TIMELINE

The consequences of political dictatorship for Russian science

Valery N. Soyfer

The Soviet communist regime had devastating consequences on the state of Russian twentieth century science. Country Communist leaders promoted Trofim Lysenko — an agronomist and keen supporter of the inheritance of acquired characters — and the Soviet government imposed a complete ban on the practice and teaching of genetics, which it condemned as a "bourgeois perversion". Russian science, which had previously flourished, rapidly declined, and many valuable scientific discoveries made by leading Russian geneticists were forgotten.

"We cannot wait for Nature's good graces — to take them from her is our goal."[1]

The Communist state that replaced the Russian Empire in 1917 was based on Marx and Engels' thesis that it was possible to quickly and successfully alter economic relationships and even change the nature of all organisms, including human beings. The belief that Nature is malleable and can be heritably altered by the environment contradicted the laws of genetics, which are incompatible with the theory of acquired characteristics proposed by Lamarck. The 1920s saw vicious debates between geneticists and Lamarkists. Although, initially, many Soviet geneticists argued that genetics was entirely compatible with Communist ideology[2], the Communists soon shifted towards supporting the inheritance of acquired characteristics. By the early 1920s, geneticists were being publicly attacked by Lamarkists[3], and by the end of the decade many of them were being condemned as "bourgeois scientists". It was also at that time that Trofim Denisovich Lysenko, an agronomist by training who sided with the Lamarkists, made his first claims of being able to create new wheat varieties by varying environmental conditions, so providing a much needed improvement in grain harvest in the USSR. Communist Party leaders wholeheartedly embraced Lysenko's promising claims. By 1934, Lysenko was proclaiming that genetics was a hostile science for those who supported communist ideology — a view that culminated in a ban on genetics[4]. Political dictatorship in science in the USSR led to the

Figure 1 | **Photo of Trofim Lysenko speaking at the Kremlin in 1935.** Also present (from left to right) are S. V. Kosior, A. I. Mikoyan, A. A. Andreev and J. V. Stalin. Reproduced from REF. 9.

complete collapse of not only genetics, but also soil sciences, mathematical economics, statistics, cybernetics and many other disciplines. Outstanding scientists who were considered the enemies of the Communist state were arrested and many were executed.

Many have considered Lysenko and his followers to be responsible for the decline of Soviet science[5–8]. But I would argue that both Lysenko's dominant role in biology and the tragic developments in Soviet science in general were determined by the crude political intervention of Communist Party leaders in science, who chose to support trends that ideologically suited their beliefs[9,10]. In this perspective, I discuss Lysenko's scientific claims and provide some historic context in which they were made (for a more in-depth discussion see REF. 10). I show that before the ban on genetics in the USSR, Russian science flourished and many important discoveries were made. I also argue that this period in the history of science ought to be seen as an example of the devastating consequences that ideology and excessive political involvement can have on science.

Lysenko's struggle against genetics

Lysenko was born into a peasant family from Ukraine. He was trained as an agronomist, but had no higher scientific education. In 1925, he started to work at the Experimental Agricultural Station in the city of Gandzha (Soviet Azerbaidzhan) on developing methods for soil enrichment, but he soon became interested in a new subject: the effects of low temperatures on crop plant development. In this study, which was published in 1928 (REF. 11), he concluded that pretreatment of soaked seeds in relatively low temperatures (*yarovizatsia* or vernalization) could change the physiological nature of plants. In 1929, he declared that this pretreatment might help to increase the yield of crops[12]. Importantly, Lysenko's claim to increase the grain harvest in Russia came at a time when the country had been suffering from extended periods of drought and famine.

At that time a leading and influential Soviet biologist, Nikolai Vavilov, was working on a method for rapidly selecting new crop varieties by crossing a large number of plant varieties from over the world. However, his experiments were impeded by the inability to synchronize the flowering and pollination times of these species. It was then that Lysenko's vernalization experiments came to Vavilov's attention. He decided that vernalization could help to synchronize flowering, and began to fervently support Lysenko by inviting him to several high-level conferences, and by nominating him for the Lenin Prize (only awarded to outstanding scholars), membership to the Ukrainian and then the USSR Academy of Sciences[9]. Lysenko's suggestion of vernalization also gained support from the Communist Party leaders, but its practical implementation soon showed that the method failed to increase crop yields[10]. To convince the Government that he was contributing to the advancement of science and bringing practical benefits to the state, Lysenko began to falsify his results. Despite the fact that his crop-improvement strategies did not bring relief to agriculture, Communist leaders continued to have a high opinion of Lysenko's contribution to agronomically orientated science (FIG. 1).

Lysenko's initial claims coincided with the totalitarian collectivization of agriculture initiated by Stalin in 1928, which resulted in the forcible unification of individual farmers into collective farms (*kolkhozes*). More than ten million of the most prosperous farmers were condemned as '*kulaks*' (a label for relatively rich landowners), arrested, and either executed or exiled to Siberia[13]. Virtually all crop varieties were lost as a result of this campaign, and so, to restore the economy, the Communist Party leaders had issued a decree in 1931 that required scientists to select new outstanding crop varieties in 4–5 years (REF. 14). Although the leading plant breeders and biologists protested that selection of new varieties required at least 12 years of breeding[15], Lysenko realized he could claim that he was able to fulfill the Communist Party decree by rejecting genetics as a scientific discipline[4].

His early work on the effects of vernalization was followed by a proposal that the genetic make-up of crops, such as potato and sugar beet, could change according to when they were planted. Later, he claimed that new highly productive wheat and cotton varieties could be obtained in only two and a half years, and that plant productivity could be markedly increased by cross-pollinating different crop varieties. Although Lysenko's work was mostly of a practical nature, he also developed his own views on many aspects of biology. He rejected the principle of pure inbred lines (Johannsen's principle) and the concept of the gene, which he claimed was introduced by "bourgeois geneticists". Having rejected the principle of intraspecies competition (the foundation of Darwin's theory of evolution), he proposed a concept of intraspecies mutual support — an idea that was in agreement with the communist belief that cooperation between individuals could improve the world. He rejected the idea that viruses decreased yields of potatoes and other crops. He later developed a new theory on the role of granulated superphosphate in mineral nutrition in higher plants, and claimed that the most important role in this process is carried out by soil microorganisms. In accordance with this statement, he recommended changes in soil fertilization.

"Lysenko and his followers declared that genetics was a deleterious perversion of science, which impeded the efforts of Soviet scientists to change the animal and plant world…"

Box 1 | Life and work of Trofim D. Lysenko

1898	Trofim Lysenko born in the Ukraine to a family of peasants.
1917	A student of Vocational School for Gardeners in Uman, Ukraine.
1920	Attended a one-month training course for sugar beet specialists.
1921–1925	A correspondence student of Kiev Agricultural Institute.
1922	Assistant Agronomist at the Belaya Tserkov Plant Breeding Station.
1925	Junior Agronomist at the Gandzha Plant Breeding Station (Azerbaidzhan).
1929	Senior Researcher (later Laboratory Head) at the Odessa Institute of Genetics.
1934	Scientific Director (Director, from 1936) of the Odessa Plant Breeding and Genetics Institute (after the arrest of the former director, A. A. Sapegin).
1934	Elected as an Active Member of the Ukraine Academy of Sciences.
1935	Appointed by the Government as an Active Member of the Lenin All-Union Academy of Agricultural Sciences (VASKhNIL).
1935	A member and, from 1937, Deputy Chairman of the USSR Supreme Soviet Council (see figure).
1938	President of the VASKhNIL (after the arrest of the former president G. Meister).
1939	Elected as an Active Member of the USSR Academy of Sciences and appointed a member of the Presidium of the Academy.
1940	A director of the USSR Academy of Sciences Institute of Genetics (after the arrest of N. I. Vavilov).
1948	Head of the Department of Grain Crops Breeding of the Moscow Timiryazev Agricultural Academy (after the dismissal of A. R. Zhebrak from this position).
1976	Died in Moscow.

Lysenko was decorated with gold medals of the Stalin Prize, and seven times with the highest Soviet decoration — the Order of Lenin. He was named as a Hero of the Socialistic Labour.

In 1936, the Communist Party ordered a large-scale conference at the Lenin All-Union Academy of Agricultural Sciences, at which geneticists, such as the US scientist Hermann Muller, who for several years worked in the USSR, presented evidence for the role of genetics in evolution and discussed its use in the improvement of agriculture[16]. In 1939, at a similar meeting with the editorial board of *Under the banner of Marxism* — the main ideological journal of the Central Committee of the All-Union Communist Party, the VKP(b) — Lysenko and his followers declared that genetics was a deleterious perversion of science, which impeded the efforts of Soviet scientists to change the animal and plant world: "I do not accept Mendelism … I do not consider formal Mendelian–Morganist genetics a science … We object to … rubbish and lies in science, we discard the static, formal tenets of Mendelism–Morganism"[17].

Although the Lysenkoites had no scientific arguments to substantiate their views, they had the complete support of the VKP(b) mass media[18]. In June 1941, Nazi Germany invaded the USSR and the war set aside the harsh biological debates, but soon after the end of the war, the arguments resumed. At this time Stalin steadfastly and decisively sided with Lysenko. In 1947, Stalin wrote to Lysenko: "… I think that the Michurinist view is the only scientific view. The Weismannists and their followers who are rejecting heredity of acquired characters do not deserve the right to speak a long time about them. The future belongs to Michurin"[19].

Weismann had postulated that the germ plasm was transmitted through the gametes from one generation to the next, thereby ruling out the inheritance of acquired characters. Michurin, an amateur horticulturist, claimed that plants often showed the characteristics of the habitat in which they were grown rather than that of their parents. Such observations naturally appealed to the Communist leaders. Thanks to Stalin's and other Communist leaders' support, and in spite of criticisms from fellow scientists, Lysenko's career flourished (BOX 1).

Condemnation of genetics

By the end of 1946, Lysenko was harshly criticized by scientists as a dictator in biology and agronomy, and began to lose his dominant role even in the eyes of many political leaders. Evaluations of Lysenko's work showed that his innovations were either unjustified or falsified[9]. To stabilize his position, in the spring of 1948 he sent a letter to Stalin seeking his support[20]. Simultaneously, he made a new promise: to increase the country's wheat yield by five- to tenfold by improving a particular wheat variety — branched wheat[20]. The promise was made in complete disregard for previous studies, which showed that branched wheat could not exceed the yields of regular varieties. Yet again, Stalin preferred to trust in "the agronomic genius" of Lysenko. Stalin also decided to show his support for Lysenko by allowing him to officially declare that genetics was a "bourgeois perversion". In July 1948, the VKP(b) Politburo unanimously declared that genetics, as a scientific discipline, must be prohibited in the USSR[21]. In accordance with this decision, a Party decree was drafted[22], and later edited by Lysenko and Stalin himself[23], and was presented by Lysenko in the August 1948 Session of VASKhNIL[24]. All genetical research was forbidden in the USSR, and no further discussions on the subject were permitted. Party leaders began to compile lists of laboratories that had to be closed, and scientists who were to be unconditionally fired[25]. At scientific meetings throughout the country, thousands of geneticists or other scientists who supported genetics were summoned, their work was condemned and they were dismissed.

The application of Lysenko's ideas in agriculture not only devastated the harvest productivity of this vital sector of the economy[26], but also had another terrible consequence: thousands of poorly educated, but ambitious, people captured leading positions in many scientific fields. Biology and related disciplines, such as medicine, suffered immensely, and Soviet science found itself in deep crisis. Several generations of students left school without any knowledge of contemporary science. To this day, Russian science has not completely recovered from this gloomy heritage.

Figure 2 | **Nikolai Koltsov in his laboratory, 1929.** Reproduced from REF. 9.

> "In 1927, Koltsov hypothesized that inherited characteristics are recorded in special double-stranded giant molecules … that would replicate in a semi-conservative fashion using each strand as a template …"

But what was the state of Russian science before the almost universal acceptance of Lamarkism and the rise of Lysenkoism?

Russian science before communism

By the end of the nineteenth century, and especially during the first two decades of the twentieth century, Russian biology had flourished. Russian scientists were at the forefront of many scientific disciplines. Dmitry Ivanovsky discovered plant viruses in 1892. In 1904, Ivan Pavlov won the Nobel Prize in Physiology or Medicine for his work on the physiology of digestion. The principles of cellular response to infection were formulated by Ilya Mechnikov, who received the Nobel Prize in 1908.

Among the leading Russian scientists were Nikolai Koltsov and Sergei Chetverikov. In 1903, Koltsov (FIG. 2) proposed that the shape of a cell is determined by a net of filaments or fibres, creating a kind of skeleton, which he called 'cytoskeleton'[27]. His theory became popular[28,29]; previously, scientists had thought that the cell shape depended on the osmotic pressure of the cell content.

In 1927, Koltsov proposed that inherited characteristics are recorded in special double-stranded giant molecules[30]. Each chromatid would consist of one giant hereditary molecule made up of two mirror strands that would replicate in a semi-conservative fashion using each strand as a template; each gene would be a segment within this molecule (FIG. 3). These ideas were a pioneering portend of the future progress of science. They were confirmed over 25 years later, when James Watson and Francis Crick published their theoretical model of a double-stranded DNA helix in 1953. They, as Watson recounted to me in 1988, had not even heard about Koltsov's hypotheses, although his theory was known in the West and was championed by Milislav Demerec and J. B. S. Haldane[31]. Koltsov was also interested in the role of ions in cellular metabolism, outpacing his contemporaries by half a century[32]. Remembering the time spent together with Koltsov, US geneticist Richard Goldschmidt wrote: "There was the brilliant Nikolai Koltsov, probably the best Russian zoologist of the last generation, an enviable,

Timeline | **Pioneering results of several Russian life scientists**

- **1880s–1900s**: Ilya Ilyich Mechnikov discovers the cellular immune response of organisms to infection.
- **1890s–1910s**: Ivan Petrovich Pavlov studies physiology and lays down the foundation of conditional reflexes.
- **1892**: Dimitri Ivanovski discovers viruses.
- **1896**: Georgii Adamovich Nadson starts teaching one of the first courses of microbiology in the world.
- **1898**: Sergei Gavrilovich Navashin discovers the double fertilization of angiosperms.
- **1903**: Nikolai Konstantinovich Koltsov proposes that cellular architecture is determined by the cytoskeleton, made up of a net of filaments or fibres.
- **1907**: Mikhail Semenovich Tsvet invents the method of chromatography.
- **1910**: Gregory Andreevich Levitsky establishes that plant cells carry mitochondria and suggests that mitochondria carry their own genetic determinants.
- **1915**: Sergei Sergeevich Chetverikov establishes the role of the exoskeleton in insect evolution.
- **1920s–1930s**: Koltsov studies the role of ions in the contraction and relaxation of biological structures.
- **1920s–1937**: Georgii Karlovich Meister uses genetic principles to produce outstanding crop varieties that were sown in the USSR on more than 10 million hectares.
- **1922**: Nikolai Ivanovich Vavilov formulates the "Law of parallel rows in hereditary variability". Parallel rows are now named 'paralogues'.
- **1925**: Nadson and Gregory Filippov prove that X-ray radiation induces mutations in yeast (two years before H. Muller).
- **1925**: Georgii Dimitrievich Karpechenko introduces artificial polyploidization and generates an amphidiploid between two genera of the Cruciferae family.

unbelievably cultured, clear-thinking scholar, admired by everybody who knew him"[33].

In 1917, the Koltsov Institute of Experimental Biology (IEB) was opened in Moscow, just a few months before the Bolsheviks seized power[34]. The IEB rapidly became a centre of excellence for genetics and cell biology, where, in 1921, Sergei Sergeevich Chetverikov established a Laboratory of Genetics. Although in 1922 Muller brought Chetverikov a small collection of mutant *Drosophila melanogaster* from the laboratory of Thomas H. Morgan, he continued to focus on naturally existing mutants. In 1915 he developed a new principle of insect evolution: he observed that the limits imposed by the exoskeleton physically determine the smaller size of insects, which, he argued, influenced the evolution of insects and allowed them to invade new ecological niches[35,36].

Chetverikov also established the role of sudden population size increases in the evolution of many species. He named these population expansions "waves of life"[37], and suggested that such bursts could facilitate the rate of evolution. In 1926, Chetverikov laid down the fundamentals of a new scientific discipline — population genetics[38]. He confirmed the importance of the accumulation of recessive mutations in genomes of different species and demonstrated their role in evolutionary changes. In contrast with Hugo De Vries, who in his monograph *Die Mutationstheorie*[39] argued that mutations could mould new species of living organisms without a Darwinian explanation, Chetverikov proved, for the first time, that there was no antagonism between genetics and Darwinian evolutionary studies. Although other biologists, such as W. Johannsen, E. Baur and H. Nilssen-Ehle, made similar claims, the first experimental analysis was provided by Chetverikov. Only several years later did Ronald Fisher and Sewall Wright, statisticians with a keen interest in genetics, use the same mathematical approach to reach a similar conclusion — that discontinuous genetic evolution could be reconciled with continuous morphological change[40]. At the Fifth International Congress of Genetics in 1927, Chetverikov presented data from his studies of natural populations of *Drosophila* that indicated that natural populations appearing phenotypically similar carry many recessive mutations[41]. "Species, like a sponge, are saturated with mutations", Chetverikov wrote.

These are just a few of the outstanding Russian biologists who contributed to the advancement of science in the early twentieth century (see timeline and BOX 2 for more information). Sadly, most of their work has now been forgotten.

Tragic fate of leading biologists

Three months before the 1917 Revolution, Lenin had written his book *The State and the Revolution*, in which he explicitly explained the future role of intellectuals in the Communist state: they were to be placed under the constant and unavoidable control of simple workers and poor peasants[42]. Naturally, the most educated intellectuals, including scientists, could not agree to such surveillance. In response, Lenin applied two strategies: more than 2,000 of the most vocal critics of the regime were expelled from Soviet Russia to the West, and the remaining scientists were put under the strict control of the Red Commissars[43]. Meanwhile, Lenin's government started its struggle to recruit new, so-called 'proletarian' or Red Intelligentsia. (As the son of a peasant, Lysenko matched the criteria perfectly.) Starting in 1929, the Politburo of the VKP(b) decided to establish strict control over natural sciences and mathematics, and began to control the election of new members to the USSR Academy of Sciences[44]. It was then

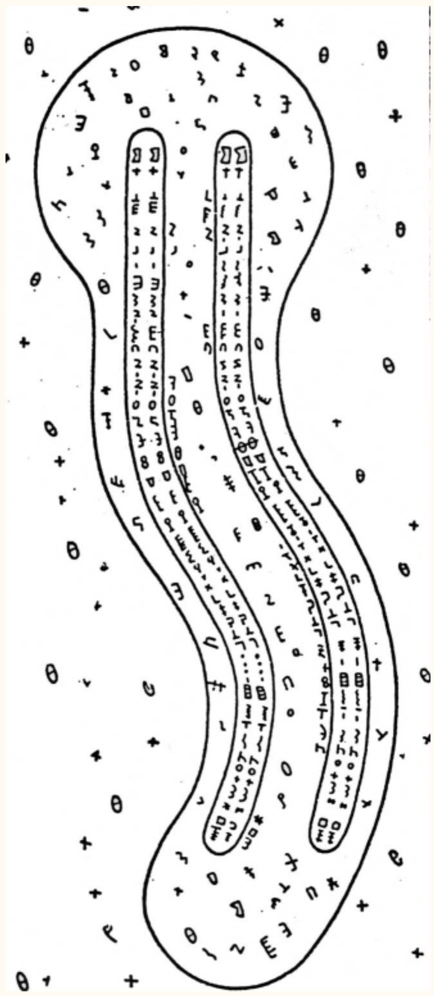

Figure 3 | **Giant hereditary molecules.** Each chromosome, in accordance with Koltsov's hypothesis, consists of two chromatids, each of which is composed of one double-stranded giant hereditary molecule, in which every gene is represented by its own symbol. During cell division, each strand is used as a template for the synthesis of its mirror copy or replica, so that the lineage can be preserved in hereditary records "through exact positioning (with the help of Van der Waals' forces, or forces of crystallization) on points in which similar side groups exist in the molecule that serves as a template". Reproduced from REF. 47.

- **1926** — Chetverikov lays down the fundamentals of population genetics.
- **1926** — Nikolai Grigorievich Kholodny isolates and studies the first plant hormones.
- **1927** — Koltsov proposes the existence of giant hereditary molecules, which would be double stranded and replicate semi-conservatively.
- **1928** — Maxim Nikolayevich Meissel discovers chemical mutagenesis while working in Nadson's laboratory.
- **1929–1930** — Aleksander Sergeevich Serebrovsky and his pupils show that a gene's function could be split by different mechanisms.
- **1930** — Solomon Grigorievich Levit opens the first biomedical institute in the world with clinics for patients with hereditary disorders. His research mainly focuses on twin studies.
- **1930s** — Vladimir Pavlovich Efroimson uses twin studies to analyse the frequency of mutations in humans and champions the role of mutations in human evolution.
- **1935** — Dimitri Anatolievich Sabinin establishes the role of cations in plant development and studies the structure and function of biological membranes.

Box 2 | **Intragenic fine structure and intergeneric hybrids**

Aleksander Sergeevich Serebrovsky was one of Koltsov's pupils. Between 1929 and 1931, he and his pupils (primarily N. P. Dubinin) provided evidence for the complex nature of genes, and showed that the gene could be split with the help of different mutations[48]. Although concerns about Bateson's 'presence/absence' principle, which proposed that any gene could either exist in a chromosome or disappear when damaged by mutation, were expressed (see, for example, REF. 49), the first strong experimental evidence for the possibility to split genes with mutations was obtained in the following experiments. Serebrovsky used X-ray irradiation and studied two X-linked genes of *Drososphila melanogaster*: *scute* and *achaete*, which contribute to the development of bristles on the head and scutellum of insects (triangular area of the exoskeleton behind the thorax). By mutagenizing flies and scoring the mutant phenotypes, the Serebrovsky laboratory disproved Bateson's principle. To account for their results, Dubinin proposed that each mutation occupies its own region in the gene and governs the development of only those bristles that are controlled by this region, and that different mutations can cover overlapping parts of the gene[50]. Serebrovsky named this effect 'step allelomorphism' (from *allele* and *morpho*). By making double-mutant flies, his group was able to construct intragenic maps of the *scute* and *achaete* genes. A quarter of a century later, a US scientist, Seymour Benzer, came to the same conclusion on fine gene structure using the simpler model of a T4 bacteriophage.

Serebrovsky was also the first to use biological methods to control natural insect crop-pests. He proposed that populations of these insects could be controlled by introducing genetically mutated insects of the same species into the same ecological zones. The interbreeding of mutant and indigenous insects favours the spread of deleterious mutations in the population and the consequent reduction in the number of insect crop-pests.

In 1922, another talented scientist, Georgii Dmitrievich Karpechenko, began his experiments on plant hybridization. In 1925, he was the first to successfully apply artificial polyploidiziation of two different genera of the Crucifera family, *Raphanus sativus* and *Brassica oleraceae*, and to create a fertile tetraploid hybrid, which he called *Raphanobrassica*[51]. Karpechenko was nominated for the Rockefeller Scholarship, and from October 1929 to February 1931, he mainly worked in Morgan's laboratory at Columbia University (New York), where another Russian, Theodosius Dobzhansky, had started his tenure. On his return to the USSR, Karpechenko organized and chaired the Department of Genetics and Selection at the Leningrad State University and continued his chairmanship at the Division of Genetics at the All-Union Plant Industry Institute.

that Stalin became deeply involved in controlling the natural sciences.

Nikolai Koltsov was among the strongest critics of the Tsarist government. However, after the 1917 Revolution all democratic ideals of society were rejected by the new power. Koltsov joined a group of intellectuals who disagreed with the new policies and proposed changes to the political climate in the country. All members of the group were arrested and Koltsov was sentenced to death. His close friend, the proletarian writer Maxim Gorky (who financially supported Lenin and his friends before the Revolution) personally appealed to Lenin, and Koltsov was released from prison and restored to his previous position as the Director of the Institute of Experimental Biology. However, Koltsov outspokenly criticized Lysenko for his ignorance and the misunderstanding of scientific principles. After sharp criticisms of his scientific views by the Communists, he died in 1940, allegedly as a result of a stroke. Recently, the biochemist Ilya Zbarsky revealed that the unexpected death of Koltsov was a result of his poisoning by the NKVD (Soviet secret service)[45].

Chetverikov was arrested in 1929 on the basis of falsified political charges and sent into exile for five years in the Urals, on the border between European Russia and Siberia. He never obtained permission to return to Moscow, his laboratory was destroyed, and in 1948 he finally lost his job. He died in Gorky, forgotten by his peers.

Many other scientists, among them Agol, Levit, Nadson and Meister (see timeline), were accused of anti-Soviet activity, and were arrested and shot during 1936–1940.

On 6 August 1940, the Russian biologist Vavilov was arrested and accused of sabotage and espionage. During long and brutal interrogation sessions[46], he was forced to name colleagues who were allegedly also involved in sabotage and espionage. Vavilov was sentenced to death, which was later commuted to 25 years in prison. But the cruelty of the regime was revealed in Vavilov's case with particular clarity: this decision was not delivered to the prison warden in Saratov where Vavilov was held. He died of hunger and dystrophy in the death cell on 23 January 1943.

In 1941, Georgii Karpechenko and Gregory Levitsky were arrested. In the arrest summons it said that accusations against them originated partially from Vavilov. Levitsky was condemned to death and immediately died in prison, possibly by commiting suicide, whereas Karpechenko was shot.

Immediately after the August 1948 VASKhNIL Session, V. P. Efroimson, the most outspoken critic of Lysenkoism, prepared a 200-page manuscript describing the negative results of Lysenko on Soviet biology and agriculture. He was courageous enough to send this manuscript to the Central Committee of the Communist Party of the Soviet Union, for which he was arrested and sent to the Gulag, where he remained until 1955.

Early in 1955, relatives and colleagues of the above-mentioned biologists, agronomists and geneticists sent appeals to the General Prosecutor of the USSR in which they asked for all cases against the condemned and executed scientists to be re-examined. All of them received written explanations that these cases were not well justified and that arrests and deaths happened because of trumped-up charges. All the aforementioned scientists were rehabilitated posthumously. After the fall of the Soviet empire, access to court papers was partially opened, and relatives and scientists received their first chance to see the accusations. It then became clear that the accusations of sabotage, or belonging to "enemies of the people and state", were all based on disagreements of these scientists with the Communist Party orders and Lysenkoist doctrines. They lost their lives because they attempted to defend science from politicization and from the Party's support of Lysenko's pseudoscience.

Totalitarian political pressure

The Soviet communist regime eliminated many of its best scientists, crushed societal morals and brought irreparable harm to the country (for a discussion see REFS 8,10). During 1919–1922, Lenin exiled thousands of philosophers, sociologists, historians and economists whose ideas contradicted his views. Stalin and the Communist Party Politburo took the next step: they decided that certain scientific fields must be forbidden as "bourgeois perversion". It is possible to argue that science is intrinsically political, and many scientists might be seen as excellent politicians when it comes to seeking financial support for their work, but, in my opinion, this behaviour cannot be compared with the hysterical appeals to the country's leaders to ban certain disciplines and calls for the arrests of 'anti-Soviet' scientists that took place in the USSR.

The intervention of the Communist leaders into science in the USSR was a particular phenomenon in the history of science in the twentieth century, comparable only with the events that took place in Nazi Germany. It is qualitatively different from the sort of everyday 'politics' in which all scientists, everwhere, engage. The most tragic consequence of totalitarian rule was the persecution of those scientists who were unable to unconditionally agree with the Party's decrees or tried to dispute its decisions. These personal tragedies of many outstanding scientists in the USSR led to much deeper and wider effects. The progress of science was slowed or stopped, and millions of university and high school students received a distorted education. A comparable example of the devastating influence of politicization of society was the Nazis' destruction of science in fascist Germany after 1933. Thousands of scientists, especially those of Jewish origins, were forced to leave Germany. Nevertheless, the mass arrests of scientists in the Soviet Union had much worse consequences for science. In my opinion, it was the most tragic event in the history of science. It demonstrated the terrible effects of a political dictatorship, and showed that science should develop in free and open competition between scientists, without political intervention.

V. N. Soyfer is at the Laboratory of Molecular Genetics, Department of Biology, George Mason University, 4400 University Drive, MSN 3E1, Fairfax, Virginia 22030, USA.
e-mail: vnsoyfer@gmu.edu

Links

FURTHER INFORMATION Nikolai Vavilov | Stalin | Ivan Pavlov | Ilya Mechnikov | Francis Crick and James Watson | Thomas H. Morgan | Lenin

1. Michurin, I. V. in *Collected Works* Vol. 1, 55 (Selkhozgi, Moscow, 1948) (in Russian).
2. Blyakher, L. Ya. *The Problem of Inheritance of Acquired Characters* (Nauka, Moscow, 1971) (in Russian).
3. Proceedings of the 2nd All-Union Conference of Marxistsko–Leninist Scientific Organizations (Moscow, 1929) (in Russian).
4. Lysenko, T. D. Physiology of plant development in relation to plant breeding. *Semenovodstvo* **2**, 20–21 (1934) (in Russian).
5. Dobzhansky, Th. The suppression of science. *Bull. Atom. Sci.* **5**, 144–146 (1949).
6. Muller, H. J. The destruction of science in the U.S.S.R. *Sat. Rev. Lit.* **31**, 13–15; 63–65 (1949).
7. Medvedev, Z. *The Rise and Fall of T. D. Lysenko* (Columbia Univ. Press, New York, 1969).
8. Joravsky, D. *The Lysenko Affair* (Harvard Univ. Press, Cambridge, Massachusetts, 1970).
9. Soyfer, V. N. *The State and Science* (Hermitage, New Jersey, 1989) (in Russian).
10. Soyfer, V. N. *Lysenko and the Tragedy of Soviet Science* (Rutgers Univ. Press, New Jersey, 1994).
11. Lysenko, T. D. Influence of thermal conditions on developmental phases duration. The experiments with cereals and cotton. *Trudy Azerbaidzhanskoi Tsentralnoi Opitno–selektsionnoi stantsii imeni tovarishcha Ordzhonikidze*, Vol. 3, Baku (1928) (in Russian).
12. Lysenko, T. D. & Dolgushin, D. A. On the essense of the winter nature of plants. *Trudy Vsesoyuznogo c'ezda po genetike, selektsii, semenovodstvu i plemennomu zhivotnovodstvu*, Leningrad 10–16 January1929, Vol. 3, 189–199 (Voennomockikh sil RKKA, Leningrad, 1929) (in Russian).
13. Churchill, W.*The Second World War* Vol. 4 (Voenizdat, Noskva, 1955) (in Russian).
14. On Plant Breeding and Seed-Growing. Postanovleniye Prezidiuma TsKK VKP(b) i Kollegii NK RKI po dokladu RKI RSFSR. *Pravda* 3 (3 August, 1931) (in Russian).
15. Abridged transcript of the discussions in *Sotsialisticheskoye zemledeliye* 2 (13 September, 1931) (in Russian).
16. Archive of the VASKhNIL, The Stenogram of the 4th VASKhNIL Session, Opis' 450, Delo 59 (in Russian).
17. Lysenko, T. D. in *Agrobiologiya* 6th edn (ed. Lysenko, T. D.) 282 (Sel'khozgiz, Moscow, 1952) (in Russian).
18. Conference proceedings. *Pod Znamenem Marksisma* **11**, 95; 96–98; 125 and others (1939).
19. Vavilov, Yu. N. Exchange with letters between Lysenko and Stalin. *Vestnik Istorii Yestestvoznaniya i Tekhniki* **2**, 153–165 (1998) (in Russian).
20. Soyfer, V. N. New light on the Lysenko era. *Nature* **339**, 415–420 (1989).
21. The decision of the Politburo of the Central Committee of the VKP(b), 15 July 1948, No. 64, Point 124 (In the Central Political Archive of the Institute of Marxism–Leninism, fund 17, file 17).
22. The Central Political Archive, fund 17, opis' 8, delo 991, list 83.
23. Rossianov, K. O. Editing nature: Joseph Stalin and the 'new' Soviet biology. *ISIS* **84**, 728–745 (1993).
24. Lysenko, T. D. *The Science of Biology Today* (International Publishers, New York, 1948).
25. Transcript of the Politburo of the CC of VKP(b) RTsKhIDNI, f. 17, op. 116, yed. khr. 365 (1948) (in Russian)
26. *Vestnik Akademii Nauk SSSR*, **11** (1965).
27. Koltzoff, N. K. Ûber formbestimmende elastiche Gebilde in Zellen. *Biol. Zbl.* **23**, 680–696 (1903).
28. Thompson, D. W. *On Growth and Form* (Cambridge Univ. Press, 1917).
29. Wilson, E. B. *The Cell in Development and Heredity* (Macmillan, New York, 1928).
30. Koltsov, N. K. Physical–chemical fundamentals of morphology. *Prog. Exp. Biol.* B **7**, 3–31 (1927) (in Russian).
31. Haldane, J. B. S. A physicist looks at genetics. *Nature* **155**, 375–376 (1945).
32. Koltsov, N. K. Organisation of the cell. *Medgiz* (1936) (in Russian).
33. Goldschmidt, R. B. *The Golden Age of Zoology. Portraits from Memory* (Univ. Washington Press, Seattle, 1956).
34. Adams, M. B. in *The Social Context of Soviet Science* (eds Lubrano, L. L. & Solomon, S. G.) 242–278 (Westview, Colorado, 1980).
35. Chetverikov, S. S. The basic factor of evolution. *Bull. Soc. Entomol. Moscow* **I**, 14–24 (1915) (in Russian).
36. Chetverikov, S. S. in *The Smithsonian Report for 1918*, Publication 2566, 441–449 (Government Printing Office, Washington, 1920).
37. Chetverikov, S. S. Life's Waves. *Dnevnik Zoologicheskogo Otdeleniya imperatorskogo obshchestva lyubiteley yrestestvoznaniya, antropologii i etnografii. M*. **3**, 6 (1905) (in Russian).
38. Chetverikov, S. S. O nekotorykh momentakh evolutsionnogo protsessa s tochki zreniya sovremennoy genetiki. *Zh. Exp. Biol.* A **2**, 3–54 (1926); complete translation by Barker, M. (ed. Lerner, I. M.) On certain aspects of the evolutionary process from the standpoint of modern genetics. *Proc. Am. Philos. Soc.* **105**, 167–195 (1961).
39. de Vries, H. Die Mutationstheorie. *Jena* B. I (1901); *Jena* B. II. (1903). (Veit & Co., Leipzig.)
40. MacKenzie, D. A. *Statistics in Britain, 1865–1930: The Social Construction of Scientific Knowledge* (Edinburgh Univ. Press, 1981).
41. Chetverikov, S. S. in *Trudy III C'ezda Zoologov, Anatomov I Gistologov*, Leningrad, 14–20 December 1927, 52–54 (Glavnayka, Leningrad, 1928).
42. Lenin, V. I. *The State and the Revolution. Collected Works* Vol. 25, 44 (Progress, Moscow, 1964) (in Russian).
43. Lenin, V. I. *Collected Works* Vol. 29, 5–6 (Progress, Moscow, 1965) (in Russian).
44. The USSR Academy of Sciences in Decrees of the Politburo of the CC of TsK RKP(b)-VKP(b)-KPSS, 1922-1992 (ed. Yeassakov, V. D.) (Rosspen, Moscow, 2000) (in Russian).
45. Zbarsky, I. B. *The Check-Point Number One* (Vagrius, Moscow, 1999) (in Russian).
46. The Central Archive of the Federal Service of Security, Issue No. R–2311, Vol. 1, 519. Cited in *Sud Palacha, Nikolai Ivanovich Vavilov v zastenkakh NKVD* (Academia, Moscow, 1999).
47. Koltsov, N. K. Hereditary molecules. *Sci. Life* **5–6**, 4–14 (1935), reprinted in *Bull. Moscow Soc. Naturalists* (Biology) **70**, 75–104 (1965) (in Russian).
48. Serebrovsky, A. S. & Dubinin, N. P. Artificial induction of mutations and the gene problem *Zh. Exp. Biol.* **4**, 235; 247 (1928) (in Russian)
49. Morgan, T. H., Bridges, C. B., Schultz, J. & Sturtevant, A. H. *The Mechanism of Mendelian Heredity* (H. Holt & Co., New York, 1915).
50. Dubinin, N. P. Step allelomorphism in *Dr. melanogaster. J. Genet.* **27**, 443–464 (1933).
51. Karpechenko, G. D. Polyploid hybrids of *Raphanus sativus L × Brassica oleraceae. Trudy Prikladnoi Botanike, Genetike i Selektsii* **17**, 305–410 (1927) (in Russian).

Acknowledgements
The author thanks M. Adams, V. Chandhoke, K. Fryxell, G. Sher and G. Brillantes for their assistance and useful comments.