

## OBITUARY

# In memoriam: Professor Ivan Pigarev (1941–2021)



Our colleague and friend, Professor Ivan Pigarev – a visionary scientist, whose work inspired many sleep researchers and neurobiologists, died unexpectedly on July 15, 2021. In the field of sleep research, Professor Pigarev is best known for providing key experimental evidence for the influential theory of “local sleep” and for his provocative “Visceral Theory of Sleep”. His legacy consists in taking a big step towards bridging the gap between local and global levels of sleep regulation, and in offering a new perspective on the question whether sleep is “of the brain, by the brain and for the brain”. His answer to this question is categorical “no”, and the unique body of work he and his collaborators have produced over the years support this conclusion. Ivan Pigarev’s work has been in the best tradition of Russian neurophysiology, where the integrative approach is the cornerstone. He had courage to tackle the system involved in sleep in its entire complexity, from the brain to the body, and was never satisfied with having a partial answer. We have much to learn from Ivan Pigarev in this regard. He is fondly remembered by his colleagues, friends, and collaborators.

## 1 | Photo credit: Andrei Lagutin

*Dr Elena Rodionova and colleagues at Institute for Information Transmission Problems (Kharkevich Institute), Russian Academy of Sciences, Moscow, Russia.* For many years we have been privileged to work in the same department with Ivan Pigarev. Ivan was a unique neurophysiologist who experimentally studied a wide range of species, including dragonflies, fish, frogs, cats, and monkeys. Ivan started his academic career with research on specific properties of visual neurones in the retina of fish and frogs. In these animals a number of behavioural responses are triggered by a given “key stimulus”, and the detection of such stimuli takes place in the retina. One of the studies supporting this hypothesis was experimental registration of the responses of visual neurones in the frog tectum while the experimental animal was allowed to move unrestricted and continue its normal behavioural activity. Ivan conducted these experiments using a miniature micromanipulator that he designed himself for the purpose; the first one in a series of similar designs that were later on used in his studies on cats and monkeys.

Following that Ivan became interested in the study of the thalamo-cortical visual signalling in awake behaving animals, especially in cats. Over the years he created a series of original electrophysiological designs allowing registering brain activity in response to a range of visual stimuli from freely behaving animals. While systematically studying new cortical areas involved in the visual information processing in cats and monkeys, Ivan came to an idea that the widespread view of the cerebral cortex as the ultimate centre of information processing and the “centre of decision-making” is misleading. Instead, cerebral cortex is an analyser that processes and combines information coming from various sensory systems.

Research conducted by Ivan in collaboration with his colleagues in Germany, Italy and Australia led to the development of a novel low-invasive and removable “halo” implantation technique that allows performing long-term recordings of neural activity in non-human primates.

While observing the natural behaviour of cats and monkeys, including the transitions from the active phase to sleep, as well as the corresponding changes in the activity of the animals’ cerebral cortex, Ivan started to develop his theory of functional shifts in signal

processing – the “Visceral Theory of Sleep”. According to this theory, cortical areas may be involved in processing different signals when the animal is alert versus asleep, and “gut-to-brain” information is transmitted to the cortex more efficiently when the animal is asleep, compared to the awake state. This line of research had been central in his recent work, which was abruptly stopped by the tragic accident.

Ivan Pigarev was an outstanding and original researcher, an extraordinary inventor of ingenious experimental methods, a meticulous yet provocative investigator – a character that science has always cherished, and a dear friend that will be much missed.

*Sabine Kastner, Professor of Psychology and Neuroscience, Princeton Neuroscience Institute, Princeton, NJ, USA.* I met Ivan at the Max Planck Institute in Göttingen during a “postdoc”. Together with Hans-Christoph Nothdurft, we were studying the neural basis of parallel and serial search in V1 and V4. Ivan taught me two major things. The first one was how to solve practical problems that occur during experimental work – Ivan had the combined knowledge and skill of all workshop people around us and, more importantly, he could apply these to scientifically guided applications – he was a renaissance man-like inventor. The enormous autonomy that came with this approach was very satisfying and refreshing. The second one was never to believe in “established textbook knowledge”. Ivan was a deep thinker and that came with a certain scepticism about other people’s data and interpretations. He was always thinking “out of the box” and would come up with the most unexpected conclusions. One day, I recorded from V4 in an attention task, and the neurones started to show a strange bursting pattern. I called Ivan – he said, “Oh I think V4 is falling asleep!” How could V4 neurones “fall asleep”, while the animal was still performing an attention task? For Ivan, that was not a conundrum, rather the beginning of an extraordinary new science puzzle. I fondly remember the many dinners after our long recording days that we had together with our families to celebrate science ... and life. Farewell, my friend – I was so fortunate to learn from you and will never forget you.

*James M. Krueger, PhD, MDHC, Regents Professor, Washington State University, Pullman, WA, USA.* The passing of Ivan Pigarev is a most unwelcome shock for the sleep research community. His scientific contributions represent the best of creative thinking and technically taxing experiments requiring a skill set possessed by few. I first met Ivan at a 1994 meeting in Ravello, Italy, a small town on the Amalfi coast. The meeting was focussed on sleep function and Ravello is the perfect place to take long undisturbed walks in one of the world’s most beautiful settings. It suited Ivan and me as a long friendship began on those walks. I was immediately captivated by his work, which was related to our new idea at the time concerning sleep being the property of local small networks initiated by prior cell/network activity. His publication showing sleep developing within the occipital cortex receptive fields while the animal was falling asleep with diminishing performance was the first electrophysiological direct demonstration of local sleep. To this day, I often cite his paper: Pigarev, IN, Nothdurft, HC, Kastner S. Evidence for asynchronous development of sleep in cortical areas. *NeuroReport*

1997; 28:2557–2560. We met at other meetings over the years and periodically exchanged emails, my latest email exchange with Ivan in March 2021. In that email, we exchanged brief memories of our 1994 meeting in Ravello, as it seemed to be important to both of us. I retained my enthusiasm for his work in all the intervening years. For example, in our last exchange, he sent several of his recent reprints dealing with altered cortical inputs during sleep. I, of course, forwarded them to my students as required reading, as they present yet again original ideas related to sleep organisation and function. I, my students, and the sleep research world, will miss him.

*Anita Lüthi, PhD, Associate Professor, University of Lausanne, Lausanne, Switzerland.* Ever since I became interested in sleep and how the modern scientific understanding of sleep develops, I had associated the name of Ivan Pigarev with some of the most exciting ideas in the field, in particular the existence of “local sleep” and the “Visceral Theory of Sleep”. But meeting the person behind these ideas at the 2016 International Forum on Sleep in Moscow turned into much more for me than merely attaching a picture of a new face to a page in textbook knowledge. On this occasion, I met an elder scientist and his wife Marina who were curiously following the latest scientific developments and who, beyond their scientific excellence, were cultivated and educated in the arts and history. When I hear of Moscow today, I still think first of the afternoon on which Ivan had offered me a guided car ride through Moscow; he showed me the Theatre Square as well as the invisible lines at which the attack of the Nazi Army was stopped and that were burned in his memory. Our discussion meandered between the centuries and between the cultures, and I could not stop listening. With Ivan, a pioneer in the field has died to whom the word “great” applies beyond his role in science.

*Yuri Saalman, Associate Professor, Department of Psychology, University of Wisconsin-Madison, Madison, WI, USA.* Two wonderful things stood out in my collaboration with Ivan: his often unconventional ideas and his technical ingenuity. Whether it be his thoughts about the extensive influence of visceral information on the cerebral cortex during sleep, or his consideration of the striatum as an elevated level of the cognitive processing hierarchy, such views gave rise to fun discussions and thinking “outside the box”. Moreover, Ivan tested these ideas in inventive ways, such as an electrophysiology rig on rails to test motion and depth perception, and a range of custom implant designs for behavioural experiments. His love of novel design solutions spilled into the everyday, with his appreciation of odd coffee machines and a woodfire pizza oven built into his *dacha* in Russia. Ivan was an important influence on me. I will remember him fondly.

*Lino Nobili, Professor of Child Neuropsychiatry, Head Child Neuropsychiatry Unit, G. Gaslini Institute, University of Genova, Genova GE, Italy.* Ivan Pigarev was a brilliant and original researcher, always a bit “out of the box”. I believe his 1997 manuscript in *Neuroreport*, showing that sleep and wakefulness can be restricted to small groups of neurones, represents a milestone in the field of sleep research and together with other studies it opened the door to the line of research on local sleep. His figure and personality has always impressed me and especially when I had the chance to get to know him better. It was at the 2015 Eighth International Youth Workshop

“Sleep: a window to the world of wakefulness” in Saint Petersburg. Sitting together at the table, with his wife Marina nearby, talking about local sleep, his fascinating theories and studies about visceral sleep but also discussing history and arts including the art of producing a very good vodka, like the one he used to make. Beyond the researcher, I will always remember his culture and kindness.

Vladimir M. Kovalzon, Principal researcher of A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia. The remarkable neurophysiologist and somnologist Ivan Nikolaevich Pigarev, who only recently celebrated his 80th birthday in good health, died on July 15, 2021 as a result of a tragic road incident: Ivan, who was driving slowly along the bike path, was hit by a man rushing towards him on an electric scooter, who himself suffered... Ivan was a brilliant experimental virtuoso who worked in leading laboratories in Germany, Italy, Spain and Australia in the field of neural activity of the cerebral cortex. In the early 1990s, he also became interested in the neurophysiology of sleep and made at least two important discoveries in this area. First, he showed that the neurones of the primary visual cortex of the cat when it falls asleep, ceasing to respond to specific visual stimuli, begin to be excited in response to visceral impulses coming from the intestinal tract. Later these studies served as the basis for the Ivan’s creation of the so-called “Visceral Theory of Sleep”. In the late 1990s, Ivan became one of the pioneers in the study of the phenomenon of “local sleep”, which has not only scientific but also applied significance. Ivan was an unusually charming and attractive person, all his colleagues loved him very much.

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