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# Radiation Risk Estimates in Normal and Emergency Situations

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# TIMOFÉEFF-RESSOVSKY: A SHORT ACCOUNT OF HIS LIFE

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**Abstract.** This paper provides a short account of the life and work of Nikolay Vladimirovitch Timoféeff-Ressovsky (1900-1981), with special reference to the 1935 monograph on the nature of the gene mutation structure by Timoféeff-Ressovsky, Zimmer, and Delbrück, its origin, its role in the development of molecular biology, and the part played in Timoféeff's own life.

**Keywords:** Personalia: Timoféeff-Ressovsky, molecular biology, biophysics, Russian science.

## 1. Introduction

The title of the Conference held in Yerevan in September 2005, “Genetics, radiobiology, radioecology, and evolution”, indicates the broad scope of scientific interests and contributions of Timoféeff-Ressovsky, which are discussed at length in the book by Babkoff and Sakanian (2002). Here I will focus on the events concerning the 1935 monograph known as TZD, whose 70<sup>th</sup> anniversary is marked by the Conference.

It was X-ray crystallography that made, in the early 1950s, a decisive contribution to the deciphering of the structure of DNA. But for the first time X-ray crystallographers (Astbury and Bernal) and geneticists (Timoféeff-Ressovsky and others) jointly discussed the problem of the chromosome and the gene in Klampenborg in April 1938, on the first of a series of meetings initiated by Timoféeff-Ressovsky and supported by the Rockefeller Foundation.

The history of the discovery of DNA has been told many times by its creators in their memories and discussed by historians in their writings. “With one exception... the historical aspects... have been adequately treated in the book “Phage and the Origin of Molecular Biology”. The exception is due to the fact that the contribution to this book by N.W. Timoféeff-Ressovsky ...could not be included in the book”, noted Max Delbrück (1970). “Perhaps molecular biology owes more to the geneticist

who began the work – N.W. Timoféeff-Ressovsky – than has so far been admitted”, – maintained R. Olby (1974).

While first visiting Niels Bohr in the early 1930s, Timoféeff-Ressovsky admired the scientific style of Bohrs Kreis (which was close to that of his Russian circles). In August, 1932 Bohr delivered address “Licht und Leben”, and stressed that physical approaches were desirable for, and needed by biology (Bohr, 1933). While European physicists were not ready to share Bohr’s views, Timoféeff was well prepared to discuss them, because of his earlier cooperation with his dear teacher N. K. Koltzoff founder and Director of the Institute for Experimental Biology in Moscow. Koltzoff’s efforts to introduce physical and chemical methods into biology, and thus to give more solid basis to life sciences, made a great impact on Timoféeff in his green years. In 1920, Koltzoff suggested Timoféeff exposing *Drosophila* flies to X-ray with the goal of producing artificial mutations. (The early results were uncertain, since he had no strains with known genetics history in his disposal, and could not estimate exact doses.) In 1925, Oscar Vogt came to Moscow to study V.I. Lenin’s brain. He had interest to establish genetic studies in his Berlin Brain Research Institute, and asked Koltzoff to recommend a young Russian geneticist. Timoféeff-Ressovsky was a natural choice, both because of his talent and ability to work by himself in his 25 years, and because Koltzoff’s wish to protect his student from troubles with political police. Over a year before the appearance of H.J. Muller’s 1927 classic paper on genetic mutations, Timoféeff was systematically irradiating *Drosophila* flies in Siemens labs. His experiments with *Drosophila* led Timoféeff to the conclusion that ionizing radiation can cause remote damage to röntgenologists working in early nuclear medicine. Timoféeff was the first who, in the beginning of 1930s, prescribed röntgenologists to use protective lead aprons. Timoféeff was very active in the dissemination of his findings, and it is because of his radiation experiments with *Drosophila* flies that the method of temporary sterilization of women by radiation, practiced then by many women’s doctors, was banned in Germany.

Following the 1932 Genetics Congress in Ithaca and a couple of months in Cold Spring Harbor Laboratory, back in Buch, Timoféeff had a guest, Hermann Joseph Muller, his friend since his visit to one of Koltzoff’s zoological stations near Moscow in 1922. Timoféeff found for Muller a good German expert in dosimetry; they discussed a broad variety of questions; they were planning a Circum-Scandinavian journey with lectures. But they were late to start for the journey: Nazis seized power on Jan. 30, 1933. It would be wiser for Timoféeff not to go now, wrote Muller to O.L. Mohr on March 13, 1933, though Muller felt himself safe in Germany. Ironically, he himself was arrested by SA-men on March 15 (by mistake, released in the morning). Another Timoféeff’s guest during these

months was N.I. Vavilov, who was coming back home via Buch-Berlin from his last foreign travel. He suggested that Muller should head a laboratory of genetics in his Institute, and soon Muller took the Circum-Scandinavian route to Leningrad.

In 1934 the Scientific Council, die Notgemeinschaft der Deutschen Wissenschaft, set a commission on the problem of hereditary damage by radiation, headed by A. Kühn. Thus the Council responded to Timoféeff's proposal made in the fall of 1933 for supporting his studies in radiation genetics, which he later expanded to include Alfred Kühn, Hans Stubbe and other radiation geneticists.

Back in Buch after visiting Bohr, Timoféeff started private discussions on the nature of the gene mutation and the structure of the gene, with Karl Günter Zimmer (1911-1988), expert in radiation dosimetry, and Max Delbrück (1906-1981), a young theoretical physicist. Timoféeff's principle of "convariant reduplication" (inspired by Koltzoff's general idea of autocatalysis in the reproduction of "hereditary molecules") became the organizing center; his radiation genetic experiments gave the material for discussions. Their cooperation resulted in 1935 paper "On the nature of the gene mutation and the structure of the gene".

The article, written first in Russian (it was a rule to Timoféeff, who had no troubles with German, English, French, Italian, but wished to come back one day to Russia with scientific works), consisted of four chapters. Chapter One (TR) expounded results of the qualitative and quantitative biophysical analysis of the mutational process, and theoretical considerations arguing the conclusion that the genes were macromolecules and mutations were intermolecular changes; on this basis the problems of the theory of the gene mutations and the structure of the gene were formulated. Chapter Two (Z) applied the hit principle to Timoféeff's results; Zimmer's formula for the number of mutations supposed a one-hit process; under the action of X- or  $\gamma$ -rays, the "hit event" meant one single ionization or excitation event. Chapter Three (D) described the model of gene mutation from the standpoint of atomic physics needed to estimate limits of the stability of the gene (regarded as "Atomverband", association of atoms, rather than a molecule) and to find correlates in the known atomic properties which would correspond to this stability. Jointly written Chapter Four argues that the view that mutation of the gene is an individual elementary process in the sense of quantum theory can be used to explain both spontaneous and induced mutation process.

Timoféeff delivered this paper to the Göttingen Scientific Society (presented by Alfred Kühn) on its meeting on April 12, 1935. It was published in its "Nachrichten" on June 29, 1935. In spite of low circulation of the "Bulletin" the work became known to a certain circle of biologists and physicists. They referred to the paper either as "TZD" (after the

authors' names), or "die Grüne Pamphlet" (because of the cover color), or, being astonished by interdisciplinary cooperative work, the "Drei-Männner-Werke" (while one man was enough to make the whole work with his woman). This paper had immediate and long-lasting consequences.

Soon after the paper was published, and in part because of it, Timoféeff-Ressovsky received from the Rockefeller Foundation an invitation to run a laboratory in the Carnegie Institution. He negotiated for a while and finally rejected the offer in the Fall of 1936. As a recognition to his contribution to modern sciences (and with the goal of preventing him from leaving the country), the Kaiser-Wilhelm-Gesellschaft appointed him Director of the autonomous Department of Experimental Genetics, directly subordinated to KWG. In May, 1937 Timoféeff-Ressovsky's Soviet passport was canceled by the Soviet Consulate in Berlin, and for five years he was playing hide-and-seek with the authorities of German science and education, successfully trying to avoid acceptance of the German citizenship as the pay for the very welcomed appointment.

On April 22, 1938, the Italian Society of Experimental Biology elected Timoféeff-Ressovsky its Honorary Member. In May, 1939 he was awarded the Lazzaro Spallanzani Medal by the University of Pavia. In May, 1938 KWG Senate elected Timoféeff-Ressovsky its Scientific Fellow – he cherished this honor, and, I witness, he was always keeping the KWG badge on his coat lapel. On April, 1940, he was elected Member of the German Academy of Naturalists Leopoldina (Timoféeff produced a broad variety of scientific results, other than TZD, and his election to Leopoldina was due, in part, to other accomplishments).

Max Delbrück won, in 1937, the Rockefeller Fellowship to work with T.H. Morgan in Caltech, and brought Timoféeff's principle of "convariant reduplication" to the New World. Timoféeff has opened the new field on the basis of physical approaches (radiation genetics experiments) and higher organisms (insects). Delbrück participated in the transforming of the field to use chemical approaches and microorganisms.

## 2. Memorandum

The nearest consequence of TZD was the start of European discussions designed by Timoféeff-Ressovsky on the model of the circle for informal discussions with S.S. Chetverikov's students in the early 1920's. Brilliant scientist and a charming personality, Timoféeff-Ressovsky was recognized in the 1930s as the 5<sup>th</sup> best geneticist in the world (after T.H. Morgan and three Morganists), and the 1<sup>st</sup> one in Europe. He became the moving spirit of the new discipline in mid-1930s. In TZD he had formulated the central problem of "convariant reduplication" which permitted to consolidate efforts of experts in genetics and X-ray crystallography, cytology and

electron microscopy, cell physiology and embryology, chemistry and biochemistry, theoretical and experimental physics, with the goal of laying the bases of what he provisionally called “biophysics”.

His memorandum to the European Bureau of the Rockefeller Foundation, signed in Paris by Boris Ephrussi, H.J. Muller, and himself on October 24, 1937, stated (as cited in Babkoff and Sakanian, pp. 464-466):

“Geneticists in general agree that the most fundamental problem of genetics is that of “convariant reduplication”, that is the induction by each gene of the formation adjacent to itself of a daughter gene having an internal pattern identical with its own, even though that pattern itself is capable of being altered by mutation, without loss of this property of reduplication. They regard this problem as of great importance not only for genetics but for biology in general, in as much as they see in this property the most unique characteristic of living matter, which in turn has given rise to the possibility of origination of many other of the distinctive properties of protoplasm. In the gene, as in the simplest living things, this primary property should exist in a form more or less separable from these secondary complications.”

“...In all described cases the material of the experiment remains biological, but the approach should be made with the aid of the methods and knowledge of modern physics and chemistry...”

“Specific problems which should be taken up by such a group in the near future are as follows:

1. The mechanism of mutations of genes, both spontaneous and induces; this involves also the problem of the energy levels necessary for different types of gene changes, which retain or destroy the property of convariant reduplication.

2. The mechanism of gene rearrangement and its relation to that of gene mutation.

3. The problem of the nature of conjugation between genes and chromosomes.

4. The structures of chromosomes and of organic fibers.

5. The problem of the method of reaction of the gene with the protoplasm (“gene function”) and of the influence of neighboring genes upon these reactions (“position effect”).

6. All the above problems are interrelated and bear more or less directly upon the central problem of convariant reduplication. But it might also be well to take up this problem in more direct form at a special meeting...”



The project to make cooperation of young physicists and biologists more permanent and efficient, by holding a regular series of conferences, got support from the European Bureau of the Rockefeller Foundation and of Warren Weaver, director for the natural sciences in the RF. Timoféeff's project to hold four meetings during two years, 1938-39, found financial support (\$ 2400) from the Rockefeller Foundation.

“Members already decided upon:

Pierre AUGER  
Hans BAUER  
DARLINGTON  
DELBRÜCK  
EPHRUSSI  
MÜLLER (if in Europe)  
RAPKINE  
TIMOFÉEFF-RESSOVSKY  
WADDINGTON (if in Europe)  
ZIMMER

Provisional list from which members will be eventually chosen:

Astbury  
Bernal  
Bawden  
A.Fischer  
A.Kühn  
Langmuir (when available)  
Needham  
Stubbe  
Wrinch  
Serologist ??...”

### 3. European Meetings

The first meeting took place in Klampenborg, near Copenhagen, in the beginning of April, 1938, with the introductory reports presented by H. Bauer (on “Chromosome structure”) and by C.D. Darlington (on “Chromosome division and conjunction”).

The physical-chemical nature of forces determining the motion of chromosomes during meioses and mitoses and their conjugation were discussed. Astbury was absorbed in the idea of the role of nucleic acid in the replication of the genes, and discussed a possibility of external matrix molecule. Darlington discussed double-thread structures in terms of “coils” and “spirals”, as described with the use of optical microscope (Klampenborg Conference, 1939; Darlington, 1969; Babkoff & Sakanian, pt. 1, ch. 6).

On the second meeting, in Spa (Belgium), in the end of October, 1938, the major reports were done by N.W. Timoféeff-Ressovsky on “Gene mutations”, and by H.J. Muller on “Chromosome and the position effect of the gene” (Babkoff & Sakanian, pt. 1, ch. 6).

While drafting 1938 Annual Report, Warren Weaver entitled the section, dedicated to the Klampenborg and Spa conferences, “MOLECULAR BIOLOGY”, and used this term for the first time (Weaver, 1970).

Taking into account that many of the participants of these meetings (and other pioneers in the field, e.g. Avery or Landsteiner) were supported by the Rockefeller Foundation, either individually or institutionally, we may speak of molecular biology as a Rockefellerian science, initiated and headed by Timoféeff-Ressovsky.

The 3<sup>rd</sup> conference scheduled in Melrose (near Edinburgh), August 31 – September 1, 1939, with a very rich scientific program, was associated with the ill-fated 7<sup>th</sup> International Congress of Genetics: scheduled for 1937 in Moscow, delayed to 1938, rescheduled for late August in Edinburgh, it was finally canceled by the approaching World War II. The war made the 3<sup>rd</sup> conference impossible (Babkoff & Sakanian, pt 1, ch. 6).

#### **4. "What is Life?"**

In the beginning of 1940s, when Erwin Schrödinger was Professor in Dublin, he met another German theoretical physicist, E.E. Ewald, who gave him a copy of the 1935 paper by Timoféeff-Ressovsky, Zimmer, and Delbrück. For some time Schrödinger paid attention to this circle of questions, but TZD impressed him so deeply that he dedicated to its analysis a series of lectures in the Trinity College in February, 1943, and published them as a book entitled "What is Life?" (Schrödinger, 1944). The author of this short fascinating book was one of fathers-founders of the "new" quantum mechanics, Nobel Prize winner, whose wave function was being studied in all universities. No wonder that the book got broad attention and interest from young physicists, chemists, and biologists in the post-war years, and attracted them to the new field. Translated into Russian and published in the beginning of 1947, the book was being discussed on special sessions in the Moscow University and in the Physical Institute of the USSR Academy of Science, and initiated a series of discussions aimed to analyzing the chemical nature of the gene. Public discussions came to an end after August, 1948 Session of the Lenin Agricultural Academy (VASKHNIL), when Trofim Denisovich Lysenko (Joravsky, 1970), who stressed that his report was completely supported by the Central Committee of the Party, accused Schrödinger of ideological sins. Meanwhile, physicists involved in the Soviet Uranium project, learned from the book that biology was a sound science and, after Stalin's death, used their influence to support genetics in Russia.

#### **5. "Biophysik"**

When the war was going to an end, the whole Brain Research Institute was evacuated to Göttingen in the Western Occupation Zone. Remained in Buch the Department of Genetics and Biophysics only. Director Dr. Spatz

demanded that Timoféeff should also join them. He stayed in Buch, and worked on the problem of dismantling of neutron generator. Timoféeff was receiving offers to go to America, England, Italy and France, that he rejected, and stayed in the future Soviet Occupation Zone.

In war-time Germany, Timoféeff summed up his vision of the new science of biophysics (as he used to designate what later came to be known as molecular biology) in “Biophysik”, vol. 1, co-authored by Zimmer. Written in 1943, the book was published in Leipzig in 1947 under permission of the Soviet Military Administration in Germany (Timoféeff-Ressovsky and Zimmer, 1947).

In April, 1945 the Red Army entered Buch, north-east of Berlin, which had never been bombed by the Allies, probably because of Timoféeff’s friend Paul Rosbaud, one of the leaders of the Julius Springer publishing house and the editor of “Die Naturwissenschaften”, who was believed to be in contact with the British Intelligence and was known as “the Griffin”. Timoféeff was made Burgomaster of Buch by the Soviet Military Administration. The staff of his Department was 12 persons, but he managed to organize regular three meals a day for more that 100 persons and their relatives.

There were many visitors to Buch from the Soviet Union in May–August, 1945. The physiologist Leon Orbeli invited Timoféeff to join his Institute; there were other suggestions, but Timoféeff accepted the first one, made by A.P. Zavenjagin, vice-director of the Soviet Uranium Project, and was waiting for the evacuation of his Department. But in September 1945, a *donos* (false political accusation) made by N.I. Nuzhdin, geneticist turned Lysenkoite, who visited Berlin-Buch, resulted in the arrest of Timoféeff, who spent several months in the Karlag concentration camp (death camp, as a matter of fact).

After the war, “Biophysik” circulated in the United States in a number of copies. There was a project to translate “Biophysik” into English, and leading geneticists supported it. There was also one geneticist, admirer of Stalin, who appeared to be able to block the road for translating the book.

Frederic Joliot-Curie, who praised Timoféeff high both because of his scientific accomplishments and his part in the European Resistance, sent a letter to Stalin concerning Timoféeff-Ressovsky. While visiting Moscow physicists he spoke to the head of Soviet Uranium Project L.P. Beria about him (Beria: “Well, is he really so gifted?” – Joliot: “He is a genius!”). Timoféeff-Ressovsky was found in a camp, taken to a hospital in Moscow, and placed to the Sungul *sharashka* in the South Urals (originally planned for his studies), where he continued his genetics and biophysical studies and started studies in radioecology.

In August, 1948 his genetics was outlawed in the USSR but in Sungul, he continued the genetics studies. Adriano Buzzati-Traverso and Luigi Luca

Cavalli-Sforza dedicated their 1948 book, entitled “La teoria dell’urto e le unità biologiche elementari”, “*A Nikolay Vladimirovich Timoféeff-Ressovsky, amico e maestro, con l’augurio che egli possa continuare la sua opera*” (to NVTR, friend and teacher, with the wishes that he will be able to continue his work).

Timoféeff was recognized as founder or co-founder of several most modern scientific problems and disciplines of the 20<sup>th</sup> century. There remained, besides genetics and among others, his radiobiology and biophysics: the physicists were making the Bomb and they knew Schrödinger’s book, in 1947 Russian translation. So what should be his social standing?

The answer was given by most popular weekly *Ogonjok* in March, 1949: the article entitled “Fly-lovers are Man-haters” was accompanied by cartoons, ordered and edited by Stalin himself, which presented his negative attitude towards Timoféeff (and the Rockefeller philanthropy). The cartoons, which came too late to mark the August, 1948 victory over genetics, and were not in accord with the announced goal of the article (to condemn H.J. Muller’s and Henry Dale’s resignation from the USSR Academy of Sciences) were: ugly scientist in a bow-tie, hanging a test-glass (with poisonous bacteria) standing in the shadow of a gallows; ugly fat financial boss in a morning-coat leading a small army of puppet-scientists under the “banner of pure science” with the dollar sign; scientist in a white doctor’s smock and black academy hat with a siring and anthropometric instrument, and test-glasses in his pocket, in between a Ku-Klux-Klan man with a rope for hanging and a club, and a gangster-looking policeman with a Thompson machine-gun; thick book entitled “Genetics” (in English) with two snakes, one in the form of the dollar sign, the other one, in the form of fly-cross, swastika; finally, someone in a morning-coat, with a gun and a fly-cross marked book in his pocket, is looking though the microscope (Fig. 1).

The cartoons series appeared at the moment when the personal prohibition of genetics studies reached Timoféeff-Ressovsky in his laboratory in Sungul, and coincided with the prohibition of “Biophysik”.

In 1950, while prisoner at a Gulag secret laboratory in the South Urals, Timoféeff was nominated for the Nobel prize, for his research in biophysics/molecular biology, by Boris Nikolajevitch Rajevsky (Director of the Max-Planck-Institut für Biophysik).

## 6. Type of Behaviour

“Radiation, especially with X-rays, is the principal means of producing such new kinds of, or rather monsters, of animals and plants, and the wizard in this business was a Russian, Dr. Timoféeff-Ressovsky, who has found an

asylum at the Kaiser Wilhelm Institute for Brain Research. An industrial concern has presented him with the enormous machines with which he radiates the minute sex cells of tiny little *Drosophila* flies. Timoféeff is a fanatic and enthusiast. I was really spellbound while he gave me a three-hour lecture on his work, incessantly gesticulating as he walked up and down the floor. The German staff of the Institute looked at this strange and temperamental Russian with amusement and sincere admiration. They even granted him a freedom of speech and opinion they would deny any other human being”, reminded an American journalist about his visit to Germany during the first war winter, 1939/1940 (Ellinger, 1942).



Figure 1. I.V. Stalin's elucidation of Timoféeff's official standig. Cartoon by. Bor. Efimov in *Ogonjok*, March 1949.

Arne Müntzing, the well-known Swedish geneticist, was in Germany at a conference in 1936 or 1937. “The meeting was interrupted. A speech by Hitler was being broadcast. Everyone was supposed to stand and listen in silence. Everyone rose, and amid the universal silence Nikolay Wladimirovitch’s voice thundered out: “Wann wird denn dieser Wahnsinn endlich aufhören?” (When will this madness finally cease?)” (Berg, 1988).

It was the type of behavior Timoféeff-Ressovsky demonstrated in Nazi Germany, in the Soviet Union, always and everywhere. After the Prague Spring, Soviet authorities found Timoféeff-Ressovsky to be the major source of ideological threat, and in May 1969 he was forced to retire. He was appointed the smallest possible sum of money per month since “the years in Germany were not included into record of scientific service”. In December that year Max Delbrück received his Nobel Prize in Stockholm and rushed to Russia (Fig. 2), to visit his old friend and teacher, and to tell the Soviet authorities that there was a job waiting for Timoféeff in the States if he was not needed at home. In January 1970 Timoféeff accepted a post of Senior Researcher-Consultant at the Institute for Medico-Biological Problems directed by Oleg Gazenko.



Figure 2. "Hooray for Delbrück" Max Delbrück the Nobelist back home from Stockholm and Moskow, California, 1970 (N.W. Timoféev-Ressovsky's personal collection).

## 7. Rehabilitation

While working on our Timoféeff' book and reading protocols of interrogations kept in his personal file at the FSB (former KGB) Archives, I was intrigued by its mild character and loyalty. For instance: Investigator: "You are charged in *nevozvrashchenii* (not having come back) and in espionage." – TR: "I am guilty in not having come back. I am not guilty in espionage." – Investigator: "H-mm. You are charged in *nevozvrashchenii*." – The protocols of interrogations and other related materials from the FSB Central Archives first appeared in Part III of our Timoféeff book (Babkoff & Sakanian, 2002). – Yes, Joliot-Curie was right: after Hiroshima, Timoféeff-Ressovsky and his art were badly needed by the Soviet Uranium Project.

Timoféeff's personal file at the KGB/FSB Archives consists of 11 volumes, vol. 1 for 1945/1946, vols. 2-11 for 1987-1992 (Elena Sakanian applied for his rehabilitation on Aug. 8, 1987, and the rehabilitation was given on June 28, 1992). I was not permitted to study vol. 11, which contains KGB's faked resolution on the 1945/1946 case. (The KGB backed publication of the protocols in a book form (Rokitjanskij, Goncharov, Nekhotin, 2003) does not include the resolution). On the basis of this resolution the secret hearings of Timoféeff-Ressovsky's case resulted in the refuse of rehabilitation. Elena Sakanian undertook an investigation of her own, produced her four-hour "Cinema-Trilogy about the Zubr" (Sakanian,

1988-1991), (Zubr, *Bison bonasus*, Timoféeff-Ressovsky, after D. Granin's glasnost novel Zubr, 1987), exposed the KGB falsification, and gained posthumous rehabilitation for Timoféeff-Ressovsky. The official rehabilitation was the cherished desire of his life. Are you interested in the slanderous accusations, I was not permitted to read? – Have a look at 1949 cartoons, and you'll see all of them.

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