BEC BIOENERGETICS COMMUNICATIONS
Bioenerg Commun 2025.2
https://doi.org/10.26124/bec.2025-0002
Open Access

Tributes to pioneers in bioenergetics
BEC Series Editors:
Angelo Azzi, Erich Gnaiger

Cite
Galkin A, Kotlyar A, Marshansky V, Maklashina E, Gostimskaya I, Ermakov A, Grivennikova V (2025) In memory of Andrei Vinogradov: A Life in Science. Bioenerg Commun 2025.2. https://doi.org/10.26124/bec.2025-0002

Conflicts of interest
The authors declare no conflict of interest.

Received 2024-10-05
Reviewed 2024-12-05
Accepted 2024-12-12
Published 2025-01-23

Academic editor
Angelo Azzi

Reviewers
Vito De Pinto
Antonio Galina
Dominik Pesta
Carlo Viscomi

Keywords
mitochondrial membrane proteins;
succinate dehydrogenase;
ATP synthase;
Complex I

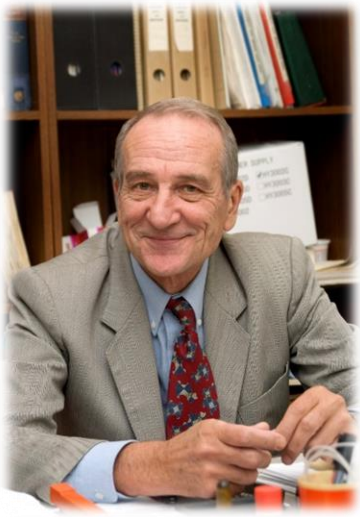
In memory of Andrei Vinogradov: A Life in Science

Alexander Galkin[1*], Alexander Kotlyar[2], Vladimir Marshansky[3], Elena Maklashina[4], Irina Gostimskaya[5], Alexander Ermakov[6], Vera Grivennikova[7]

[1] Feil Family Brain and Mind Research Institute, Weill Cornell Medicine, 407 East 61st Street, New York, NY 10065, USA
[2] Faculty of Life Sciences, Biochemistry Molecular Biology, Tel Aviv University, Tel Aviv, Israel
[3] Neuro-Horizon Pharma Inc., Sharon, MA, 02067, USA
[4] Department of Biochemistry and Biophysics, University of California, San Francisco, CA 94143, USA
[5] Yusuf Hamied Department of Chemistry, Lensfield Road, Cambridge, UK
[6] Department of Embryology, School of Biology, Moscow State University, Moscow, Russian Federation
[7] Department of Biochemistry, School of Biology, Moscow State University, Moscow, Russian Federation

* Corresponding author: alg2057@med.cornell.edu

Summary



Prof Andrei Vinogradov (1942-2021)

This paper honors the legacy of Professor Andrei Vinogradov, a prominent Russian biochemist whose pioneering work in bioenergetics has had a lasting impact on the field of mitochondrial biochemistry.

Andrei's scientific career started at Moscow State University in 1964, during the former USSR. He later pursued postdoctoral training in the laboratories of the world-known figures in bioenergetics—Britton Chance, Efraim Racker, and Thomas Singer – where he focused on purifying and characterizing mitochondrial membrane proteins. In

the 1970s, Vinogradov established a laboratory at the Biochemistry Department of Moscow University. Over the years, his research group performed extensive studies of key mitochondrial membrane enzymes, including succinate dehydrogenase, calcium transporters, ATP synthase, and Complex I.

This tribute, composed by his colleagues and former students, honors Andrei Vinogradov's extraordinary contributions to mitochondrial biochemistry and the enduring impact he left on the bioenergetics community.

1. Introduction

This tribute honors Professor Andrei Vinogradov, a distinguished Russian biochemist whose contributions have left a lasting mark on the field of bioenergetics. Renowned for his groundbreaking research in mitochondrial biochemistry, Vinogradov's career spanned decades of dedicated inquiry and discovery.

Andrei Vinogradov was born in Samarkand, Uzbekistan, in 1942 during an evacuation in World War II and passed away on March 16, 2021, in Moscow, at the age of 78. He graduated from Moscow State University in 1964 and continued his postgraduate studies in the field of mitochondrial energy metabolism in Moscow. He received his postdoctoral training with several world-renowned bioenergeticists. In the 1960s, Andrei started his postdoctoral research in the Britton Chance lab at the University of Pennsylvania and continued his research at Efraim Racker's lab at Cornell studying mitochondrial ATPase, and in the lab of Prof. Thomas Singer in San Francisco working on succinate dehydrogenase (SDH, Complex II). During this time, he focused on the purification and characterization of mitochondrial membrane proteins, on which he continued to work all his life.

In the 1960s, Andrei was among the pioneering scientists investigating reverse electron transfer (Vinogradov et al 1966)—a process that has recently emerged as a key driver of several metabolic pathways. In the 1970s, he established a laboratory in the Biochemistry Department of Moscow University, where he flourished. Over the years, his team systematically analyzed the enzymatic properties of key mitochondrial enzymes such as succinate dehydrogenase, mitochondrial calcium uniporter, ATP synthase, and Complex I. His group predicted the structure of the active center of mitochondrial succinate dehydrogenase (Kotlyar, Vinogradov 1984a; b; Vinogradov, Zuevsky 1973; Vinogradov et al 1975a; Vinogradov et al 1975b; Vinogradov et al 1976), which was later confirmed by X-ray analysis (Cecchini et al 2002; Yankovskaya et al 2003). In the early 1990s, he described and biochemically characterized the active/deactive conformational transition of mitochondrial Complex I (Kotlyar, Vinogradov 1990; Kotlyar et al 1992), an area that has become central to studies of tissue ischemia/reperfusion injury (Dröse et al 2016; Galkin 2019).

In 1990, his lab reported the existence of "succinate only"-supported reverse electron transfer in bovine heart submitochondrial particles (SMP) (Kotlyar, Vinogradov 1990). In that process, oxidation of the ubiquinol produced by the operation of Complex

II creates proton-motive force via the combined activity of Complexes III and IV, which can be used to drive the reverse electron flow from ubiquinol to NAD^+ even without ATP-hydrolysis. In the first decade of 2000, his lab started to work on Reactive Oxygen Species (ROS) metabolism in mitochondria and identified Complex I and alpha-ketoglutarate dehydrogenase as the main sites of generation of ROS. Andrei remained scientifically active in his later years and proposed a new model considering the existence in coupling membranes of two non-equilibrium isoforms of $F_o{\cdot}F_1$ unidirectionally catalyzing synthesis and/or hydrolysis of ATP (Vinogradov 2019).

Andrei D. Vinogradov was a highly respected figure in the fields of bioenergetics and biochemistry. He served on the editorial boards of several national and international journals, and his research was supported by numerous grants from both domestic and international foundations. His works, which became classics, were recognized with the prestigious State Prize of the Soviet Union, awarded to him as part of an authorial team for the series of studies titled "Chemical Foundations of Biological Catalysis" (1964–1982).

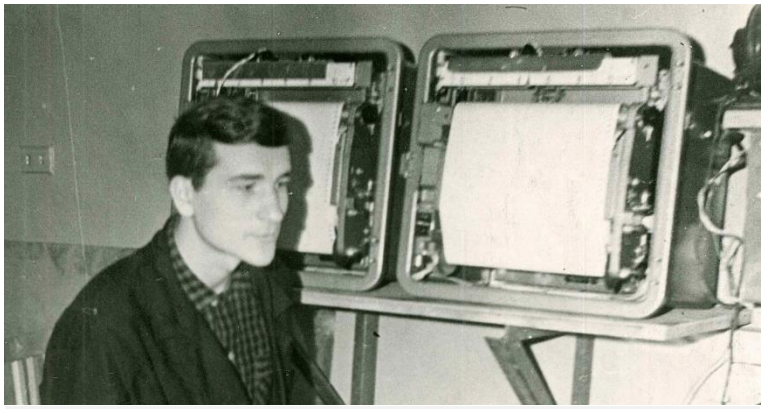
Prof Andrei Vinogradov in his office, School of Biology, Moscow State University, 2005.

Andrei dedicated significant time to popularizing bioenergetics in Russia. Starting in the mid-1970s, he actively participated for over a decade in organizing and conducting annual symposia on mitochondrial biochemistry. The proceedings of these symposia were published in the "Mitochondria" collections by Nauka Publishing in Moscow. He was a regular participant in the seminars held by the Department of Bioenergetics, led by Academician Vladimir Skulachev, where scientists from various institutes across Moscow and the nearby suburbs gathered weekly. These seminars were a forum for discussing the latest scientific developments, sharing experimental data from department members, and featuring presentations from invited speakers, including international ones. Every seminar was marked by fruitful critical discussions, often sparked by Andrei himself. Many were grateful for his input, as his fresh perspective significantly contributed to advancing and refining scientific research.

Andrei Vinogradov also devoted much of his time to mentoring the next generation of bioenergeticists. Though he was a strict and demanding leader for his group, he was also patient and attentive with students and graduate trainees, clearly explaining the challenges faced in the lab. Many future scientists passed through his lab; some continued their careers abroad. Regardless of where they ended up, they all fondly remember their time under Andrei's guidance, grateful for all they learned from him.

This tribute, prepared by Andrei's colleagues and disciples, honors his remarkable contributions to bioenergetics and his lasting influence on the scientific community.

2. Alexander Galkin, Brain and Mind Research Institute, Cornell Medicine, USA (1994-2001)



Andrei Vinogradov in the lab, near paper chart recorders (circa the '60s).

My first encounter with Andrei was when I had been measuring lactate dehydrogenase activity during the main summer practice of my third year of university - as students we had to isolate each enzyme of glycolysis from a rabbit muscle one by one, estimate the yield, and measure their activities. I had been measuring LDH activity using absorbance at 340 nm on a spectrophotometer equipped with an old chart recorder and a roll of paper when he approached and asked,

"What is your scale?" (meaning from the top to the bottom edge of the graph paper).

"0.1 absorbance at 340 nanometers," I replied.

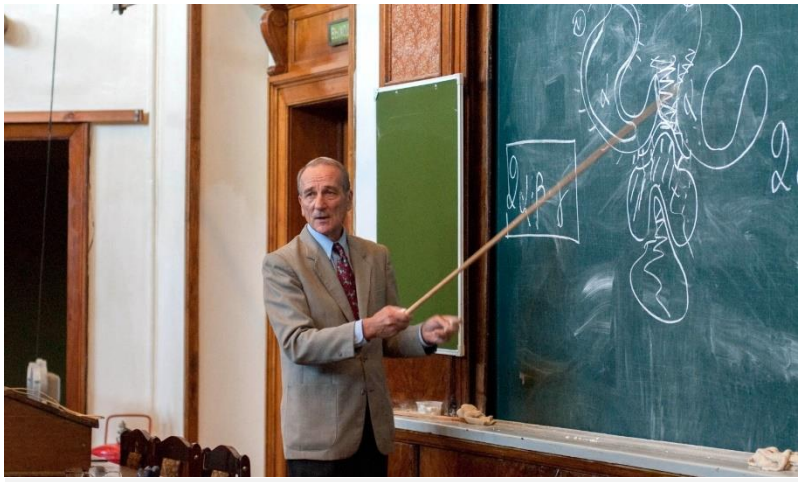
"No, no, no, what is the scale in micromoles of NADH you have there?" (I had no idea).

"As a biochemist, you must simply feel these kinds of things!" he said, smiling.

Later I went to Andrei's lab for a PhD program studying proton translocation by the respiratory chain enzymes. He had incredible scientific knowledge, and he was a great, albeit very strict mentor. He had extensive encyclopedic knowledge - if an enzymatic assay was not working, you could have asked him and his reply would be something like "Hmmm, look at this and that lab JBC paper 1980 at the end of the issue 86, I think figure number 3 – check it - you have to add 0.1 mM magnesium into the assay and preincubate for 5 min before the start of the reaction - this might help." And indeed, it always did!

Andrei worked with many different systems and in my opinion, in a more fundamental footing. Andrei believed that the forward and reverse reactions of the respiratory chain enzymes such as Complex I (Vinogradov 1998), Complex II (Grivennikova et al 1993) and ATPase (Vinogradov et al 1975c; Vinogradov 2000; Vinogradov et al 2004) were provided by distinct mechanisms that were regulated differently. Some of his kinetic observations on different substrate binding sites in Complex I (Grivennikova et al 2003; Vinogradov, Grivennikova 2001; Zakharova et al 1999; Zharova, Vinogradov 1997) still await structural explanation. His review on Complex I catalytic properties (Vinogradov 1998), is one of the most useful references for biochemists working with this enzyme.

Unlike most researchers, he also had great expertise in mechanics, electronics, and optics, with extensive experience in instrument-building and set up. While being the Head of Department he often complained, "This administrative stuff is so dull - I would rather be in a workshop building some high-precision instruments – fluorimeters, spectrophotometers and ion selective electrodes."



General Biochemistry lectures, Moscow State University (circa 2000).

At the beginning of the '90s, democratization and perestroika led to a shift at Moscow State University, and many professors became less formal with their peers and students. Not Andrei. He adhered to the formal etiquette of pre-revolutionary Russia and remained Professor Andrei Dmitrievich Vinogradov, even for his close colleagues in the lab and other university professors. He was also the head of PhD graduation committee and was feared by all PhD students for his challenging questions and witty remarks.

He was an excellent lecturer and I still watch videos of his lectures at the beginning of every teaching year before preparing my own. And yes – he used chalk on a board!

3. Alexander Kotlyar, Tel Aviv University, Israel (1983-1992)

I met him a long time ago, when Jorge Hirsch hadn't even thought about creating his famous index and science was driven mainly by curiosity. I first encountered him while attending his enzyme kinetics course. He was a tall, slim professor chain-smoking cheap, strong, unfiltered cigarettes. Smart and charismatic, he often paralyzed our class with equations too complex for biological students. I had a deep interest in mathematics at the time, and that likely led me to join his lab as a Master's student.

The small seminar room in Andrei's lab was a space where creativity and intellect collided, where new ideas emerged and were swiftly discarded in rapid succession. The space felt charged with intellectual energy and creativity. It was my first experience with science – a great journey into the unknown.

For a young scientist, nothing is more motivating than striving to reach the intellectual heights of the mentor, and I worked hard to close the gap between my own shortcomings and his exceptional capabilities.

One day in the lab, while I was struggling to inhibit succinic dehydrogenase with oxaloacetic acid, Andrei came over and asked,

- How's it going?

- Not well, - I replied. – The enzyme is getting blocked even if the buffer not containing the inhibitor is added.

- Did you use the same 100-µl glass Hamilton syringe to add the oxaloacetate and the buffer? - he inquired.

- Yes, I did, - I confirmed.

- Try using the automatic pipette instead, - he suggested and walked away.

I was skeptical, convinced that adding the inhibitor, whether through the syringe or pipette, would make no difference.

Andrei, however, was right. The spontaneous inhibition was gone. I racked my brains trying to understand how that could be. I even ground down the metal part of the syringe, dissolved the resulting shavings in a strong acid, and attempted to inhibit the enzyme with the solution. Nothing helped. I gave up after a week. I then approached Andrei and asked:

- Could you please explain the damn reason behind this?

- I must have appeared utterly lost. He laughed and said:

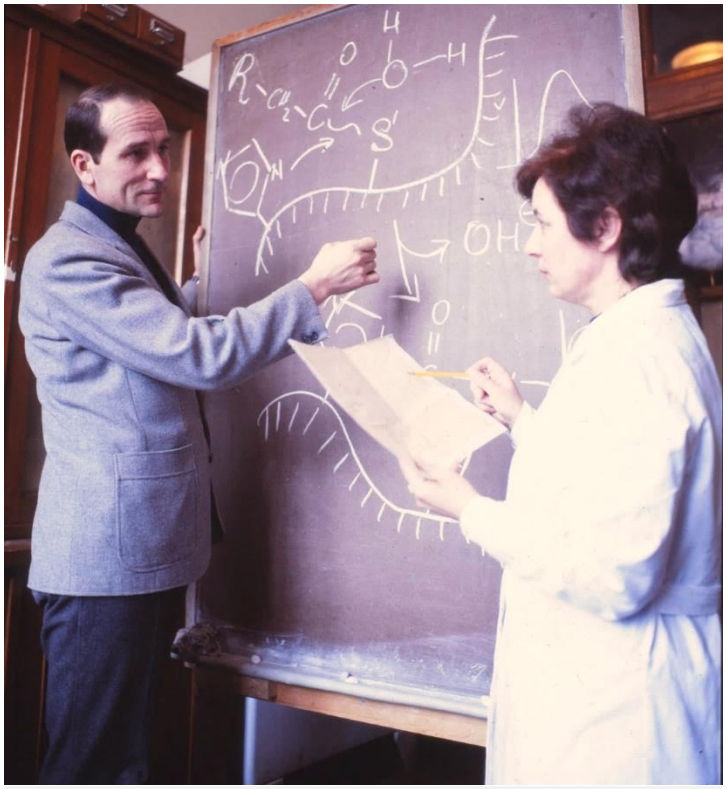
- The inhibition caused by oxaloacetate is so potent that even trace amounts of the inhibitor, which you can't get rid of despite repeated rinsing of the syringe, can completely block your enzyme.

At that time, I learned from Andrei an essential lesson: being an experimental scientist isn't about speculating on how the results of irreproducible experiments can support one's theories. It's about knowing how to obtain accurate answers from nature through well-designed, professional experiments. Throughout my scientific career, I have carried forward this and other lessons Andrei taught me. When I think on the essence of a scientific "school"- where great minds pass down their knowledge, ways of thinking, and unique styles - I think of Andrei. I consider myself fortunate to have been one of his followers, continuing along the path he showed us. I'm deeply grateful for the chance to be part of his intellectual environment and learn from his exceptional knowledge and expertise.

9th European Bioenergetics Conference, Louvain-la-Neuve, Belgium. Alexander Kotlyar, Andrei Vinogradov, Vera Grivennikova

4. Irina Gostimskaya, Cambridge University, UK (2000-2008)

I first met Andrei Dmitrievich when I was a student, he was my examiner in General Biochemistry, and later in the more specialised Enzymology for Biochemists course. At the time I was terrified of getting him as my examiner! He appeared very strict, and he demanded a deep understanding of the subject rather than just memorising facts and numbers. I didn't do well in either of those exams, and had to re-sit both: the only exams I didn't pass well in my whole 5 years of studies in the Moscow State University. I went on to receive the Cum Laude ("red") diploma meaning I wasn't too bad at passing exams after all! Despite his strictness, or maybe because of it, I chose to join his group to do my undergraduate and postgraduate lab projects. I'm very glad that he accepted me. There was obviously more than just a stern examiner to his personality, as he attracted some outstanding people to work with him.



In the lab, discussing active center of succinate dehydrogenase with Eleonora Gavrikova (circa the '90s).

He used to smoke like a chimney in his office so, health-wise, it was better to meet him outside of his "headquarters". He also had a habit of walking through the faculty long corridors carrying his chalk for the lectures on a pretty tea-saucer, as he didn't trust there would be a good piece of chalk prepared for him by the blackboard in the lecture room. Therefore, in my memories of him he is either sitting in his office with a cigarette, or walking with the saucer and a long wooden pointer stick to do his teaching.

He was certainly a very charismatic person, and extremely intelligent. I remember him saying that it is in fact almost easier for a very young, and naïve, scientist to discover something completely novel. In his opinion more experienced scientists, like himself, knew a bit too much about their subject and wouldn't commit to an experiment which is unlikely to work - but could potentially lead to something completely new! And indeed, all the experiments he suggested were working out the way he predicted; as a PhD student I was very impressed. I also remember him saying that a real scientist can't leave their project behind even when not at work. He would continue: "For example, what do you do when on a tram on your way home in the evening? Personally, I think about science! What else?". The only time he was completely "switched-off" was while on his annual camping holiday in the Russian forest. He would go hunting for ducks and fishing somewhere remote and wild for a month or so. On his return he would joke that he couldn't remember what he was supposed to do at the university, or who he actually was as a scientist and a member of the society. He

enjoyed classical music, and was particularly fond of the violin repertoire. I believe he could play the violin very well, although, sadly, never played for us at work. We all looked up to him as a prominent scholar, a remarkable teacher, and an exceptional person!

5. Alexander Ermakov, Embryology Department, Moscow State University, Russia (1992-2001 and 2018-2025)

Excerpt from a book "Myths and Legends of Moscow State University" by Alexander Ermakov. The information presented in the Legend is based on university folklore and may not reflect actual facts!

Andrei as an official examiner at the PhD defense in Martin Wikström lab in Helsinki (circa the '90s).

Professor Andrei Vinogradov and the "Hat Snatchers"

«In a time not long past, in the grand city of Moscow, there lived a noble scholar known as Professor Andrei Dmitrievich Vinogradov. A master of biochemistry and bioenergetics, he was celebrated far and wide for his groundbreaking research on the mysterious energies of mitochondria. For many years, he shared his wisdom with the eager minds of students at the Biological Faculty of Moscow State University, captivating them with his brilliant lectures and igniting within them a passion for scientific exploration.

Professor Vinogradov was no ordinary man. He embodied the spirit of the great Russian professors of yore: strong and elegant, kind and deeply honorable, with a brilliance that astonished all who crossed his path. His presence was a reminder that true scholars still walked among them, much like the revered sages of the XIX century.

Yet, unbeknownst to many, this learned man harbored a secret. In the shadows of his scholarly life, he had mastered a form of martial arts, honing his skills in the art of combat. Tales whispered among the university halls spoke of his bravery in times of peril, where he faced foes with the courage of a lion, emerging victorious from many a fierce encounter.

At the time of this story in which Professor Vinogradov lived was fraught with danger. The tumultuous 1990s brought forth an age of chaos in Moscow—a time marked by economic strife and rampant crime. Dark figures roamed the streets, and the specter of danger loomed ever closer.

Among these miscreants was a notorious gang known as the "Hat Snatchers." This band of ruffians plagued the vicinity of the university, lurking in the shadows of the grand trees and arched buildings, waiting to strike unsuspecting victims from behind to snatch

a fur hat. Their mischief brought fear to the learned scholars who wandered the campus, often lost in profound thoughts about the mysteries of life and the universe.

But fate would have it that the Hat Snatchers overstepped their bounds when they dared to target none other than Professor Vinogradov. On one fateful night in the '90s, the Professor and a dear friend were returning from a scientific seminar held in the hallowed halls of Belozersky Institute, where the legendary Academician Skulachev, a revered biologist, had shared his insights.

As the Professor and his companion discussed the wonders of science, a ruffian suddenly sprang from the darkness, seizing the friend's fur hat and attempting to flee. The icy ground betrayed the villain, sending him tumbling. In an instant, chaos erupted as his accomplice emerged from the shadows, ready to unleash a flurry of blows upon the unsuspecting scholars.

Little did they know that they had provoked a force unlike any other. With a swift and graceful movement, Professor Vinogradov struck the first villain with a powerful left hook, sending him sprawling onto the cold, unforgiving ground. The Professor then rushed to assist his friend, who was still grappling with the first attacker. Together, they swiftly subdued the miscreant.

But alas, the villain who had been knocked down soon regained his wits and managed to flee into the night. With resolve, Professor Vinogradov left his friend to guard the captured ruffian while he hurried to summon the local authorities. At the crossroads near the Main Building, a patrol was waiting, and with the call of a whistle, they swiftly apprehended the fleeing criminal.

The arrest of this nefarious character led to the unraveling of the entire gang, bringing to justice those who had terrorized the learned men and women of Moscow State University.

With the threat now diminished, Professor Vinogradov and his friend resumed their journey towards the subway station, their minds still intertwined with the important scientific discussions sparked by Skulachev's seminar. And thus, in the heart of Moscow, the legacy of the brave and wise Professor Vinogradov lived on, a tale of intellect, courage, and the eternal quest for knowledge.

And so, dear listener, remember: in every shadow, light and darkness dance, and sometimes, the greatest heroes wear the guise of scholars, wielding not only knowledge but also the strength to protect it.»

6. Vera Grivennikova, Biochemistry Department, Moscow State University, Russia (1972-2021)

I came to Vinogradov's laboratory in 1972 to complete my graduation project and I am still working here. I consider myself infinitely lucky to work under his guidance. The depth and breadth of Andrei's knowledge was simply amazing. He could answer almost any question. That is why scientists from other laboratories often came to him and he always gave them qualified advice. Andrei's passion for science generated a creative atmosphere in the laboratory. As a leader, he not only discussed experimental results, but often conducted experiments himself, even synthesizing some unavailable reagents. Importantly, Andrei instilled in his colleagues an honest attitude to their work, an

invaluable experience that we gained for a lifetime. Our published works have always been a guarantee of quality and reproducibility.

In the mid-1980s, Vinogradov's lab conducted intensive studies on reactions catalyzed by mitochondrial Complex II, or succinate dehydrogenase (SDH). Key results obtained under his guidance—such as the identification of cysteine and arginine residues in the enzyme's active center, a catalytic model involving the formation of a thiosemiacetal, detailed investigations into the enzyme's interaction with inhibitors, and the discovery of a novel, previously unknown catalytic activity of a soluble, reconstitutively active form of SDH—anticipated the three-dimensional structure data of the enzyme published at the turn of the century. A notable anecdote in Vinogradov's career involved the discovery of a new ferricyanide reactive site in succinate dehydrogenase. A widely used method for determining SDH activity in both soluble and membrane-bound forms in leading labs worldwide involved using the artificial electron acceptor ferricyanide at high concentrations (K_m ~ 3 mM). Vinogradov's lab discovered that at micromolar concentrations, the catalytic activity of soluble SDH, but not membrane-bound forms, sharply increased. This new SDH activity was found to be highly sensitive to oxygen and other oxidants. Further experiments showed that the high reactivity of soluble SDH was due to an FeS center of the S-3 HiPIP type, accessible to oxygen and oxidants in the soluble enzyme but hidden in the membrane-bound preparations (Vinogradov et al 1975a).

Vinogradov's lab, Moscow State University, 1999. From left to right: Robert Roth, Alexandra Ushakova, Andrei Vinogradov, Eleonora Gavrikova, Vera Grivennikova, Natalia Zakharova, Alexander Galkin

Shortly after discovering this "new ferricyanide reactive site," Andrei went on a scientific mission to the U.S. to Tom Singer's lab, where he shared the finding. Singer and his team were skeptical, as they had been using ferricyanide to measure SDH activity for many years without observing anything similar. They asked Andrei to demonstrate this

activity. When the experiment was prepared, all the lab members gathered around the instrument. Andrei added ferricyanide to the reaction mixture, but no activity was observed! The audience began to tease him, and Andrei, feeling embarrassed, internally blamed his team for the irreproducibility of their experiments. Quickly regaining composure, he suggested adding EDTA, a chelator of heavy metal ions, to the reaction. This solved the issue immediately: the activity appeared! Singer's lab was left "humbled," and Andrei emerged victorious. It turned out that the double distilled water apparatus in Singer's lab contained copper pipes. Therefore, the distilled water contained traces of copper ions that irreversibly destroyed the "new ferricyanide reactive site". Of course, Singer was furious, the technicians responsible for water quality in Singer's lab were fired and all the copper pipes were replaced with plastic. Andrei published his new results in BBRC in 1975 (Vinogradov et al 1975a) followed by joint publication with Singer's lab (Vinogradov et al 1975b).

Andrei never turned away from the simplest tasks in the lab. When quartz sand was needed to prepare the Keilin-Hartree reagent from bovine heart, he accompanied his team to a sand quarry by the Moscow River and returned with several buckets of sand. In a subsequent joint publication (Vinogradov, King 1979)), Vinogradov and Tsoo King humorously noted: "*The sand may be obtained from a clean beach such as that of the Moscow River, but not the Hudson River. We suspected that the latter contained too many pollutants, and in fact it has recently been reported that hundreds of tons of PCB (polychlorinated biphenyl) from the General Electric Co. have been poured into the Hudson. <…> Therefore, it is advisable to use "natural" sand after acid washing, suitable ashing, and other precautions.*"

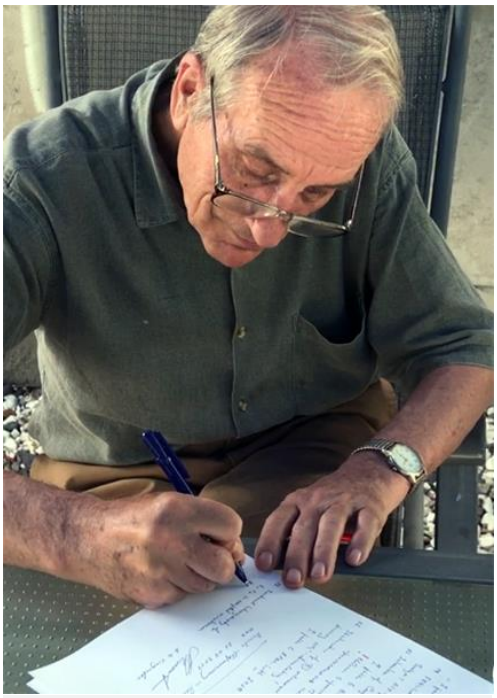
7. Vladimir Marshansky, Neuro-Horizon Pharma Inc., USA

I want to dedicate my narrative to the blessed memory of Professor Andrei Dmitrievich Vinogradov as a testimony of my most profound respect for an outstanding Russian biochemist!

I met Professor Vinogradov in 1980 at the beginning of my scientific formation while doing a PhD thesis in Bioenergetics/Biochemistry at Moscow State University. It was an enormous gift of destiny for me to meet Professor A.D. Vinogradov and become one of his students while listening to his inspiring lectures on Biochemistry and participating in scientific seminars on Bioenergetics. Later, during my

Vladimir Marshansky and Andrei Vinogradov during his visit to our home at Sharon in 2011. Made in his unique loving life manner, the self-portrait and dedication to all scientists who are following his steps are in the center: *Успехов! – Good Luck!* These drawings and writings were made during his visit to Sharon on July 10-11, 2017

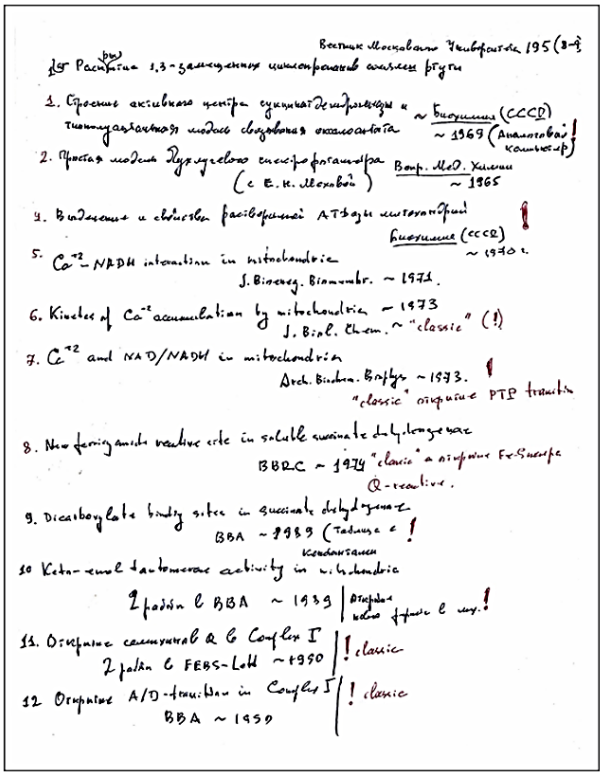
scientific career as a professor at Université de Montréal (Montreal, Canada) and Harvard Medical School (Boston, USA), we became colleagues, sharing similar scientific interests, and finally, very good friends. The formulation of the experimental problems, the originality of their solution, and the depth of scientific understanding were unique to Professor A.D. Vinogradov's style of research work. During all this time, Andrei Dmitrievich was both a mentor and a source of inspiration for my scientific research.

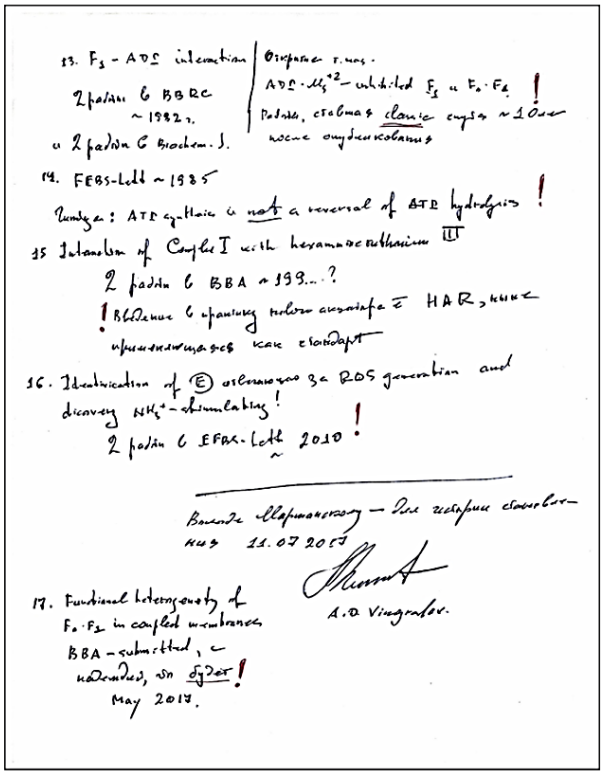


Andrei Vinogradov is finishing his notes *"The history of formation."* (Sharon, Massachusetts, 2017)

The account of scientific development presented in this section was handwritten by Professor A.D. Vinogradov and called "*The history of formation*". It covers the most productive period of his career, spanning from 1961 to 2017. In a clear and concise manner, Andrei Dmitrievich listed his key scientific contributions clearly and concisely, providing insights into the major discoveries he made in biochemistry over the course of more than 55 years of research.

These notes below were written by Professor A.D. Vinogradov (in photo) in the summer of 2017, during his visit to our home in Sharon, Massachusetts, USA, following his participation in the Gordon Bioenergetics Conference in 2017. This unique document was entrusted to my archive by Andrei as a framework for a future book, intended to provide a historical analysis of the development of his scientific career. Andrei's research interests were vast, and the list of his important discoveries in biochemistry is extensive. His hand-written list speaks to us in his own words about these groundbreaking achievements.





"The history of formation" transcript of Prof. Vinogradov notes

1a. Unveiling of 1,3-disubstituted cyclopropanes by mercury salts, *Vestnik of Moscow University*, 195(8-9).

1. Structure of the active center of succinate dehydrogenase and the thioacetal model of oxaloacetate binding ~ *Biochemistry* (USSR) ~ 1969 (Analog computer!).
2. A simple model of a dual-beam spectrophotometer (with E.N. Mokhova), *Voprosy Meditsinskoi Khimii* ~ 1965.
3. Isolation and properties of soluble mitochondrial ATPase, *Biochemistry* (USSR) ~1970!
5. Ca^{2+}-NADH interaction in mitochondria, *J. Bioenerg. Biomembr.* ~ 1971.
6. Kinetics of Ca^{2+} accumulation by mitochondria, ~ 1973, *J. Biol. Chem.* ~ "classic"!
7. Ca^{2+} and NAD/NADH in mitochondria, *Arch. Biochem. Biophys.* ~1973. "classic"! Discovery of PTP transition.
8. New ferricyanide reactive site in soluble succinate dehydrogenase, *Biochem.Biophys.Res.Comm.* ~ 1974, "classic" and discovery of the Fe-S Q-reactive center.
9. Dicarboxylate binding sites in succinate dehydrogenase, *BBA* ~ 1989 (Table with constants!).
10. Keto-enol tautomerase activity in mitochondria, 2 works in *BBA* ~ 1989, Discovery of a new enzyme in mitochondria!
11. Discovery of semiquinones Q in Complex I, 2 works in *FEBS Lett.* ~ 1990, classic!
12. Discovery of A/D transition in Complex I, *BBA* ~ 1990, classic!
13. F1-ADP, 2 works in BBRC ~ 1982 and 2 works in *Biochem. J.*, Discovery of the so-called ADP·Mg^{2+}-inhibited F1 and F1·Fo. This work became a classic about 10 years after publication.
14. *FEBS Lett.* ~ 1985, Hypothesis: ATP synthesis is not a reversal of ATP hydrolysis!

15. Interaction of Complex I with hexaammineruthenium III, 2 works in *BBA* ~1993-1995 Introduction of a new electron acceptor HAR, now used as a standard!
16. Identification of the enzyme responsible for ROS generation and the discovery of NH_3^+ stimulation! 2 works in *FEBS Lett.* ~ 2010!

To Volodya Marshansky – for the "History of formation"
11.07.2017
A.D. Vinogradov

17. Functional heterogeneity of F1·Fo in coupled membranes, BBA-submitted, with the hope that it will be accepted! May 2017.

8. Final note

Andrei was known to be an excellent violinist and a dazzling lecturer and presenter. His General Biochemistry and Enzyme Kinetics lectures were the most memorable events for many of his students in the last three decades and served as a beacon of inspiration for future generations of scientists.

Andrei will be greatly missed by family, friends, colleagues, and a wide circle of colleagues and scholars who valued him as a brilliant facilitator of science and unforgettable mentor. We all have been incredibly fortunate to have known Andrei.

Andrei at the game birds hunting (circa the '70s).

References

Cecchini G, Schroder I, Gunsalus RP, Maklashina E (2002) Succinate dehydrogenase and fumarate reductase from Escherichia coli. https://doi.org/10.1016/s0005-2728(01)00238-9

Dröse S, Stepanova A, Galkin A (2016) Ischemic A/D transition of mitochondrial Complex I and its role in ROS generation. https://doi.org/10.1016/j.bbabio.2015.12.013

Galkin A (2019) Brain Ischemia/Reperfusion Injury and Mitochondrial Complex I Damage. https://doi.org/10.1134/S0006297919110154

Grivennikova VG, Gavrikova EV, Timoshin AA, Vinogradov AD (1993) Fumarate reductase activity of bovine heart succinate-ubiquinone reductase. New assay system and overall properties of the reaction. https://doi.org/10.1016/0005-2728(93)90067-p

Grivennikova VG, Roth R, Zakharova NV, Hagerhall C, Vinogradov AD (2003) The mitochondrial and prokaryotic proton-translocating NADH:ubiquinone oxidoreductases: similarities and dissimilarities of the quinone-junction sites. https://doi.org/10.1016/j.bbabio.2003.09.001

Kotlyar AB, Vinogradov AD (1984a) Evidence for an essential arginine residue in the substrate binding site of the mammalian succinate dehydrogenase. https://pubmed.ncbi.nlm.nih.gov/6477618/

Kotlyar AB, Vinogradov AD (1984b) Interaction of the membrane-bound succinate dehydrogenase with substrate and competitive inhibitors. https://doi.org/10.1016/0167-4838(84)90168-7

Kotlyar AB, Vinogradov AD (1990) Slow active/inactive transition of the mitochondrial NADH-ubiquinone reductase. https://doi.org/10.1016/0005-2728(90)90137-s

Kotlyar AB, Sled VD, Vinogradov AD (1992) Effect of Ca^{2+} ions on the slow active/inactive transition of the mitochondrial NADH-ubiquinone reductase. https://doi.org/10.1016/s0005-2728(05)80329-9

Vinogradov AD (1998) Catalytic properties of the mitochondrial NADH-ubiquinone oxidoreductase (Complex I) and the pseudo-reversible active/inactive enzyme transition. https://doi.org/10.1016/s0005-2728(98)00026-7

Vinogradov AD (2000) Steady-state and pre-steady-state kinetics of the mitochondrial F(1)F(o) ATPase: is ATP synthase a reversible molecular machine? https://doi.org/10.1242/jeb.203.1.41

Vinogradov AD (2019) New Perspective on the Reversibility of ATP Synthesis and Hydrolysis by $F_o{\cdot}F_1$-ATP Synthase (Hydrolase). https://doi.org/10.1134/S0006297919110038

Vinogradov AD, Zuevsky VV (1973) The sulfhydryl groups and stability of the soluble succinate dehydrogenase. https://doi.org/10.1016/0014-5793(73)80346-1

Vinogradov AD, King TE (1979) The Keilin-Hartree heart muscle preparation. https://doi.org/10.1016/0076-6879(79)55017-4

Vinogradov AD, Grivennikova VG (2001) The mitochondrial Complex I: progress in understanding of catalytic properties. https://doi.org/10.1080/15216540152845920

Vinogradov AD, Gavrikova EV, Goloveshkina VG (1975a) A new ferricyanide reactive site in soluble succinate dehydrogenase. https://doi.org/10.1016/s0006-291x(75)80366-4

Vinogradov AD, Ackrell BA, Singer TP (1975b) On the possible interrelations of the reactivity of soluble succinate dehydrogenase with ferricyanide, reconstitution activity, and the Hipip iron sulfur center. https://doi.org/10.1016/0006-291x(75)90884-0

Vinogradov AD, Gyurova ZS, Fitin AF (1975c) Effect of sh-reagents on the mitochondrial ATPase and induction of respiratory control in EDTA particles. https://doi.org/10.1016/0014-5793(75)80080-9

Vinogradov AD, Gavrikova EV, Zuevsky VV (1976) Reactivity of the sulfhydryl groups of soluble succinate dehydrogenase. https://doi.org/10.1111/j.1432-1033.1976.tb10238.x

Vinogradov AD, Nikolaeva LV, Ozrina RD, Kondrashova MN (1966) [Reversed electron transfer and parallel changes in the SH-group content of mitochondria after addition of cysteine].

Vinogradov AD, Gostimskaya IS, Loskovich MV, Grivennikova VG (2004) Possible mechanisms of regulation of the mitochondrial Complex I as related to its slow active/inactive transition.

Yankovskaya V, Horsefield R, Tornroth S, Luna-Chavez C, Miyoshi H, Leger C, Byrne B, Cecchini G, Iwata S (2003) Architecture of succinate dehydrogenase and reactive oxygen species generation. https://doi.org/10.1126/science.1079605

Zakharova NV, Zharova TV, Vinogradov AD (1999) Kinetics of transhydrogenase reaction catalyzed by the mitochondrial NADH-ubiquinone oxidoreductase (Complex I) imply more than one catalytic nucleotide-binding sites. https://doi.org/10.1016/S0014-5793(99)00062-9

Zharova TV, Vinogradov AD (1997) A competitive inhibition of the mitochondrial NADH-ubiquinone oxidoreductase (Complex I) by ADP-ribose. https://doi.org/10.1016/s0005-2728(97)00029-7