References

1. Clyde A. Hutchison, III *et al.*, Design and synthesis of a minimal bacterial genome. *Science* 351,aad6253(2016).DOI:10.1126/science.aad6253
2. Goold, H.D., Kroukamp, H., Erpf, P.E. et al. Construction and iterative redesign of synXVI a 903 kb synthetic Saccharomyces cerevisiae chromosome. Nat Commun 16, 841 (2025). https://doi.org/10.1038/s41467-024-55318-3
3. Greg Schuette et al. ,ChromoGen: Diffusion model predicts single-cell chromatin conformations.Sci. Adv.11,eadr8265(2025).DOI:10.1126/sciadv.adr8265
4. DaSilva LF, Senan S, Patel ZM, et al. DNA-Diffusion: Leveraging Generative Models for Controlling Chromatin Accessibility and Gene Expression via Synthetic Regulatory Elements. Preprint. bioRxiv. 2024;2024.02.01.578352. Published 2024 Feb 1. doi:10.1101/2024.02.01.578352
5. Jinek M, Chylinski K, Fonfara I, Hauer M, Doudna JA, Charpentier E. A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity. Science. 2012 Aug 17;337(6096):816-21. doi: 10.1126/science.1225829. Epub 2012 Jun 28. PMID: 22745249; PMCID: PMC6286148.
6. Zhao C, Wang Y, Nie X, et al. Evaluation of the effects of sequence length and microsatellite instability on single-guide RNA activity and specificity. Int J Biol Sci. 2019;15(12):2641-2653. Published 2019 Oct 3. doi:10.7150/ijbs.37152
7. Eghbalsaied, S., Lawler, C., Petersen, B. et al. CRISPR/Cas9-mediated base editors and their prospects for mitochondrial genome engineering. Gene Ther 31, 209–223 (2024). https://doi.org/10.1038/s41434-023-00434-w
8. Jiang, T., Henderson, J.M., Coote, K. et al. Chemical modifications of adenine base editor mRNA and guide RNA expand its application scope. Nat Commun 11, 1979 (2020). https://doi.org/10.1038/s41467-020-15892-8
9. Lin SW, Nguyen VQ, Lin S. Preparation of Cas9 Ribonucleoproteins for Genome Editing. Bio Protoc. 2022;12(10):e4420. Published 2022 May 20. doi:10.21769/BioProtoc.4420
10. Cheng H, Zhang F, Ding Y. CRISPR/Cas9 Delivery System Engineering for Genome Editing in Therapeutic Applications. Pharmaceutics. 2021;13(10):1649. Published 2021 Oct 9. doi:10.3390/pharmaceutics13101649
11. Kolb HC, Finn MG, Sharpless KB. Click Chemistry: Diverse Chemical Function from a Few Good Reactions. Angew Chem Int Ed Engl. 2001;40(11):2004-2021. doi:10.1002/1521-3773(20010601)40:11<2004::AID-ANIE2004>3.0.CO;2-5
12. Scinto SL, Bilodeau DA, Hincapie R, et al. Bioorthogonal chemistry. Nat Rev Methods Primers. 2021;1:30. doi:10.1038/s43586-021-00028-z
13. Mitry, M. M., Greco, F., & Osborn, H. M. (2023). In vivo applications of bioorthogonal reactions: chemistry and targeting mechanisms. Chemistry–A European Journal, 29(20), e202203942.
14. Takahashi K, Yamanaka S. Induction of pluripotent stem cells from mouse embryonic and adult fibroblast cultures by defined factors. Cell. 2006;126(4):663-676. doi:10.1016/j.cell.2006.07.024

Resources

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Additional References

1. Ponce-Alvarez, A., Deco, G. The Hopf whole-brain model and its linear approximation. Sci Rep 14, 2615 (2024). https://doi.org/10.1038/s41598-024-53105-0
2. Herculano-Houzel S. The human brain in numbers: a linearly scaled-up primate brain. Front Hum Neurosci. 2009;3:31. Published 2009 Nov 9. doi:10.3389/neuro.09.031.2009
3. Yang, Y., DeWeese, M. R., Otazu, G. H. & Zador, A. M. Millisecond-scale differences in neural activity in auditory cortex can drive decisions. Nat. Neurosci. 11, 1262–1263 (2008).
4. von Bartheld CS. Myths and truths about the cellular composition of the human brain: A review of influential concepts. J Chem Neuroanat. 2018 Nov;93:2-15. doi: 10.1016/j.jchemneu.2017.08.004. Epub 2017 Sep 2. PMID: 28873338; PMCID: PMC5834348.
5. Kaposzta Z, Stylianou O, Mukli P, Eke A, Racz FS. Decreased connection density and modularity of functional brain networks during n-back working memory paradigm. Brain Behav. 2021;11(1):e01932. doi:10.1002/brb3.1932
6. Tomasi D, Volkow ND. Functional connectivity density mapping. Proc Natl Acad Sci U S A. 2010;107(21):9885-9890. doi:10.1073/pnas.1001414107
7. Cooray GK, Cooray V, Friston K. A cortical field theory - dynamics and symmetries. J Comput Neurosci. 2024;52(4):267-284. doi:10.1007/s10827-024-00878-y
8. Rădulescu, A., Herron, J., Kennedy, C. et al. Global and local excitation and inhibition shape the dynamics of the cortico-striatal-thalamo-cortical pathway. Sci Rep 7, 7608 (2017). https://doi.org/10.1038/s41598-017-07527-8
9. Rueda-Castro V, Azofeifa JD, Chacon J, Caratozzolo P. Bridging minds and machines in Industry 5.0: neurobiological approach. Front Hum Neurosci. 2024;18:1427512. Published 2024 Aug 27. doi:10.3389/fnhum.2024.1427512
10. Vaz AP, Wittig JH Jr, Inati SK, Zaghloul KA. Replay of cortical spiking sequences during human memory retrieval. Science. 2020;367(6482):1131-1134. doi:10.1126/science.aba0672
11. R.B. Yaffe, M.S.D. Kerr, S. Damera, S.V. Sarma, S.K. Inati, K.A. Zaghloul, Reinstatement of distributed cortical oscillations occurs with precise spatiotemporal dynamics during

successful memory retrieval, Proc. Natl. Acad. Sci. U.S.A. 111 (52) 18727-18732, https://doi.org/10.1073/pnas.1417017112 (2014).
12. Yaffe, R. B., Shaikhouni, A., Arai, J., Inati, S. K., & Zaghloul, K. A. (2017). Cued Memory Retrieval Exhibits Reinstatement of High Gamma Power on a Faster Timescale in the Left Temporal Lobe and Prefrontal Cortex. The Journal of neuroscience : the official journal of the Society for Neuroscience, 37(17), 4472–4480.
13. Davidson, T. J., Kloosterman, F., & Wilson, M. A. (2009). Hippocampal replay of extended experience. Neuron, 63(4), 497–507. https://doi.org/10.1016/j.neuron.2009.07.027
14. Huelin Gorriz, M., Takigawa, M. & Bendor, D. The role of experience in prioritizing hippocampal replay. Nat Commun 14, 8157 (2023). https://doi.org/10.1038/s41467-023-43939-z
15. Graham Findlay, Giulio Tononi, Chiara Cirelli, The evolving view of replay and its functions in wake and sleep, SLEEP Advances, Volume 1, Issue 1, 2020, zpab002, https://doi.org/10.1093/sleepadvances/zpab002
16. Le Duigou C, Simonnet J, Teleñczuk MT, Fricker D, Miles R. Recurrent synapses and circuits in the CA3 region of the hippocampus: an associative network. Front Cell Neurosci. 2014;7:262. Published 2014 Jan 8. doi:10.3389/fncel.2013.00262
17. Sammons RP, Vezir M, Moreno-Velasquez L, et al. Structure and function of the hippocampal CA3 module. Proc Natl Acad Sci U S A. 2024;121(6):e2312281120. doi:10.1073/pnas.2312281120
18. Klinshov VV, Teramae JN, Nekorkin VI, Fukai T. Dense neuron clustering explains connectivity statistics in cortical microcircuits. PLoS One. 2014;9(4):e94292. Published 2014 Apr 14. doi:10.1371/journal.pone.0094292
19. Udvary D, Harth P, Macke JH, et al. The impact of neuron morphology on cortical network architecture. Cell Rep. 2022;39(2):110677. doi:10.1016/j.celrep.2022.110677
20. Hunt, D.L., Linaro, D., Si, B. et al. A novel pyramidal cell type promotes sharp-wave synchronization in the hippocampus. Nat Neurosci 21, 985–995 (2018). https://doi.org/10.1038/s41593-018-0172-7
21. Wiera G, Mozrzymas JW. Extracellular proteolysis in structural and functional plasticity of mossy fiber synapses in hippocampus. Front Cell Neurosci. 2015;9:427. Published 2015 Nov 4. doi:10.3389/fncel.2015.00427
22. Fujise, K., Mishra, J., Rosenfeld, M.S. et al. Synaptic vesicle characterization of iPSC-derived dopaminergic neurons provides insight into distinct secretory vesicle pools. npj Parkinsons Dis. 11, 16 (2025). https://doi.org/10.1038/s41531-024-00862-4
23. Lee B, White KI, Socolich M, et al. Direct visualization of electric-field-stimulated ion conduction in a potassium channel. Cell. 2025;188(1):77-88.e15. doi:10.1016/j.cell.2024.12.006
24. Alonso, N., Krichmar, J.L. A sparse quantized hopfield network for online-continual memory. Nat Commun 15, 3722 (2024). https://doi.org/10.1038/s41467-024-46976-4
25. Predictive Sequence Learning in the Hippocampal Formation. Chen Y, Zhang H, Cameron M, Sejnowski T. bioRxiv 2022.05.19.492731; doi: https://doi.org/10.1101/2022.05.19.492731

26. Alonso, N., Krichmar, J.L. A sparse quantized hopfield network for online-continual memory. Nat Commun 15, 3722 (2024). https://doi.org/10.1038/s41467-024-46976-4
27. Insel N, Takehara-Nishiuchi K. The cortical structure of consolidated memory: a hypothesis on the role of the cingulate-entorhinal cortical connection. Neurobiol Learn Mem. 2013;106:343-350. doi:10.1016/j.nlm.2013.07.019
28. Woolnough O, Donos C, Rollo PS, et al. Spatiotemporal dynamics of orthographic and lexical processing in the ventral visual pathway. Nat Hum Behav. 2021;5(3):389-398. doi:10.1038/s41562-020-00982-w
29. Kong, X., Kong, R., Orban, C. et al. Sensory-motor cortices shape functional connectivity dynamics in the human brain. Nat Commun 12, 6373 (2021). https://doi.org/10.1038/s41467-021-26704-y
30. Nature news | Wi-Fi for neurons: first map of wireless nerve signals unveiled in worms: https://www.nature.com/articles/d41586-023-03619-w
31. Insanally, M.N., Albanna, B.F., Toth, J. *et al.* Contributions of cortical neuron firing patterns, synaptic connectivity, and plasticity to task performance. *Nat Commun* 15, 6023 (2024). https://doi.org/10.1038/s41467-024-49895-6
32. “Human Brain cellular composition (demythed)”: von Bartheld CS. Myths and truths about the cellular composition of the human brain: A review of influential concepts. J Chem Neuroanat. 2018 Nov;93:2-15. doi: 10.1016/j.jchemneu.2017.08.004. Epub 2017 Sep 2. PMID: 28873338; PMCID: PMC5834348.
33. “Measure the absorbance of Cas9 protein at 280 nm using a NanoDrop Lite spectrophotometer.” https://pmc.ncbi.nlm.nih.gov/articles/PMC9183966/
34. Stanley S. Biological nanoparticles and their influence on organisms. Curr Opin Biotechnol. 2014 Aug;28:69-74. doi: 10.1016/j.copbio.2013.11.014. Epub 2014 Jan 8. PMID: 24832077. https://www.sciencedirect.com/science/article/abs/pii/S0958166913007155
35. Kaposzta Z, Stylianou O, Mukli P, Eke A, Racz FS. Decreased connection density and modularity of functional brain networks during n-back working memory paradigm. Brain Behav. 2021 Jan;11(1):e01932. doi: 10.1002/brb3.1932. Epub 2020 Nov 13. PMID: 33185986; PMCID: PMC7821619.
36. Lynn, C.W., Holmes, C.M. & Palmer, S.E. Heavy-tailed neuronal connectivity arises from Hebbian self-organization. Nat. Phys. 20, 484–491 (2024). https://doi.org/10.1038/s41567-023-02332-9
37. Wheeler, M., Smith, C., Ottolini, M. et al. Genetically targeted magnetic control of the nervous system. Nat Neurosci 19, 756–761 (2016). https://doi.org/10.1038/nn.4265
38. Ferritin nanocages: A biological platform for drug delivery, imaging and theranostics in cancer
39. Recent progress in targeted delivery vectors based on biomimetic nanoparticles | Signal Transduction and Targeted Therapy, https://www.nature.com/articles/s41392-021-00631-2
40. Wheeler, M., Smith, C., Ottolini, M. *et al.* Genetically targeted magnetic control of the nervous system. *Nat Neurosci* 19, 756–761 (2016). https://doi.org/10.1038/nn.4265
41. Tomasi D, Volkow ND. Functional connectivity density mapping. *Proc Natl Acad Sci U S A*. 2010;107(21):9885-9890. doi:10.1073/pnas.1001414107

42. Micrometer figure: https://pubmed.ncbi.nlm.nih.gov/38723085/#&gid=article-figures&pid=figure-5-uid-4
43. Yang W, Yuste R. Brain maps at the nanoscale. *Nat Biotechnol*. 2019;37(4):378-380. doi:10.1038/s41587-019-0078-2
44. In Situ Nanoscale Redox Mapping Using Tip-Enhanced Raman Spectroscopy., Kang G, Yang M, Mattei MS, Schatz GC, Van Duyne RP., Nano Lett. 2019 Mar 13;19(3):2106-2113. doi: 10.1021/acs.nanolett.9b00313. Epub 2019 Feb 19., PMID: 30763517
45. Nanoscale friction and wear maps., Tambe NS, Bhushan B., Philos Trans A Math Phys Eng Sci. 2008 Apr 28;366(1869):1405-24. doi: 10.1098/rsta.2007.2165., PMID: 18156128
46. In situ nanoscale mapping of the chemical composition of surfaces and 3D nanostructures by photoelectron spectromicroscopy., Ratto F, Heun S, Moutanabbir O, Rosei F., Nanotechnology. 2008 Jul 2;19(26):265703. doi: 10.1088/0957-4484/19/26/265703. Epub 2008 May 20., PMID: 21828691
47. Global order and local disorder in brain maps., Rothschild G, Mizrahi A., Annu Rev Neurosci. 2015 Jul 8;38:247-68. doi: 10.1146/annurev-neuro-071013-014038. Epub 2015 Apr 9., PMID: 25897872 Review.
48. Self-organizing maps for internal representations., Ritter H., Psychol Res. 1990;52(2-3):128-36. doi: 10.1007/BF00877520., PMID: 2281125 Review.
49. Borah BJ, Sun CK. A rapid denoised contrast enhancement method digitally mimicking an adaptive illumination in submicron-resolution neuronal imaging. *iScience*. 2022;25(2):103773. Published 2022 Jan 15. doi:10.1016/j.isci.2022.103773
50. Hancock, F., Rosas, F.E., Luppi, A.I. *et al.* Metastability demystified — the foundational past, the pragmatic present and the promising future. *Nat. Rev. Neurosci.* 26, 82–100 (2025). https://doi.org/10.1038/s41583-024-00883-1
51. Liu, J., Jiang, C., Yu, Q. *et al.* Multidimensional free shape-morphing flexible neuromorphic devices with regulation at arbitrary points. *Nat Commun* 16, 756 (2025). https://doi.org/10.1038/s41467-024-55670-4