

Matthew Larkum

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Born: Cambridge, UK, on May 2, 1967
Nationality: German (naturalized)



Curriculum vitae

Since 2018 Speaker for DFG Collaborative Research Center 1315 on memory consolidation
Since 2011 Full Professor (W3), Neurobiology, Humboldt Universität zu Berlin
2004 – 2011 SNSF Professor, Institute of Physiology, University of Bern
1997 – 2003 Postdoctoral fellow (Advisor: Bert Sakmann), Max Planck Institute for Medical Research, Heidelberg
1992 – 1996 PhD (supervisor: Hans-Rudolf Lüscher), Institute of Physiology, University of Bern
1991 First class honours in Physiology (supervisor: Max Bennett), University of Sydney
1987 – 1990 Bachelor of Science, University of Sydney

Research fields

Our group focuses on the processing of feedforward and feedback information in the cortex, and particularly, on the contribution of active dendritic properties to the computational power of neocortical pyramidal neurons. Recent topics include:

- Dendritic spikes in the tuft and basal dendrites of neocortical pyramidal neurons
- Memory consolidation with active dendritic mechanisms
- Mechanisms underlying perceptual processes
- Development of behavioural methodologies for rodents
- Inhibitory control of cortical microcircuits
- Cellular basis for interhemispheric inhibition in the cerebral cortex
- Effect of fetal alcohol syndrome on dendritic processing
- Effects of common anesthetics on single-cell computation in the cortex
- Development of state-of-the-art optical approaches for studying cortical dendritic activity

Teaching and supervision

Larkum is a full professor in the Biology Institute of the Humboldt University of Berlin and in the Bernstein Center for Computational Neuroscience. This involves teaching many courses on neuroscience topics including (introductory neuroscience, cerebral cortex, methods in neuroscience research, etc.). He has a large laboratory (currently 28 people) including 5 PhD students and many Masters and Bachelor students. Several post-doctoral fellows have gone on to lead outstanding laboratories at top institutions around the world (e.g. RIKEN, Tokyo; Florey Institute, Melbourne; CNRS, Bordeaux; Ecole Normale Supérieure, Paris; University of Surrey). Over the past 20 years he has supervised over 30 PhD students, and even more Masters and Bachelor students. As speaker for a Collaborative Research Center on memory consolidation (SFB1315), he is a co-coordinator of the PhD program within the center and is an active part of the International PhD Program of the Einstein Center for Neurosciences Berlin. He also participates regularly in student schools including as a regular speaker for the Australasian Course in Advanced Neuroscience (ACAN) and the Cold Spring Harbor Imaging course.

Activities in the scientific community, honors, awards

2018	Speaker of SFB1315 – <i>Mechanisms and disturbances in memory consolidation: from synapses to systems</i>
2016	ERC program grant
2010	Robert Bing Prize, Swiss Academy of Medical Sciences
2007	Pfizer Prize for the best neuroscience paper published by a Swiss group
2006	Theodor Kocher Prize
2004	Professorship, Swiss National Science Foundation (SNSF)
2003	Nikon Research Fellowship, Woods Hole Research Laboratories
2002	Woods Hole Research Fellowship
1999 – 2001	Max Planck Society Scholarship
1997 – 1998	Alexander von Humboldt Scholarship
1992 – 1995	Australian Postgraduate Research Award

H-index (Google scholar)

Overall 48, since 2017: 37
27 papers with >100 citations

Major scientific achievements and publications since 2016

Matthew Larkum has proposed a theory of cortex that hypothesizes that feedback and feed forward information streams are integrated at the cellular level via a cellular mechanism located in the apical dendrites of neocortical pyramidal neurons. Since 2015, this hypothesis has proven extremely successful for investigating the nature of cognition and conscious processing in the brain. For instance, Larkum and coworkers were able to show that activation of a dendritic spike is causally related to the “moment of perception” (i.e. at perceptual threshold). This work was published in the journal *Science* in 2016 (Takahashi et al., 2016). Larkum also demonstrated that dendritic calcium fluctuations during slow-wave sleep correlate with spindle activity suggesting an important link between the dendritic mechanism for perception and the mechanism for memory consolidation (Seibt et al., 2017). In the same year, he also showed that the dendritic spikes crucial for conscious perception are detectable at the cortical surface with EEG recordings (Suzuki & Larkum, 2017) which may facilitate the recording of such events non-invasively in humans. Both these studies were published in *Nature Communications*. 2020 was a particular productive year for Larkum. In this year alone he and his laboratory discovered that human cortical neurons have a new channel type that allows them to compute more sophisticated functions than neurons in other species (Gidon et al., 2020 in *Science*). They also discovered what propose as the mechanism for anesthesia (Suzuki & Larkum, 2020 in *Cell*). They showed for the first time that cortical layer 1 plays a primary role in the formation of memories (Doron et al., 2020 in *Science*). They showed that the “moment of perception” is intrinsically bound to the dendritic activation of a particular subclass of layer 5 pyramidal neurons (pyramidal tract neurons; Takahashi et al., 2020 in *Nature Neuroscience*). They also published a work showing the connectivity to a very under-researched deep layer of the cortex (layer 6b) and described the ramifications for cortical processing (Zolnik et al., 2020 in *Cell Reports*). These publications led to different opinion pieces including a new theory of consciousness (“Dendritic Integration Theory”) based on this body of work (Aru et al., 2020 in *Trends in Cognitive Sciences*).

In summary, Larkum’s scientific output has been very successful in the last 5 years and has led to new understandings about how the cortex operates and how the events related to conscious perception involve and rely on memory. This work lays out a roadmap for the next decade for understanding some of the deepest mysteries of the brain.

Selected publications since 2016

1. Shin JN, Doron G, **Larkum ME** (2021) Memories off the top of your head. *Science*, 374: 538–539.
2. Doron G, Shin JN, Takahashi N, Drücke M, Bocklisch C, Skenderi S, de Mont L, Toumazou M, Ledderose J, Brecht M, Naud R, **Larkum ME** (2020) Perirhinal input to neocortical layer 1 controls learning. *Science*, 370, 1435-1444.
3. Gidon A, Zolnik TA, Fidzinski P, Bolduan F, Papoutsi A, Poirazi P, Holtkamp M, Vida I, **Larkum ME** (2020) Dendritic action potentials and computation in human layer 2/3 cortical neurons. *Science* 367:83-87.

4. Suzuki M, **Larkum ME** (2020) General anesthesia decouples cortical pyramidal neurons. *Cell* 180:666-676.
5. Takahashi N, Ebner C, Sigl-Glöckner J, Moberg S, Nierwetberg S, **Larkum ME** (2020) Active dendritic currents gate descending cortical outputs in perception. *Nature Neuroscience*, **23**, 1277-1285.
6. Aru J, Suzuki M, **Larkum ME** (2020) Cellular Mechanisms of Conscious Processing. *Trends in Cognitive Sciences*: 24, 814-825.
7. Zolnik TA, Ledderose J, Toumazou M, Trimbuch T, Oram T, Rosenmund C, Eickholt BJ, Sachdev RNS, **Larkum ME** (2020) Layer 6b is driven by intracortical long-range projection neurons. *Cell Reports* **30**: 3492-3506.
8. Suzuki M, **Larkum ME** (2017) Dendritic calcium spikes are clearly detectable at the cortical surface. *Nature Communications* **8**: 276-286.
9. Seibt, J., Richard, C.J., Sigl-Glöckner, J., Takahashi, N., Kaplan, D., Doron, G., de Limoges, D., Bocklisch, C., **Larkum, M.E.**, (2017) Cortical dendritic activity correlates with spindle-rich oscillations during sleep in rodents. *Nature Communications* **8**: 684-696.
10. Takahashi N, Oertner T, Hegemann P, **Larkum ME**. (2016) Active cortical dendrites modulate perception. *Science* **354**: 1587-1590.

Full list of publications since 2016

1. Berlage C, Tantirigama MLS, Babot M, Di Battista D, Whitmire C, Papadopoulos IN, Poulet JFA, **Larkum M**, Judkewitz B (2021) Deep tissue scattering compensation with three-photon F-SHARP. *Optica* **8**, 1613-1619. <https://doi.org/10.1364/OPTICA.440279>
2. Suzuki M, Aru J, **Larkum ME** (2021) Double- μ Periscope: a tool for multi-layer optical recordings, optogenetic stimulations or both. *eLIFE*, **10**:e72894. <https://doi.org/10.7554/eLife.72894>
3. Shin JN, Doron G, **Larkum ME** (2021) Memories off the top of your head. *Science*, **374**, 538–539. <https://doi.org/10.1126/science.abk1859>.
4. Schulz JM, Kay JW, Bischofsberger J, **Larkum ME** (2021) GABAB receptor-mediated regulation of dendro-somatic synergy in layer 5 pyramidal neurons. *Frontiers in Cellular Neuroscience*, **15**. <https://doi.org/10.3389/fncel.2021.718413>
5. Takahashi N, Moberg S, Zolnik TA, Catanese J, Sachdev RNS, **Larkum ME**, Jaeger D (2021) Thalamic input to motor cortex facilitates goal-directed action initiation. *Current Opinion in Neurobiology*, **31**, 1-8. <https://doi.org/10.1016/j.cub.2021.06.089>.
6. K Sehara, P Zimmer-Harwood, **ME Larkum**, RNS Sachdev (2021) Real-time closed-loop feedback in behavioral time scales using DeepLabCut. *ENeuro* **8** (2).
7. Doron G, Shin JN, Takahashi N, Drüke M, Bocklisch C, Skenderi S, de Mont L, Toumazou M, Ledderose J, Brecht M, Naud R, **Larkum ME** (2020) Perirhinal input to neocortical layer 1 controls learning. *Science*, **370**, 1435-1444. <https://doi.org/10.1126/science.aaz3136>.
8. Aru J, Suzuki M, **Larkum ME** (2020) Cellular Mechanisms of Conscious Processing. *Trends in Cognitive Sciences*: **24**, 814-825. <https://doi.org/10.1016/j.tics.2020.07.006>.
9. Takahashi N, Ebner C, Sigl-Glöckner J, Moberg S, Nierwetberg S, **Larkum ME** (2020) Active dendritic currents gate descending cortical outputs in perception. *Nature Neuroscience*, **23**, 1277-1285. <https://doi.org/10.1038/s41593-020-0677-8>
10. Papadopoulos IN, Jouhannau JS, Takahashi N, Kaplan D, **Larkum M**, Poulet J, Judkewitz B Dynamic conjugate F-SHARP microscopy (2020) *Light Sci Appl*, **9**, 110. <https://doi.org/10.1038/s41377-020-00348-x>
11. Tukker J, Beed P, Schmitz D, Larkum ME, Sachdev RNS (2020) Up and Down States and Memory Consolidation across Somatosensory, Entorhinal, and Hippocampal Cortices. *Frontiers in Systems Neuroscience*. *Frontiers in Systems Neuroscience*, **14**, 22. <https://doi.org/10.3389/fnsys.2020.00022>
12. Tantirigama MLS, Zolnik TA, Judkewitz BJ, **Larkum ME**, Sachdev RNS (2020) Perspective on the multiple pathways to changing brain states. *Frontiers in Systems Neuroscience*, **14**, 23. <https://doi.org/10.3389/fnsys.2020.00023>
13. Zolnik TA, Ledderose J, Toumazou M, Trimbuch T, Oram T, Rosenmund C, Eickholt BJ, Sachdev RNS, **Larkum ME**. Layer 6b is driven by intracortical long-range projection neurons. (2020) *Cell Reports* **30**: 3492-3506. doi:<https://doi.org/10.1016/j.celrep.2020.02.044>.
14. Suzuki M, Larkum ME. General anesthesia decouples cortical pyramidal neurons. (2020) *Cell* **180**: 666-676. doi: 10.1016/j.cell.2020.01.024
15. Gidon A, Zolnik TA, Fidzinski P, Bolduan F, Papoutsi A, Poirazi P, Holtkamp M, Vida I, **Larkum ME**. Dendritic action potentials and computation in human layer 2/3 cortical neurons. (2020) *Science* **367**:83-87. doi: 10.1126/science.aax6239
16. Sigl-Glöckner J, Maier E, Takahashi N, Sachdev R, **Larkum M**, Brecht M. Effects of Sexual Experience and Puberty on Mouse Genital Cortex revealed by Chronic Imaging. (2019) *Curr Biol*. **29**:3588-3599.e4. doi: 10.1016/j.cub.2019.08.062.
17. Sehara K, Bahr V, Mitchinson B, Pearson MJ, **Larkum ME**, Sachdev RNS. Fast, Flexible Closed-Loop Feedback: Tracking Movement in "Real-Millisecond-Time". (2019) *eNeuro*. **6**. pii: ENEURO.0147-19.2019. doi: 10.1523/ENEURO.0147-19.2019.
18. Aru J, Suzuki M, Rutiku R, **Larkum ME**, Bachmann T. Coupling the State and Contents of Consciousness. (2019) *Front Syst Neurosci*. **13**:43. doi: 10.3389/fnsys.2019.
19. Dominiak SE, Nashaat MA, Sehara K, Oraby H, **Larkum ME**, Sachdev RNS. Whisking asymmetry signals motor preparation and the behavioral state of mice. (2019) *J Neurosci*. 1809-1819. doi: 10.1523/JNEUROSCI.1809-19.2019.
20. Hasan MT, Althammer F, Silva da Gouveia M, Goyon S, Eliava M, Lefevre A, Kerspern D, Schimmer J, Raftogianni A, Wahis J, Knobloch-Bollmann HS, Tang Y, Liu X, Jain A, Chavant V, Goumon Y, Weislogel JM, Hurlmann R, Herpertz SC, Pitzer C, Darbon P,

- Dogbevia GK, Bertocchi I, **Larkum ME**, Sprengel R, Bading H, Charlet A, Grinevich V. A Fear Memory Engram and Its Plasticity in the Hypothalamic Oxytocin System. (2019) *Neuron*. **103**:133-146.e8. doi: [10.1016/j.neuron.2019.04.029](https://doi.org/10.1016/j.neuron.2019.04.029)
21. Ebner C, Ledderose J, Zolnik TA, Dominiak SE, Turko P, Papoutsis A, Poirazi P, Eickhot BJ, Vida I, **Larkum ME**, Sachdev RNS (2019). Optically induced calcium-dependent gene activation and labeling of active neurons using CaMPARI and Cal-Light. *Frontiers in Synaptic Neuroscience* **11**: doi: 10.3389/fnsyn.2019.00016
 22. Moeyaert B, Holt G, Madangopal R, Perez-Alvarez A, Fearey BC, Trojanowski NF, Ledderose J, Zolnik TA, Das A, Patel D, Brown TA, Sachdev RNS, Eickholt BJ, **Larkum ME**, Turrigiano GG, Dana H, Gee CE, Oertner TG, Hope BT, Schreiter ER. (2018) Improved methods for marking active neuron populations. *Nature Communications* **9**: 1-12. doi: [10.1038/s41467-018-06935-2](https://doi.org/10.1038/s41467-018-06935-2)
 23. **Larkum, M.E.**, Petro, L.S., Sachdev, R.N.S., Muckli, L. (2018) A perspective on cortical layering and layer-spanning neuronal elements. *Frontiers in Neuroanatomy* **12**: doi:[10.3389/fnana.2018.00056](https://doi.org/10.3389/fnana.2018.00056)
 24. Lissek, T. et al. (2017) Building bridges through science. *Neuron* **96**: 730-735. doi: [10.1016/j.neuron.2017.09.028](https://doi.org/10.1016/j.neuron.2017.09.028)
 25. Shai, A., **Larkum, M.E.** (2017) Deep Learning: Branching into brains. *eLife* 2017;6:e33066 DOI: [10.7445/eLife.33066](https://doi.org/10.7445/eLife.33066)
 26. Seibt, J., Richard, C.J., Sigl-Glöckner, J., Takahashi, N., Kaplan, D., Doron, G., de Limoges, D., Bocklisch, C., **Larkum, M.E.**, (2017) Cortical dendritic activity correlates with spindle-rich oscillations during sleep in rodents. *Nature Communications* **8**: 684-696. doi: [10.1038/s41467-017-00735-w](https://doi.org/10.1038/s41467-017-00735-w)
 27. Micaller, A.F., Takahashi, N., **Larkum, M.E.**, Palmer, L.M. (2017) A reward-based behavioral platform to measure neuronal activity during head-fixed behavior. *Frontiers in Cellular Neuroscience*. doi: 10.3389/fncel.2017.00156
 28. Suzuki, M., **Larkum, M.E.** (2017) Dendritic calcium spikes are clearly detectable at the cortical surface. *Nature Communications* **8**: 276-286.
 29. Nashaat MA, Oraby H, Peña LB, Dominiak S, **Larkum ME**, Sachdev RN. (2017) Pixying Behavior: A Versatile Real-Time and *Post Hoc* Automated Optical Tracking Method for Freely Moving and Head Fixed Animals. *eNeuro* **4**: ENEURO.0245-16. doi: 10.1523/ENEURO.0245-16.2017.
 30. Zolnik TA, Sha F, Johenning FW, Schreiter ER, Looger LL, **Larkum ME**, Sachdev RN. (2017) All-optical functional synaptic connectivity mapping in acute brain slices using the calcium integrator CaMPARI. *J Physiol*. **595**: 1465-1477. doi: 10.1113/JP273116
 31. Takahashi, N., Oertner, T., Hegemann, P., **Larkum, M.E.** (2016) Active cortical dendrites modulate perception. *Science* **354**: 1587-1590. Doi: 10.1126/science.aah6066.
 32. Phillips, W.A., **Larkum, M.E.**, Harley, C.W., Silverstein, S.M. (2016) The effects of arousal on apical amplification and conscious state. *Neuroscience of Consciousness* 2016:niw015.
 33. Nashaat, M.A., Oraby, H., Sachdev, R.N.S., Winter, Y., **Larkum, M.E.** (2016) A real-world floating environment for active sensing in head-fixed mice. *J Neurophysiology* **116**: 1542-1553.
 34. Murphy, S.C., Palmer, L.M., Nyffeler, T., Müri, M.R., **Larkum, M.E.** (2016) Transcranial magnetic stimulation (TMS) inhibits cortical dendrites. *eLife* pii: e13598. doi: 10.7554/eLife.13598.