LEONID L. MOROZ, Ph.D.
Distinguished Professor of Neuroscience, Genetics, Biology and Chemistry
Research Topics: (i) **Deciphering Genealogy of Neurons, Neuronal Evolution & Memory Mechanisms at Single-Cell Resolution;** (ii) **Planetary Biodiversity**

Our laboratory characterizes basic mechanisms underlying the origins and parallel evolution of neural systems, circuits, and brain signaling mechanisms. The major questions are: (1) *why are individual neurons so different from each other*, (2) *how do they maintain such precise connections between each other*, (3) *how does this fixed wiring result in such enormous neuronal plasticity,* and (4) *how does this contribute to learning and memory mechanisms?*

By taking advantage of relatively simpler nervous systems of marine invertebrates, we combine neuroscience, genomics, bioinformatics, evolutionary theory, zoology, molecular biology, microanalytical chemistry, and nanoscience to understand how neurons operate, learn and remember; and how this complexity evolved.

Most of my work is performed on ctenophores, placozoans, and molluscs as critical reference species for evolutionary studies and fundamental biomedicine. My research program is supported by grants, including NIH, NSF, Human Frontiers Science Program and private foundation projects.

I. **NeuroEpigenomics of Memory Persistence:** *Genomic deciphering of memory circuits at the single-cell resolution*.

To do so, we develop innovative genomic approaches for cost-efficient single-cell epigenomic profiling. Specifically, we performed RNA-seq of more than 400,000 individual cells starting from memory circuits in the marine sea slug, *Aplysia*, to neurons in *Octopus*, *Drosophila* & mammalian brains. Here, we are investigating the genomic bases of learning and memory. Two major breakthrough is (i) integration of scRNA-seq with behavioral learning (using advanced imaging) and (ii) identifying and quantifying novel RNA modifications in single identified cells and the ability to monitor the changes in transcription associated to learning in all single/individual cells of the brain simultaneously – this is the first time such resolution has been achieved elsewhere. As a result, we uncover novel mechanisms in the maintenance of neuronal individuality and plasticity. This work is primarily supported by NIH, including the development of new imaging tools using invertebrates as models.

II. **Sequencing at Sea in Real Time:** *Planetary Scale Biodivestity through the lens of single-cell genomics*.

At the same time, we continue to work with representatives of more than a dozen animal phyla (focusing on ctenophores, sponges, and various bilaterians) to characterize the molecular organization of their neural systems.

Here, we introduced and continue to implement a concept of *Ship-Seq*. For the first time, we have performed genome-scale sequencing aboard oceanic ships at remote world locations. Importantly, it was done with real-time assembly and analysis of the genomic data via satellite connections to *HiPerGator* supercomputer. We complemented these biodiversity studies using scRNA-seq.

Essential is completing 15,000 nautical miles segment of the Pacific-TransAtlantic voyage by retracing the famous Darwin's expedition on Beagle, but with genomic tools abroad.

Since 2001-2006, the Moroz lab pioneered the field of single-cell genomics and its implementation to comparative and evolutionary biology with the largest in the world collection of single-cell data across 12 animal phyla (> 3 million of single-cell sequenced). Our ongoing program is a set of around-the-world biodiversity/genomic expeditions to *decipher the genealogy of neurons* by probing rare, fragile species critical for our understanding of evolution and biodiversity. The sailing under the Gator Flag provides the broadest outreach beyond specific scientific questions.

By recruiting science citizens and oceanic vessels, we are forming a biodiversity fleet with access to the most remote areas of the globe. Our proof-of-concept expeditions received global coverage in thousands of media outlets and dozens of languages. These Marine Genomics Expeditions (from Antarctica to tropical Pacific, Hawaii, New Caledonia, Panama, Palau, & Philippines) specifically deal

with the biodiversity of basal metazoans and little investigated lineages of bilaterians and basal deuterostomes.

The marriage of biodiversity and neuroscience also promotes distant learning and cyber-education around the globe. We have completed the deep biodiversity profiling of the New Caledonia areas – such sampling of thousands of species are complemented by their molecular (DNA and RNA bar-coding) and high-quality imaging. The coast of South America [segment] is under current investigation. The illustrated atlas of species is under construction. This work leads to revisiting of critical questions in basal animal phylogeny, Ctenophore and molluscan relationships.

III. **Independent Origins of Neurons & NeuroRegeneration Mechanisms:** *Neurogenesis in Ctenophores***.**

For more than 15 years, ctenophores (or comb jellies) have been my primary targets in deciphering the genealogy of neural cell types. Our work on enigmatic ctenophores (Moroz ***et al***, *Nature, PNAS* 2014, 2016, 2017) strongly suggests that neurons evolved more than once, implying the development of different chemical signaling languages for intercellular communication, neurogenesis, and behaviors – the paradigm shift, which challenges a century hold view of how animals and the nervous system evolved. Our systematic stydies allowed us to map the nervous system in 11 species of ctenophores, including nervous system development in such popular models as *Pleurobrachia* and *Mnemiopsis*.

We also provide evidence that the centralization of nervous systems might also occur at least 9-12 independently with unique subsets of molecular toolkits (possible more than 20 times independently, according to our recent analysis – Moroz et al., 2021). Now, we identified more than one hundred candidates for novel signal molecules in ctenophores. Currently, we are working to complete more detailed microscopic atlases of different neuronal types in several related species of ctenophores. It provides resources for the unbiased reconstruction of neuronal genealogies toward modeling, designing, and engineering new circuits and even simpler brains. This work is also reshaped the animal tree of life by challenging more than a century hold view of how basal animal lineages are related (see also our recent paper (Whelan et al, *PNAS*, 2015, 2016; Moroz & Halanych, *Nature*, 2016; Whelan et al. Nature Ecology and Evolution 2017;). With more than 37 ctenophore species now investigated, we started to decipher molecular mechanisms of one of the fastest neural regeneration in the animal kingdom and identified a number of novel candidate molecules and mechanisms, which enhance and modulate the regeneration potential. This ctenophore work is supported by NSF and private foundation grants focusing on the mechanisms of neurogenesis and regeneration in ctenophores with tools of single-cell genomics.

Current Research Agenda:

I am actively promoting collaboration among UF scientists engaged in biodiversity, (neuro)genomics, memory research & evolution, including the development and implementation of cutting-edge technologies (e.g., single-cell epigenomics, RNA editing & modifications) to understand the mechanisms that control neurogenesis, neural circuit formation, regeneration & neuroplasticity. We also collaborate with more than 160 scientists worldwide. My Goal is to decipher the genealogy of neurons, animal cell type evolution, and use this knowledge to repair, design, and construct novel neural circuits; enhance memory and regeneration capabilities.

Education:

1985-1989	Ph.D., Institute of Developmental Biology, Moscow Mentor: Prof. Dmitry A. Sakharov
1982	B.S., Animal & Human Physiology, Belarus University, Minsk

Professional Experience:

2014-Present	Distinguished Professor University of Florida
2011-Present	Professor of Genetics, Genetic Institute & UF Genomic Graduate Program, University of Florida, Gainesville, FL (secondary affiliation)
2010-Present	Professor of Biology, Department of Biology, University of Florida, Gainesville, FL (secondary affiliation)
2006-Present	Professor of Chemistry, Department of Chemistry, University of Florida, Gainesville, FL (secondary affiliation)
2006-Present	Professor of Neuroscience, Department of Neuroscience, Brain Institute & The Whitney Laboratory for Marine Biosciences, University of Florida, Gainesville/St. Augustine, Florida
2003-2006	Associate Professor of Neuroscience, Department of Neuroscience, University of Florida, Gainesville, FL
1998-2003	Assistant Professor of Neuroscience, Department of Neuroscience, University of Florida, Gainesville, FL
1997-1998	Research Specialist in Life Sciences, Single-Cell Microchemical Assays, Beckman Institute, Department of Chemistry, University of Illinois Urbana-Champaign, IL
1994-1997	Postdoc, Research Associate, Nitric Oxide Signaling & Electrophysiology, Department of Molecular & Integrative Physiology, University of Illinois Urbana-Champaign, IL (Dr. Gillette lab)
1993-1994	Researcher, Cellular Bases of Behavior, Department of Physiology, University of Leeds, UK (Supported by Royal Society)
1992-1993	Researcher, Reconstruction of Neural Circuits in Culture, Department of Physiology, University of Calgary, Canada
1992	Researcher, Comparative Neuroanatomy, Department of Zoology Lund University, Sweden
1991-1992	Researcher, Ion Channel Biophysics, Hungarian Academy of Sciences, Hungary Mentor: Professor Janos Salanki
1990	Visiting Researcher, Neural Circuit Organization, Department of Physiol, University of Leeds, UK Mentor: Professor William Winlow

Membership in Professional Societies:

Invertebrate Neuroscience – Council Member
Society for Neuroscience – Member
International Brain Research Organization – Member
International Society for Neuroethology – Member
American Association for the Advancement of Science – Member
Analytical Chemistry – Member

Honors:

2016	University of Florida Research Professor Awardee
2014	Distinguished Professor, University of Florida College of Medicine
2011	Journal of Neurogenetics, Editorial Board
2000-Present	International Society for Invertebrate Neurobiology, Elected Council Member
2007	Faculty Achievement Recognition Honoree & Award
2005/2007/2011	McKnight Brain Research Foundation Awards
2005	NIH Science Award (Nitrite Research)

2002	Packard Interdisciplinary Science Award
2000	NSF Medal, Research in Antarctica
1995-2000	Howard Hughes Medical Institute: International Scholar
1993-1994	Royal Society Postdoctoral Fellow Award, UK
1992	European Training Program in Brain and Behavioral Research (ETP) Research Award
1989	European Training Program in Brain and Behavioral Research (ETP) Award

In addition to being the Distinguished Professor of Neuroscience, other honors include serving on NIH and NSF Special Emphasis Panels (2012-2018), Editorial Board for J. of Neurogenetics, (2011- present), Research Council for International Society of Invertebrate Neurobiology; Global Ocean Marine Genomic Initiative; Presidential BRAIN initiative discussions. My lab was the 1st to perform genome-scale sequencing directly aboard ocean-going ships with real-time bioinformatic analysis via satellites (using UF supercomputer). I have received national and international recognition in the form of more than 100 invited talks and participation as an organizer or chair for dozen symposiums focused on neurogenomics and neuronal evolution as well as biodiversity.

National /International Professional Service:

2021-Present	Ocean Genome Atlas Project, United Nation Ocean Decade Program, Scientific Advisor
2013-Present	International SeaKeepers Soc./Ocean Genome Atlas Project, United Nation Ocean Decade Program, Scientific Advisor
2008-2011	University of Marie Curie, Paris/France, Evolutionary Genomics Neuroscience, Advisor
2008-2010	University of Prague, Genomics Initiative, Scientific Advisor 2000- International Society for Invertebrate Neuroscience, Elected Council Member 2006-

Recent & Relevant Publications: (out of >160 peer-reviewed papers)

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Moroz, L.L., Mukherjee, K., Romanova, D.Y. 2023. Nitric oxide-cGMP signaling in Ctenophores. Frontiers in Neuroscience 17:1-18

Corrales, M., Cocanougher, B.T., Kohn, A.B., Wittenbach, J.D., Long, X.S., Lemire, A., Cardona, A., Singer, R.H., **Moroz, L.L.**, Zlatic, M. 2022. A single-cell transcriptomic atlas of complete insect nervous systems across multiple life stages. Neural Dev 17:8

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Drabkova, M., Kocot, K.M., Halanych, K.M., Oakley, T.H., **Moroz, L.L.**, Cannon, J.T., Kuris, A., Garcia-Vedrenne, A.E., Pankey, M.S., Ellis, E.A., Varney, R., Stefka, J., Zrzavy, J. 2022. Different phylogenomic methods support monophyly of enigmatic 'Mesozoa' (Dicyemida + Orthonectida, Lophotrochozoa). Proc Biol Sci 289:20220683

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Romanova, D.Y., Nikitin, M.A., Shchenkov, S.V. & **Moroz, L.L.** 2022. Expanding of Life Strategies in Placozoa: Insights From Long-Term Culturing of Trichoplax and Hoilungia. Frontiers in Cell and Developmental Biology, 10, 1-15. DOI: 10.3389/ fcell.2022.823283

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Stern-Mentch, N., Bostwick, G.W., Belenky, M., **Moroz, L.L.** & Hochner, B. 2022. Neurotransmission and neuromodulation systems in the learning and memory network of *Octopus vulgaris*. J Morphol. p 1-28. DOI: 10.1002/jmor.21459

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Research Support (Total: >$20,000,000 during the last 10 years):

My current projects use a diversity of organisms as experimental models to characterize (i) genomic bases of neuronal identity, learning, and memory; (ii) genomic bases of cell type evolution;
(iii) genomic mechanisms of evolution of nervous systems and origins of innovations in signaling systems. In addition, we develop novel technologies for unbiased genome-wide molecular profiling of single cells and cell compartments (including direct single-cell transcriptome, methylome profiling and imaging).

Ongoing Research Support:

"**Signal Molecules in Ctenophores**"
Funding Agency: **NSF**; PI: L.L. Moroz
Period: 03/01/16- 10/01/2022

The Goal is to characterize cellular, developmental and genomic organization of nervous systems in comb-jellies or ctenophores – the earliest branching animal lineages. We explored the hypothesis that neurons can be evolved independently from other animals using different molecular toolkits to control polarized secretion and intercellular communications. The research of this grant focuses on deciphering genomic bases of neurogenesis in ctenophores and single-cell analyses of these processes; the overall task to reconstruct ancestral neural systems and genealogy of cell types across metazoans.

"Development of neuron-specific nanoscale toolkits for single-cell recognition"
Funding Agency: **NIH**: **R01**NS114491 PI: L.L. Moroz
Period: 09/30/2020-06/30/2025
Goal: This project aims to implement nanotechnology approaches to identify neurons molecularly, focusing on surface molecules and using a diversity of marine invertebrates as models.

"**Nanoscale Probes and Infrastructure for Real-time and Single-Cell Genomics across Metazoa**"
Funding Agency: **NSF** EDGE Program PI: L.L. Moroz
Period: 08/1/2017-07/30/2021
Goal: This project is designed to develop novel-single cell genomic approaches for ctenophores, basal metazoans, and selected bilaterians as critical reference species in biology. Here, we also develop criteria and approaches to recognize cell types across phyla and characterize genomic bases of establishing unique cell phenotypes.

"**How to make a heartbeat? Basic principles for novelties and parallel innovations in cephalopods**."
Funding Agency: Human Frontiers Science Program. Co-PIs: L.L. Moroz; M-A. Yoshida
Period: 08/01/17-07/30/2022
This project will decipher genomic bases of neuronal and cardiovascular innovations in cephalopod molluscs such as squids, octopuses and *Nautilus*.

"**Retracing Darving: Planetary Biodiversity through the lens of single-cell genomics**." PI: L.L. Moroz
Funding: This ongoing (**2021-2025**) project is supported by a private foundation (University of Florida Foundation)
Goal: Explore of global biodiversity of pelagic and planktonic species using floating mobile laboratories with mobile genomic and imaging equipment aboard of research vessels.

Recently Completed projects:

"INSPIRE_Deciphering the Genealogy of Neurons via Planetary Biodiversity Capture"
Funding Agency: National Science Foundation, NSF 1548121 PI: L.L. Moroz
This BRAIN initiative project is focused on the reconstruction of the natural classification of neurons (NeuroSystematics) including reconstruction of ancestral cell lineages leading to formation of neural circuits and behaviors.

"Genomic Organization of Cephalopod Brains: *Origins of Complex Brains & Elementary Cognition*"
Funding Agency: NSF# 1146575; PI: L.L. Moroz Period: 03/01/15-28/05/2019
Here, we will look for genomic bases underlying the convergent evolution of memory-forming neural circuits and the complex brains.

"Real-time Marine Genomics"
Funding Agency: Ocean Research LLC; PI: L.L. Moroz
This project is designed to develop mobile instrumentation and technology for oceanic field research with high-throughput capacity and single-cell resolution for RNA-seq, genomic, proteomic and metabolomic analysis. This equipment will be tested at remote locations and used for drug discovery and fundamental neuroscience research. We plan to initiate this project later this year, and an exact starting date is flexible due to field research logistics.

Public Outreach:

My research was covered by more than one hundred media outlets both internationally (from Australia to Europe, translated to Japanese, Chinese, Arabic, Spanish, German, Russian and French, etc.) and nationally including ***Associated Press***, ***Reuters***, ***BBC*** (UK), ***ABC News*** and ***MSNBC***, ***Fox News***, ***National Geographic***, ***Spiegel*** (Germany), ***New York Times***, ***Washington Post***, ***Chicago Tribune***, ***Scientific American***, ***the Scientist***; ***New Scientist***, ***History Channel***, etc.

The stories were picked up as the leading edge research selection in *Cell*, and news coverage in *Science*.

We worked with several private oceanic ships toward global biodiversity genomic profiling with more than 100 citizens of science as well as performed three biodiversity public training workshops.