant in striking ways, and even the topics on which they worked are linked to the situations in which they found themselves. During their lives the Russian university

system grew impressively, even though it often suffered from political oppression and financial deprivation. The tsarist government gradually came to realize that the promotion of science and technology was in its interest. By the end of the century, science had become an important part of Russian culture, and in some areas – mathematics, physiological psychology, soil science, animal and plant ecology – Russia was emerging as a leader.

Chapter 3 concentrates on the ways in which the Russian socio-economic environment affected one area of science: the reception of Darwinian evolution. By the late nineteenth century radical political views, of several different types, were beginning to sweep across Russia. Politics affected attitudes toward evolution, resulting in debates that differed in some ways from those going on at the same time in Western Europe and America. A number of Russian scientists and analysts of evolution maintained that Charles Darwin himself had been influenced by the politics of nineteenth-century England while developing his great theory, and they tried to make revisions to Darwinism that would make it more palatable both to them and their Russian audience.

The second part of the book, opening with Chapter 4, analyzes the impact of the Russian Revolution of 1917 and the early Soviet regime on the development of science. The relationship of science to that revolution was far more intimate than a casual observer might think. The victorious Marxist leaders of the Revolution considered their view of history and politics to be scientific, and they had begun developing even before 1917 a Marxist philosophy of science. They wanted to promote science and technology rapidly, but they distrusted many of the scientists and engineers who had been educated before the Revolution, most of whom had little sympathy with the Bolsheviks. Gradually, however, a number of the scientists and especially the engineers began to work out a modus vivendi with the new government. The 1920s was a time when the future of the Soviet Union was still undetermined, and some technical specialists became intrigued with the vision of a scientifically planned economy. On the other hand, the most militant of the revolutionaries continued to be suspicious of the technical specialists. The scene was gradually set for a violent confrontation, which was promoted by Stalin in 1929.

Chapter 5 explores the ways in which several distinguished Soviet scientists were influenced by Marxism in the development of innovative theories about nature. This is an aspect of the history of Soviet science that is little known, and which, with the fall of communism in the Soviet Union in the 1990s, is now often denied, both in the former USSR and abroad. Most people now assume that all influence of Marxism on Soviet science was deleterious. On the contrary, in the works of scientists such as L. S. Vygotsky, A. I. Oparin, V. A. Fock, O. Iu. Schmidt, and

A. N. Kolmogorov, the influence of Marxism was subtle and authentic. It shows up in the cognitive core of their work.

Better known, although often misunderstood, is the catastrophe of Soviet biology because of Lysenkoism, the subject of Chapter 6. Many foreign commentators on Lysenkoism have assumed that its origins can be found in the hope of creating a "New Soviet Man" through the inheritance of acquired characteristics by human beings. On the contrary, Lysenko rejected such arguments and based his "Michurinist biology" on an effort to increase yields from agricultural crops and livestock. His rise was intimately connected with the crisis of Soviet agriculture stemming from the disastrous forced collectivization program. His overthrow was an incredibly protracted affair that involved the efforts of dozens of heroic Soviet scientists and intellectuals. The Lysenko affair was only the most dramatic of many political intrusions in Soviet intellectual life under Stalin and his immediate successors that resulted in the deaths of tens of thousands of Soviet scientists and engineers.

The last part of the book contains three chapters analyzing the ways in which Soviet society and the Soviet government over seventy-four years from 1917 to 1991 formed attitudes toward science and technology and the organizational framework of research and development. Chapter 7 shows that the Soviet Union was a pioneer in the 1920s in promoting the historical and social study of science and technology but that this effort soon was stymied by major political troubles. Chapter 8 examines the complicated relationship between the technical intelligentsia and the leaders of the Soviet state, two groups who simultaneously needed and yet distrusted each other. In the life of Andrei Sakharov, the famous physicist and dissident, we see a poignant illustration of this ambiguous relationship. Chapter 9 examines the history of the organization of science in the Soviet Union. This history is particularly striking, for it contains an ambitious effort by the Soviet Union to establish an alternative to the organization of science in the West that would, Soviet leaders thought, produce the finest and most productive science establishment in the world. The failure of that utopian scheme and the effort in the nineties to return to Western models of research are the subjects of the last section of this chapter.

The two appendix chapters, which examine each field of Russian and Soviet science and technology separately, describe the strong and weak aspects of research and then attempt to explain those strengths and weaknesses in terms of the social, economic, and political factors discussed in the earlier chapters. The history of Soviet science and technology contains impressive achievements, many of them little known in the West. How many people in the West know, for example, that the term "gene pool" is of Russian origin? Or that several of the pioneers of population genetics worked in Russia in the 1920s? Or that the basic terminology of

soil science is Russian? Or that the Soviet Union held many aviation records before World War II? Better known are the spectacular early achievements of the Soviet space program. The Soviet Union was the first country in the world to launch an artificial satellite and the first to place a human being in orbit. Western physicists know that the prevalent design for nuclear fusion, the Tokamak reactor, is also of Soviet origin.

Despite these achievements, the overall record of Soviet science and technology, considering the enormous size of the Soviet science establishment, was disappointing, especially to Soviet leaders. Fields with tens of thousands of researchers, such as chemistry, failed to match the level of outputs of countries with many fewer specialists in the field. In computers, after an early rather promising start, the Soviet Union fell behind badly. Medicine and public health, fields the Soviet Union held up for emulation by other developing countries in past decades, slipped catastrophically, as evidenced by deteriorating life expectancy and infant mortality statistics. Soviet biology never attained the excellence that it possessed before the calamity of Lysenkoism. Throughout the Soviet science establishment creativity fell to low levels, even in fields such as physics where a strong tradition of excellence existed.

These weaknesses have organizational, political, and social roots. Soviet science was not traditionally organized on the basis of peer review and research grants, but instead on block funding of entire institutes. This funding system is one of the many factors analyzed that contributed to the low productivity in Soviet science.

The end of the Soviet Union in late 1991 means that "Soviet science" as such has disappeared. "Russian science," however, will continue, and it will be one of the largest science establishments in the world, even if diminished from its size of a few years ago. The biggest scientific centers of the old Soviet Union – in Moscow, Leningrad (now again St. Petersburg), Novosibirsk – are in Russia. The new Russian Academy of Sciences, created in 1991, inherited most of the institutions and personnel of the old Soviet Academy of Sciences. Throughout the former Soviet Union the center of gravity shifted to the newly independent republics, and Russia, while dominant in science, is not the only one with a viable scientific establishment; Ukraine, in particular, has an impressive scientific community.

In the coming era, the influence of scientific institutions and modes of management formed during the Soviet period will long exercise influence in the successor states to the Soviet Union. A great debate is currently going on there about how much these institutions and their modes of governance should be changed in the post-Soviet era, a debate that I witnessed and even participated in while in Moscow in the last weeks of 1991, as the Soviet Union collapsed around us. I have described these discussions in the last part of Chapter 9.

In short, I began writing this book when one could speak of Soviet science as currently organized and practiced and Russian science as historically organized and practiced. By the time this book was completed the situation was reversed. Soviet science is now historical and Russian science is both historical and current.

PART I

The tsarist period

1

Russian science before 1800

WHY DIDN'T A SCIENTIFIC TRADITION DEVELOP IN OLD RUSSIAN CULTURE?

The study of the history of science in Russia and the Soviet Union raises basic questions about both Russian history and the nature of science. Some historians of Russia have argued that old Russia was particularly backward compared to Western Europe in the area of rational and naturalistic thought, and that the cause of this backwardness was an irrational or mystical characteristic in Russian Orthodoxy or even in the Slavic personality.[1] A study of the history of science in Russia will allow us to examine this viewpoint critically. This issue is elevated from a historical to a contemporary one by virtue of the fact that the Soviet Union became a major scientific force with an enormous scientific and technical community.[2]

Although I will concentrate in this book on the Soviet period, I will consider in the first four chapters the history of science before 1917, when the Soviet system of government was established. It is important, therefore, to recall the major divisions of Russian history: the first state, known as that of the Kievan Rus', from the ninth century A.D. to its conquest by the Mongols in approximately 1240; the period of Mongol rule from 1240 to 1480; the time of Muscovite primacy from 1480 to 1700; the Imperial period centered on St. Petersburg from 1700 to the Revolutions of 1917; and the Soviet period from 1917 to 1991. A new period commenced with the end of Communist Party rule in the latter year. The systematic study of nature according to the methods of Western science is almost entirely a phenomenon beginning in the early eighteenth century, but the cultural matrix in which this science arose in Russia had deep roots in the earlier periods.

The Kievan era was the formative period of Russian culture, the time when the Rus' were Christianized (988), and when they turned to Byzantium for religious, ideological, and literary models. It was also a period of remarkable cultural and economic development. Kiev at the end of the tenth and the beginning of the eleventh centuries was one of the largest cities in Europe, possessing, according to foreign accounts, some 400

churches and eight markets.[3] In architecture and some of the decorative arts the legacy of Kiev remains a world treasure to this day.

If one considers the place of Kiev in terms of its potential in the history of science, examining the issue at first from a speculative point of view, one might think that the culture of the Rus' was advantageously placed for scientific development. Historians of science in Western Europe often observe that two significant ingredients of the Scientific Revolution of the seventeenth century were ancient Greek thought and Arabic science. In geographic and cultural terms, the Kievan Rus' seem, at first sight, to have been well positioned. Kiev was a part of the Byzantine intellectual world with its ancient Greek sources of knowledge; furthermore, it had trading and even dynastic ties with the medieval cities of Europe, the Islamic centers of Asia, and with Constantinople itself. At the very beginning of Russian history, then, we face a riddle in the history of science: Why did Kiev miss this apparent opportunity to develop into a center of scientific studies?

Of the two important possible influences, the Arabic and the Byzantine, the Arabic is the easier to analyze. The possibilities of the Kievan Rus' for making contact with Arabic science were much more apparent than real. The most productive Islamic centers of scientific learning were at the Western end of the tier of Islamic lands – Moorish Spain (Toledo), Morocco, Southern Italy (Salerno), Sicily – and were therefore far from Kiev geographically. The Salerno school of medicine was very significant in the twelfth and thirteenth centuries. Recent research has shown that intricate mechanical clocks and devices were developed in Morocco in the same period. The Eastern tier of Muslim states, with which Kiev was in the closest proximity, seems to have been somewhat less creative in the natural sciences. Important exceptions exist, to be sure – Avicenna, or Ibn Sina, the greatest of the Arabic philosophers of the East – lived in Bukhara (later a Soviet city) exactly at the time of Kiev's flowering. Throughout this period, however, the Rus' were cut off from the enlightened Persian dynasty of the Saminids by fierce nomadic tribes such as the Patzinaks and the Cumans. The Rus' did have contact with the Volga Bulgars, Muslims who traded with the Arabs, but who were not interested in natural philosophy. Still, some knowledge penetrated to Kiev, especially in medicine, a field in which the Rus' became strong, and where Armenian, Syrian, and Arabic influences were important. The Bulgars also supplied silver to the Rus' and contributed to the development of a sophisticated art of the working of precious metals.

The failure of the Kievan Rus' to partake deeply of the Greek sources in science available in Byzantium is somewhat more difficult to explain. To the Kievans, Byzantium was not just one more potential influence or source of knowledge, it was *the* preeminent cultural force, sometimes disliked or envied, to be sure, but never disregarded. In liturgy, theol-

ogy, political ideology, and art, Byzantine influences were dominant in early Kievan culture. Yet, oddly enough, the Rus' and other Orthodox Slavs were not as interested in Byzantine science as members of some other cultures more peripheral to the Byzantine orbit. As Ihor Sevcenko, who studied the issue, remarked, the "Orthodox Slavs as a whole were certainly more influenced in their culture and literature by Byzantium than were Islam or Western Christianity, and even perhaps the Syrian Christians. With these Slavs, translated literature by far outranked original works in bulk, prestige and popularity. Yet, the Orthodox Slavs translated fewer of the scientific and philosophical works available in Byzantium than did the Syrians, Arabs or Latins."[4]

In fact, during the middle ages the Orthodox Slavs translated no complete major work of ancient Greek science.[5] And yet in this same period they translated many Greek manuscripts on other subjects into Church Slavonic, a language common to the Eastern Slavs. The most active translators were the Bulgarians, who created a literature in translation upon which the Kievan Rus' drew.

At the time of the greatest translation activity, the tenth century, Byzantium was actually enjoying a modest scientific revival. In the ninth century Byzantine scholars produced standard texts of Ptolemy and Euclid, and one of them, Leo the Mathematician, was familiar with the works of Archimedes and Proclus as well. None of these texts showed up in Kiev, however, a riddle that appears even deeper when one notices that Leo was described as the teacher of the Apostle of the Slavs, Cyril.

Despite the relative lack of interest in the Eastern Slavs in Byzantine science, Kiev did not go uninfluenced by Greek ideas about the natural world. Translations of Euclid or Ptolemy were not necessary in order for Greek terms and rudimentary ideas of nature to penetrate Kievan culture. Some of the Kievan monks and literati could read Greek, and even for those who did not, the translations of nonscientific texts from Byzantium often provided glimpses of Greek ideas about nature. According to these sources, fire, for example, was described as one of the four elements, and not as a pagan principle, as it had been regarded by the pre-Christian Rus'. The concept of the sphericity of the earth was also contained in some of the translated texts, as were tidbits of knowledge about biology that can be traced back to Aristotle. Educated Kievans encountered the names, and some of the sayings (often incorrect or distorted), of Thales, Parmenides, Democritus, Pythagoras, Socrates, Plato, and Aristotle. Words such as "planet" (*planida*, *planeta*), the translations of the signs of the zodiac, and technical terms crept into Kievan writings from Byzantine sources. But, considering the possibilities, the total impact of Greek and Byzantine science upon the Kievan Rus' was still quite small.

Some writers have attempted to account for the inattention of the