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ORIGINAL ARTICLE



## Elena Alexandrovna Timofeeva-Resovskaya at the forefront of radiobiology in the XX century

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### ABSTRACT

**Purpose:** The purpose of the study was to show the outstanding contribution of Elena Alexandrovna Timofeeva-Resovskaya (1898–1973) to the development of radiobiology.

**Materials and methods:** We reviewed the author's memoirs and materials from the personal archive, as well as literary and electronic sources.

**Results and conclusions:** For the first time the autobiography of Elena A. Timofeeva-Resovskaya and the periods of her scientific activity were revealed. We demonstrated the primary role of Elena A. Timofeeva-Resovskaya in the research of aquatic ecosystems. The results of her research turned out to be important both for solving the problems of radioactive contamination of territories and for the development of modern radioecology. Throughout her life, she worked with her husband Nikolay V. Timofeev-Resovsky (1900–1981), a great scientist and prominent scientific enlightener. There was no purpose to describe the life of Timofeev-Resovskies family, full of exciting events, but it was not possible to avoid it. For young women in science, Elena A. Timofeeva-Resovskaya can provide an example of a successful scientific career even in turbulent times.

### ARTICLE HISTORY

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*So, my wife was an absolutely wonderful woman (N.V. Timofeev-Resovsky)*

*Many called her Saint Helena, this is how we imagine the saints (A.N. Timofeev, the youngest son)*

An outstanding woman scientist, radiobiologist Elena Alexandrovna Timofeeva-Resovskaya performed researches from the 1920s to the 1970s (Figure 1). In her experiments on different objects using various radioisotopes, she investigated the effect of radiation exposure at the main levels of organization of living matter such as genetic, organismic, population, and biocenotic. Her radiobiological researches were among the first regarding each of these levels. This fact can be proved by her bibliography, which includes 55 scientific articles, 1 monograph and 28 scientific reports (Babkov and Sakanyan 2002). In the early 50s, when E.A. Timofeeva-Resovskaya took part in the USSR Atomic Project, she conducted the first research on the radiobiology of aquatic ecosystems. The research results turned out to be important both for solving the problems of radioactive contamination of territories and for the development of modern radioecology.

In the handwritten autobiography<sup>1</sup> on her 65th birthday in 1963, she briefly listed her scientific milestones and areas of study.

### Autobiography

*Timofeeva-Resovskaya*

*Elena Alexandrovna*

I was born on 21 June 1898 in Moscow. In 1917, I graduated from the gymnasium. From 1918 to 1919 I studied at the Faculty of Natural Sciences of the Shanyavsky University. In the spring of 1919, I went on a business trip to Askania-Nova for summer. From the fall of 1919 till the spring of 1921 I studied in Simferopol at the natural department of the physics and mathematics faculty. In the spring of 1921, I returned to Moscow and entered the 1st Moscow State University particularly, the biological department of the physics and mathematics faculty. In 1925, I graduated from the University with a degree in descriptive zoology.

From the fall of 1919 till the spring of 1921 I worked as a laboratory assistant at M.M. Zavadovsky in Simferopol. From the autumn of 1921–1925 I occupied the position of an assistant at the Department of Zoology of the Biotechnical Faculty of the Practical Institute in Moscow; from 1925 till 1937 I worked as a research assistant in the genetics laboratory of the Institute of the Brain in Berlin-Buch; from 1937 till 1946 as a researcher at the Department of Genetics and Biophysics in Berlin-Buch; from 1946 till 1947 as a senior researcher at the Academy of Sciences of the GDR; from 1947 till 1955 as a researcher of the Biophysics Department of the object, PO Box 0215<sup>2</sup>. From 1955 to the present, I am a junior researcher of the Biophysics Laboratory of the Biological Institute of the Ural branch of the USSR Academy of Sciences in Sverdlovsk.

From 1921 I worked in the field of hydrobiology under the guidance of prof. S.N. Skadovsky. And since 1923, I began to research in experimental genetics, firstly studying the phenotypic manifestation of traits, and continuing with



Figure 1. Elena Alexandrovna Timofeeva-Resovskaya, 1926.

the experimental analysis of natural populations and radiation genetics. Moreover, since the end 1930s, I have been working in the field of biological application of the method of tagged atoms, mainly for the distribution of radioisotopes of phosphorus, chlorine, manganese, and arsenic in the animal body. In Object 0215, I researched, the one hand, the determination of various radioisotopes in the organism of vertebrates and the use of certain protective substances, and the other hand, the determination of the accumulation coefficients of various radioisotopes by different types of freshwater organisms and the deactivation of water in low-flow experimental ponds. In the Laboratory of Biophysics of the Biological Institute of the Ural branch of the USSR Academy of Sciences, I studied mainly the distribution of radioisotopes introduced into water regarding the components of the reservoir and performed the comparative study of the accumulation coefficients of radioisotopes by freshwater organisms.

*I have published 40 scientific papers, written 20 reports, and published one monograph.*

*Signature: E. Timofeeva-Resovskaya*

22.VI.63

In August 1898, the parish priest Nikolay Smirnov performed the sacrament of the baptism of the newborn Elena in the Assumption Church of the village of Kartina of the Ruza district near Moscow. Her father, Alexander Alexandrovich Fiedler, a physics teacher, was a well-known schoolmaster in Moscow. For 30 years, he worked as a director of the Rukavishnikov's orphanage for juvenile delinquents on Smolensky Boulevard. Her mother Sofia



Figure 2. Memorial plaque in Ebensee (Austria).

Yegorovna Schultz was a housewife. They raised seven daughters and two sons. Elena was the sixth daughter. The noble and orthodox Fiedler family had German and Italian roots and were related to the Ferreins, Vogts, and distantly related to Immanuel Kant. They lived in Moscow on Arbat in Glazovsky Lane and were familiar with the Timofeevs-Resovskies, who lived next door in Plotnikov Lane (Timofeev-Resovsky 2000).

In the scientific circle of the Moscow University, Elena Fiedler met Nikolay Timofeev-Resovsky, who was a student of N.K. Koltsov and S.S. Chetverikov, and later became a world-famous scientist, one of the founders of molecular genetics and biophysics<sup>3</sup>. In 1922, they got married in the Church of the Assumption of the Blessed Virgin Mary on Mogiltsy in Moscow.

They had two sons: Dimitry (1923–1945), whom everyone called Foma (Thomas), and Andrei (1927–2014). Only the eldest son had a double surname Timofeev-Resovsky. During the Second World War, Dimitry became a student of the zoological faculty of the Berlin University. In 1943, he was arrested for participating in the anti-Nazi struggle, put in prison, and then transported to the Mauthausen and Ebensee concentration camps, where he died on May 1, 1945. A document confirming his death was obtained from the Arolsen Archives (Austria) only in 1996. His mother never found out about the death of her eldest son, and until the end of her days, she believed that he was alive. In the summer of 2014, the Austrian architect Gunter Eberhardt installed a memorial plaque in the memory alley at the site of the Ebensee concentration camp with a text written by Andrei Nikolaevich Timofeev (Figure 2).

The youngest son, Andrei Timofeev, was a student of the physicist and the best dosimetry specialist Karl Günther Zimmer in Germany. Afterwards for several years they worked together in the USSR. Subsequently, A.N. Timofeev became a researcher at the Institute of Physics of Metals, and together with his wife, radiobiologist Nina Alekseevna Timofeeva (1927–2014), lived in Sverdlovsk (now

Yekaterinburg). They had no children. A.N. and N.A. Timofeevs were buried in the city of Kasli, Chelyabinsk region.

The scientific path of E.A. Timofeeva-Resovskaya in radiobiology lasted more than half a century. It can be divided into five periods, according her places of work and subjects of scientific research. At the same time, throughout her life, she invariably worked together with her husband N.V. Timofeev-Resovsky. In 1963, in her main publication 'Distribution of Radioisotopes in Basic Components of Fresh-Water Bodies' she expressed her special heartfelt gratitude to him for his constant help and discussion of her research (Timofeeva-Resovskaya 1963a).

**1919–1925, the first period of scientific work** was held under the leadership of N.K. Koltsov (genetics), S.N. Skadovsky (hydrobiology), and M.M. Zavadovsky (zoology) at the universities of Simferopol and Moscow. Academician V.I. Vernadsky also had a great influence on E.A. Timofeeva-Resovskaya. The Vernadsky and Fiedler families were friends.

Being students, the Timofeevs-Resovskies studied the hydrobiology of lakes, and also researched the genetics of fruit flies natural populations. In 1923, in the first published scientific article by N.V. Timofeev-Resovsky on the variability of wing venation in *Drosophila*, he introduced quantitative indicators of the phenotypic variability of the gene manifestation, later called penetrance and expressiveness, which became fundamental concepts of genetics (Timofeev-Resovsky 2009). Before their departure to Germany in 1925, E.A. Timofeeva-Resovskaya had no publications.

**1925–1946, the second period of scientific work** took place in Berlin and its suburb Buch (Germany), where the Timofeev-Resovsky family came from Russia to organize genetic research, invited by Oskar Vogt, director of the Institute for Brain Research of the Kaiser Wilhelm Society (now the Max Planck Society for the Advancement of Science). They were recommended by the founder and director of the Institute of Experimental Biology in Moscow N.K. Koltsov and People's Commissar of Health of the RSFSR<sup>4</sup> N.A. Semashko. In Germany, N.V. Timofeev-Resovsky organized the Laboratory of Genetics. In 1937 it was transformed into the Department (Institute) of Biophysics and Genetics, which existed until 1946. The main team consisted of 12 people, but during World War II N.V. Timofeev-Resovsky increased it up to 65 or even more to save people from the Nazi regime. There are many testimonies of people who were rescued by the Timofeevs-Resovskies in Berlin-Buch (Babkov and Sakanyan 2002).

In the 1930s, the Department of Biophysics and Genetics in Berlin-Buch became a recognized scientific radiobiological center. In 1940 N.V. Timofeev-Resovsky was elected as a full member of the German National Academy of Sciences Leopoldina in Halle. Their researches on radiation and population genetics were presented at conferences in the USSR, USA, European countries, as well as at the seminars of physicists in Copenhagen, which were conducted by Niels Bohr. Among the publications were the famous work by N.V. Timofeev-Resovsky, M. Delbrück, and K.G. Zimmer

'On the nature of gene mutations and gene structure' (1935), widely known by the color of the book cover as 'Grünes Pamphlet' (Green Notebook), in which the probable volume of the gene was measured, which turned out to be equal to the value of the macromolecular order. This publication formed the basis for E. Schrödinger's book 'What is Life? The Physical Aspect of the Living Cell', published in 1944, and was also important for such scientists as James D. Watson and Francis Crick who published their work on the structure of DNA. The Timofeevs-Resovskies worked closely with major biologists, among whom we could name T.H. Morgan, H.J. Muller, Boris Ephrussi, H. Stubbe, F. Dobzhansky, N.I. Vavilov, V.I. Vernadsky; physicists: N. Bohr, M. Planck, W. Heisenberg, Frederic Joliot-Curie, M. Delbrück, K.G. Zimmer, N. Riehl, and many other scientists.

In Berlin-Buch, E.A. Timofeeva-Resovskaya published 18 scientific papers on phenogenetics, population genetics, and mutagenesis (Figure 3). These scientific publications were devoted to the variability of phenotypic manifestations of hereditary traits in *Drosophila funebris*, phenogenetics, and genetic variability in populations of the ladybug *Epilachna chrysomelina*. Her research on the evolution of populations included genetic analysis of the free-living population of *Drosophila melanogaster*, temporal and spatial parameters of the distribution of individuals in populations, and population dynamics. E.A. Timofeeva-Resovskaya was one of the first to publish data on the genetic effects of X-ray irradiation, as well as on latent genetic variability, following H.J. Muller's report at the 5th International Genetic Congress in 1927 in Berlin. Corresponding experiments were also performed on *Drosophila funebris* (Timofeeva-Resovskaya 1930, 1932).

An interesting fact is that while working in Germany, she did not receive a salary, because according to the rules of funding the Institute by the Kaiser Wilhelm Gesellschaft (KWG) Society for the Promotion of Sciences, relatives of KWG executives were not allowed to work for money. The famous physicist Robert Rompe, who was a friend of N.V. Timofeev-Resovsky, noted: 'Elena Alexandrovna ran the laboratory without being an employee of the Institute. She did not only conduct various experiments planned by her husband but also gave orders to the employees of his



Figure 3. E.A. Timofeeva-Resovskaya with her sons. Berlin, 1928.



laboratory and carefully monitored their execution.’ (Babkov and Sakanyan 2002).

In September 1945 N.V. Timofeev-Resovsky was arrested, deported to the USSR, and imprisoned in Moscow. In 1946 he was sentenced to 10 years in prison for not returning to the USSR before the war. After her husband’s arrest, Elena Alexandrovna acted as director of the Institute of Genetics and Biophysics in Berlin-Buch. In 1946 the Institute was liquidated. Professor Hans Nachtsheim helped her find a job in Berlin, and she worked for a year at the Academy of Sciences of the GDR and at the Humboldt University, where she had the genetics practice with students. During that time, she did not have certain information about both the eldest son and her husband.

In the spring of 1947, N.V. Timofeev-Resovsky was transferred as a prisoner from a concentration camp to the South Urals to participate in radiobiological research in the USSR Atomic Project. That same year, in fall, his wife and youngest son returned from Germany to Russia. All of them began to work in the new Laboratory (Institute) ‘B’, which became the base of the future nuclear center of Russia – the All-Union (All-Russian) Scientific Research Institute of Technical Physics (Snezhinsk, Chelyabinsk Region).

By that time, in the USSR, E.A. Timofeeva-Resovskaya had a brother and two sisters repressed, and N.V. Timofeev-Resovsky had two brothers repressed. Their eldest son Dimitry was repressed in Germany. Elena Alexandrovna and her youngest son were deprived of the rights and did not have passports until 1953. The conviction of N.V. Timofeev-Resovsky was removed only in 1955. While serving his sentence in the Karaganda region camp, N.V. Timofeev-Resovsky lost his central vision because of hunger and diseases, therefore he could no longer read. For many years Elena Alexandrovna read to him daily for 5–6 h and carried on an extensive correspondence.

**1947–1955, the third period of scientific work** took place in the secret Laboratory ‘B’ of the Ministry of Internal Affairs of the USSR, which was created in 1946 near the town of Kasli in the Chelyabinsk region, on the shore of the lake Sungul. Over the years, its staff changed from 100 to 500 employees, including both civilian and imprisoned Soviet specialists, as well as interned German scientists and specialists. Among the German scientists there were Karl Gunter Zimmer, Hans Joachim Born, Alexander Siegfried Katsch, Joseph Schintlmeister, Wilhelm Menke, Henry Ernst Ortmann, Kurt Rintelen, Renata von Ardenne and others. N.V. Timofeev-Resovsky headed the Department of Biophysics, E.A. Timofeeva-Resovskaya worked as a researcher. Their son Andrei worked as a laboratory assistant (Figure 4). From 1950 to 1952, the scientific director of Laboratory ‘B’ was a friend of the Timofeevs-Resovskies, physicist and radiochemist Nikolaus Riehl (Emelyanov and Gavrilchenko 2000).

The scientific problems the Department of Biophysics had to solve were caused by radioactive contamination of the environment during the development, creation, and testing of atomic weapons in the USSR. The department conducted the study of the effect of ionizing radiation on living organisms, including genetic effects; study of the ways to accelerate the elimination



Figure 4. Timofeevs-Resovskies with their youngest son Andrei. Sungul, 1949.

of radionuclides from the body of animals; study of the effect of low doses of radiation on the growth and development of living organisms and on the productivity of plants; study of the distribution of radionuclides in soils and water bodies; and biological treatment of radioactive wastewater.

In 1948, the first industrial reactor in the USSR was put into operation for the production of weapons-grade plutonium. It was located 40 km from Laboratory ‘B’, which made it possible to carry out a constant supply of radioactive solutions of uranium fission fragments, necessary for the research.

E.A. Timofeeva-Resovskaya became the author of 28 scientific reports out of a total of 365 reports from Laboratory ‘B’. All of the reports were classified documents until 1954. Now the originals of the reports are in museums and private archives.

Since 1948, her scientific work was devoted to biophysical analysis of the effect of ionizing radiation on living organisms, the formation of chromosomal rearrangements under the influence of radiation, as well as the study of the patterns of behavior of incorporated radionuclides, the development and study of various antiradiation agents, as well as complex ones that increase the release of toxic metals and emitters from the body (Timofeeva-Resovskaya 1948a, 1948b, 1949).

Since 1950, in her experimental radiobiological studies, E.A. Timofeeva-Resovskaya moved from the genetic, organismal, and population levels to the level of the model and natural biogeocenoses<sup>5</sup>. Her reports included the study of the effect of various doses of ionizing radiation and emitters on communities of terrestrial and freshwater organisms, the distribution of radionuclides among various components of biogeocenoses, and soil-biological treatment of wastewater containing weak concentrations of emitter solutions. Thus, she had priority in the radiobiology of aquatic ecosystems (Timofeeva-Resovskaya 1951, 1952).

N.V. Timofeev-Resovsky considered these radioecological studies in the Urals to be the most productive in his scientific life from the experimental point of view. Following the traditions and heritage of the great Russian scientists V.I. Vernadsky, V.V. Dokuchaev, G.F. Morozov, B.B. Polynov, and V.N. Sukachev he preferred the name ‘radiation

biogeocenology' instead of 'radioecology' (Timofeev-Resovsky 1962; Aleksakhin 2000).

In 1955 Laboratory 'B' was liquidated, the reports on scientific works were declassified, so their open access publication became possible.

**1955–1964, the fourth period of scientific work** took place in Sverdlovsk (now Yekaterinburg) at the Biological Institute of the Ural branch of the USSR Academy of Sciences (the director of the Institute was S.S. Schwartz). N.V. Timofeev-Resovsky organized and headed the Laboratory of Biophysics with 16 employees. E.A. Timofeeva-Resovskaya worked as a junior researcher.

In 1955, under the leadership of N.V. Timofeev-Resovsky, the biological station 'Miassovo' was built in the Ilmensky state reserve near the city of Miass, Chelyabinsk region. It included several summer houses and a wooden laboratory building. In summer and fall, scientists conducted experimental radiobiological studies at the Miassovo biological station, and in winter and spring, they worked in Sverdlovsk. Along with the results from new researches, they published the results of declassified scientific reports from Laboratory 'B'. During these years, under the influence of the Timofeevs-Resovskies, the Ural school of radioecologists was founded, and the development of radioecological centers in the USSR was enhanced, in particular, marine radioecology in Sevastopol and continental radioecology in Yekaterinburg (Kulikov 2000; Polikarpov 2001).

In the late 1950s - early 1960s, informal summer scientific seminars were held at the Miassovo biological station (Figure 5). It was really scientific Mecca and the capital of genetics and biophysics for progressive scientific young generation throughout the country. Despite the fact that it was a forest corner on the shore of a lake, remote from civilization, and they had to live in tents, the list of seminars' participants included about 400 people from all over the USSR. In the center of general attention there were N.V. Timofeev-Resovsky and his friend, an outstanding mathematician, one of the founders of cybernetics, Alexei Andreevich Lyapunov. Academician R.V. Petrov called these seminars 'the University of Miassovo' (Lyapunova 1993; Petrov 1993). The biological station 'Miassovo' was closed in 1977.

In 1963, E.A. Timofeeva-Resovskaya published her monograph 'Distribution of Radioisotopes in Basic Components of Fresh-Water Bodies', which was immediately republished twice in English at the Oak Ridge National Laboratory in the USA (Timofeeva-Resovskaya 1963b, 1964). She dedicated it to the centenary of the birth of Academician Vladimir Ivanovich Vernadsky. This monograph summarized the results of prolonged researches in radiation hydrobiogeocenology, describing about 20 different chemical elements in the experiments with radioisotopes. The experiments were carried out in glass aquariums, as well as in low-flow reservoirs, that is, small experimental ponds or in a series of tanks of different sizes, connected by an upper channel (Figure 6). About 25 species of freshwater animals and about 35 species of freshwater plants were studied. At certain intervals after the introduction of the solution of the emitters, the concentration of the emitter in water, soil, and



**Figure 5.** E.A. Timofeeva-Resovskaya prepares lunch near the stove in Miassovo, 1960s.

various types of living organisms was determined. Mainly, the distribution of radioisotopes was studied by components such as water, soil, biomass; concentration and accumulation of radioisotopes by different types of plants and animals; a decrease in the radioactivity of water when it passes through weak-flowing reservoirs.

E.A. Timofeeva-Resovskaya was the first who used the calculation of accumulation factors for a quantitative comparison of the accumulative capacity of organisms. According to the definition introduced by E.A. Timofeeva-Resovskaya, the accumulation coefficient is a value equal to the ratio of the concentrations of a radionuclide in the body and in the environment when a dynamic equilibrium is established. She showed that the limits of accumulation of radionuclides are extremely wide both for different types of organisms and for different radionuclides. For almost every studied radionuclide, species of organisms with especially high accumulation factors were identified. Such types were called 'specific storages'. Later they began to be used as bio-indicators of radionuclide contamination of the environment. Taking into account the high storage capacity of aquatic plants and soils, the possibility of using low-flow sedimentation reservoirs for the treatment of low-radioactive wastewaters from industrial enterprises was also justified. In addition, in experiments with freshwater periphyton, it was shown that at relatively low doses of radiation exposure, some general stimulation of these communities takes place





Figure 6. E.A. Timofeeva-Resovskaya is at work, 1960s.

without noticeable rearrangement, and at high doses of irradiation, deep disturbances in the species composition of communities and their structure occur.

Thus, E.A. Timofeeva-Resovskaya has fundamentally solved the most important task to protect territories from radiation pollution by depositing radioactive wastewater from enterprises of the atomic industrial complex with special cascades of reservoirs with appropriately selected biota. These radioecological researches had been carried out long before the first radiation incidents occurred and turned out to be relevant primarily in the Urals, after the Kyshtym accident in 1957. As a result of this accident, vast territories contaminated with long-lived radionuclides (cesium-137 and strontium-90) appeared in the Chelyabinsk region, especially in the Techa river and Karachay lake. To protect against the spread of radioactive contamination along with the Ob-Irtys river system, the construction of the Techensky cascade of reservoirs was completed in 1964. In its theoretical foundation, this grandiose protective structure fully corresponds to the models and results in radiobiological studies on the protection and cleaning of hydrobiocenoses from radioactive contamination, described by E.A. Timofeeva-Resovskaya.

In Sverdlovsk, E.A. Timofeeva-Resovskaya published 32 scientific works. On November 29, 1963, she was awarded

the degree of candidate of biological sciences. N.V. Timofeev-Resovsky became a doctor of biological sciences at the end of 1964, and before that, he worked for several years without a scientific degree and, while heading the laboratory, he got the salary of a laboratory assistant.

It is important to note that the Laboratory, created by N.V. Timofeev-Resovsky in the Urals in 1955, continues working nowadays. From 1964 till 1993, it was headed by N.V. Kulikov. Over the years, a new Biophysical (radioecological) Station was built near the Beloyarsk Nuclear Power Plant named after I.V. Kurchatov in the city of Zarechny. Its opening took place in 1979 when it became the successor to the Miassovo biological station. In 1982, based on the laboratory, the Department of Continental Radioecology was organized. Since 1993 and till now the Department and the Biophysical Station has been headed by A.V. Trapeznikov. The scientists develop theories and conduct researches in the areas of radioecology based on the traditions laid down by the Timofeevs-Resovskies in the Urals (Trapeznikov and Yushkov 2005; Trapeznikov and Trapeznikova 2006).

**1964–1973, the fifth period of scientific work.** In the spring of 1964, E.A. and N.V. Timofeevs-Resovskies moved from Sverdlovsk to Obninsk, Kaluga Region. N.V. Timofeev-Resovsky became the head of the Department of Radiation Genetics and Radiobiology of the Institute of Medical Radiology of the USSR Academy of Medical Sciences (the director was G.A. Zedgenidze). Among the employees of this Department there were such famous scientists as V.I. Ivanov, V.I. Korogodin, Zh.A. Medvedev, K.P. Kashkin, N.P. Bochkov, A.V. Sevankaev, N.V. Glotov, E.K. Ginter, Yu.D. Abaturonov, A.N. Tyuryukanov, Yu.M. Svirezhev, and others.

E.A. Timofeeva-Resovskaya worked there as a junior researcher. She conducted experiments and published 16 works on radiobiology and radiation genetics of *Arabidopsis thaliana*, which has now become a 'botanical fruit fly', and it has one of the leading places in genetic research all over the world (Timofeeva-Resovskaya 1969, Ivanov 1998).

In the fall of 1965, an order came from the personnel department of the USSR Academy of Medical Sciences to dismiss E.A. Timofeeva-Resovskaya as she had reached the age of 65. Since she did not have any documents regarding her 20-year work experience, she was left without a pension after her dismissal. However she continued to work at the institute without a salary on a voluntary basis for several more years.

In 1966, N.V. Timofeev-Resovsky became a laureate of the Kimber Prize, an award from the US National Academy of Sciences, which can be considered as an analog of the Nobel Prize in genetics. The prize and medal were presented in the spring of 1967. But the joy was short-lived. In 1969, according to the directive of the party-political officials of Obninsk, the department of radiation genetics and radiobiology was liquidated. The Timofeevs-Resovskies were left without work and only on one beggarly pension (Medvedev 2019). Then, at the invitation of O.G. Gizenko, who was the director of the Institute of Biomedical Problems in Moscow, N.V. Timofeev-Resovsky began to work as a consultant on space biology and medicine. He usually traveled by train

from Obninsk to Moscow, and lived there for several days with his friends. He also began to give a course of lectures at the Moscow University.

It was a hard time in their life, aggravated by age and illness. They were always supported and helped by close friends and their students, especially from Obninsk and Moscow. Many of their foreign friends always tried to help, in particular Irina A. Pabst<sup>6</sup> from Berlin, in her younger age she was a friend of their eldest son Dimitry. In the late 1960s, friends of the Timofeevs-Resovskies, Hans Stubbe and Max Delbrück, managed to visit them in Obninsk. It became obvious to them that the Timofeevs lived in very modest conditions, as evidenced by the situation in their apartment. But accommodation poverty did not interfere with traditional hospitality, a samovar was put on the table, which the hostess inherited from her parents, and the tea drinking happened.

Elena Alexandrovna helped her husband until the last day of her life. She died on the bright day of Easter on April 29, 1973. In July 1973, the 13th International Genetic Congress in the USA unanimously adopted a message to the great geneticist N.V. Timofeev-Resovsky, expressing deep condolences to him.

From the memorial letter written by Hans Stubbe: 'We all grieve with you, and my memories go into the past, when in 1929 I first arrived in Buch and was in the Laboratory, and then at your home, and then often visited you and could experience great hospitality and humanity. Both of you have always been an example of excellent cooperation in scientific work and great human unity for me. She understood us perfectly, and in our often heated discussions, she smoothed the situation. In an eventful time, I learned a lot from you in the field of science and mutual understanding and unconditional unity.'<sup>7</sup>

Without Elena Alexandrovna, N.V. Timofeev-Resovsky lived for another 8 years. Two months after his death in 1981 the London Linnaeus Society elected him as its foreign member. The Timofeevs-Resovskies were buried at the Konchalovskoye cemetery in Obninsk.

At the request of his youngest son and closest friends, N.V. Timofeev-Resovsky was rehabilitated posthumously in 1992. The main role in his rehabilitation was played by Granin's novel 'Bison' (1987) and documentary films directed by E.S. Sakanyan (1988, 1989, 1990). Sadly, during their lifetime the Timofeevs-Resovskies did not receive recognition in the USSR, they did not have any titles or awards. They were downgraded, being under constant control and oppression by the state and party authorities. Unfortunately, to this day, the fate of the memory of the Timofeevs-Resovskies in Russia has not been resolved (Kapitsa 1993).

The published memoirs of N.V. Timofeev-Resovsky and the memories of him by his friends and students could have a great cultural and patriotic significance in the education system and for young scientists, but almost no attention is paid to them. In Russia, only four memorial plaques have been erected in memory of N.V. Timofeev-Resovsky: they are in Obninsk, Chelyabinsk, in the village of Sungul, and on the building of the Institute of Plant and Animal Ecology

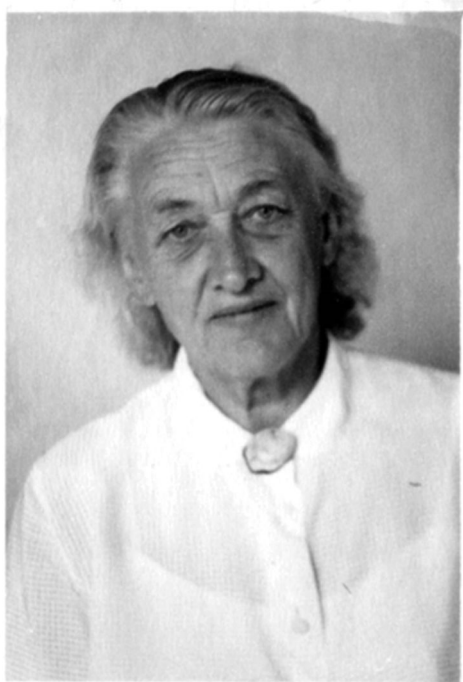
in Yekaterinburg. In addition, the Museum of the History of Obninsk presents the exposition 'The Room of N.V. Timofeev-Resovsky', and in 2016 the Memorial Office of N.V. Timofeev-Resovsky was opened at the Medical Radiological Research Center. This is clearly not enough for our country to make people remember the great scientist of the XX century. As a result of this attitude and ingratitude on the part of the state, in March 2020, the administration of Yekaterinburg renamed Timofeev-Resovsky Street, which caused confusion and protests of many scientists both in Russia and abroad (Litovsky and Kulikov 2020).

In Germany, in Berlin-Buch, at the Max Delbrück Center for Molecular Medicine at the Helmholtz Association (MDC), honoring the memory of N.V. Timofeev-Resovsky took several forms. In 2006 a new building where the laboratory of medical genomics is located (by architect Volker Staab) was named after him; in 1992 a memorial plaque was erected near the house where he lived, and in the front of the research building of Timofeev-Resovsky they put his sculptural bust, created by Stefan Kaehne in 2006. In his memorial study, there is a stand dedicated to his eldest son Dimitry, who gave his life in the fight against Nazism during World War II.

Since 2011, in honor of Elena A. Timofeeva-Resovskaya, an outstanding woman scientist who researched the Berlin-Buch campus in 1925–1946, a cycle of lectures has been held twice a year with the support of the Society of MDC Friends. These workshops aim to present successful role models for young women scientists and inspire them to pursue their careers. The MDC notes that N.V. Timofeev-Resovsky and his wife Elena are among the most recognized, highly respected, and famous scientists in the world. They were among the first scientists to work on the Berlin-Buch campus as visiting researchers when the Kaiser Wilhelm Institute for Brain Research moved to a new building in Buch in 1930. Their work at that time can be considered a pioneering one and it initiated the researches that have been carried out here till nowadays, where the scientists continue to use molecular genetic methods to study the foundations of human diseases being very proud of their role as pioneers in this field (Vogt 2008).

E.A. Timofeeva-Resovskaya wrote in one of her last letters: 'Still, what a blessing that we have returned to our Motherland!' It was also a great happiness for all their friends in Russia. The meetings and work with the Timofeevs-Resovskies were fateful for numerous students, many of whom became academicians and doctors of sciences, heading their own scientific schools. In general, the return of the Timofeevs-Resovskies to their homeland contributed to the restoration of biological education and science, genetic research in biology and medicine, and also stimulated the development of radioecology, biophysics, space biology and medicine, and the collaboration of various scientific centers. The progress of these biological sciences and modern scientific achievements in Russia is undoubtedly associated with scientific education and the continuation of the traditions of scientific schools, which was





**Figure 7.** E.A. Timofeeva-Resovskaya, 1963.

largely facilitated by the Timofeevs-Resovskies during their work in the USSR.

Everyone who knew E.A. Timofeeva-Resovskaya noted her kindness and humanity, attention to others and extraordinary charm, optimism, diligence, cordiality, and hospitality (Figure 7). Academician S.V. Vonsovsky wrote: 'In the life of Nikolay Vladimirovich, the fact that he was lucky to meet such a wonderful woman as his wife Elena Alexandrovna was of great importance. She was a completely exceptional, wonderful person. Her whole life was devoted to the same science. Here, of course, an analogy with two other couples – P. Curie and M. Sklodovskaya, F. Joliot and I. Curie, can be suggested. But, probably, this is only an external analogy. There were too much truly Russian in the Timofeevs-Resovskies. The whole appearance of the Timofeevs-Resovskies was one hundred percent intelligent in the highest sense of the word. There was the highest culture of speech, invariable originality and depth of judgment, no matter what was discussed, amazing ease of communication. I am very grateful to the fate that I had met the Timofeev-Resovsky spouses and spend several years in interesting communication with these remarkable scientists and remarkable people as well.' (Vonsovsky 1993).

My parents were students of N.V. Timofeev-Resovsky. In 1975 my father dedicated the monograph 'Continental Radioecology' to the blessed memory of Elena Alexandrovna Timofeeva-Resovskaya (Kulikov and Molchanova 1975, 1982). My mother called her memoirs 'About the Timofeevs-Resovskies with love and gratitude.' She wrote: 'Elena Alexandrovna was a divine woman. Long-term meetings with her at work and home were pleasant and instructive for us being young people. Always cheerful and friendly, she started every day with a smile. In the summer she swam in the lake every morning. She went to work fresh and

energetic. It was necessary to check the state of the cascade of tanks with different types of biocenoses, then proceeded to the analysis of the accumulated material. Her hands did not leave the adding machine and the counting ruler all day long. Her diligence could be endlessly admired. Every evening Elena Alexandrovna was a hospitable hostess. So many guests attended these numerous tea parties! These meetings were remembered by everyone and they played no less important role than anything else.' (Kulikova 2000).

In this article, I also express my admiration and gratitude to Elena Alexandrovna Timofeeva-Resovskaya, the wonderful scientist who was at the forefront of radiobiology in the XX century!

## Notes

1. In the author's archive.
2. It was the secret Laboratory 'B' of the Soviet Atomic Project.
3. Timofeev-Resovsky NV (1900–1981) Russian Soviet zoologist, geneticist, biogeocenologist, and evolutionist. The main areas of research by N.V. Timofeev-Resovsky: biophysics, radiation genetics, population genetics, microevolution and synthetic theory of evolution, biogeocenology, radiobiology, radioecology, and space biology. He was one of the founders of molecular biology, quantitative biophysics of ionizing radiation, the author of the target theory, the principle of hitting and the amplifier principle in radiobiology, the genetic concepts of expressivity and penetrance, and the biophysical model of a gene. His scientific research made fundamental contributions to a number of areas of modern biology.
4. The Russian Soviet Federative Socialist Republic.
5. The concept of 'biogeocenosis' as an elementary chorological subdivision of the biosphere was developed in the 1940s by Academician VN Sukachev, a friend of the Timofeev-Resovskies.
6. Irina Pabst, nee Udintsova (1927–2004). Actress. Public figure. Renowned benefactor. Cavalier highest German award 'Cross of Merit (Verdienstkreuz)'. Winner of the 2001 Berliner Bär Prize.
7. In the author's archive.

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No potential conflict of interest was reported by the author.

## Notes on contributor

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