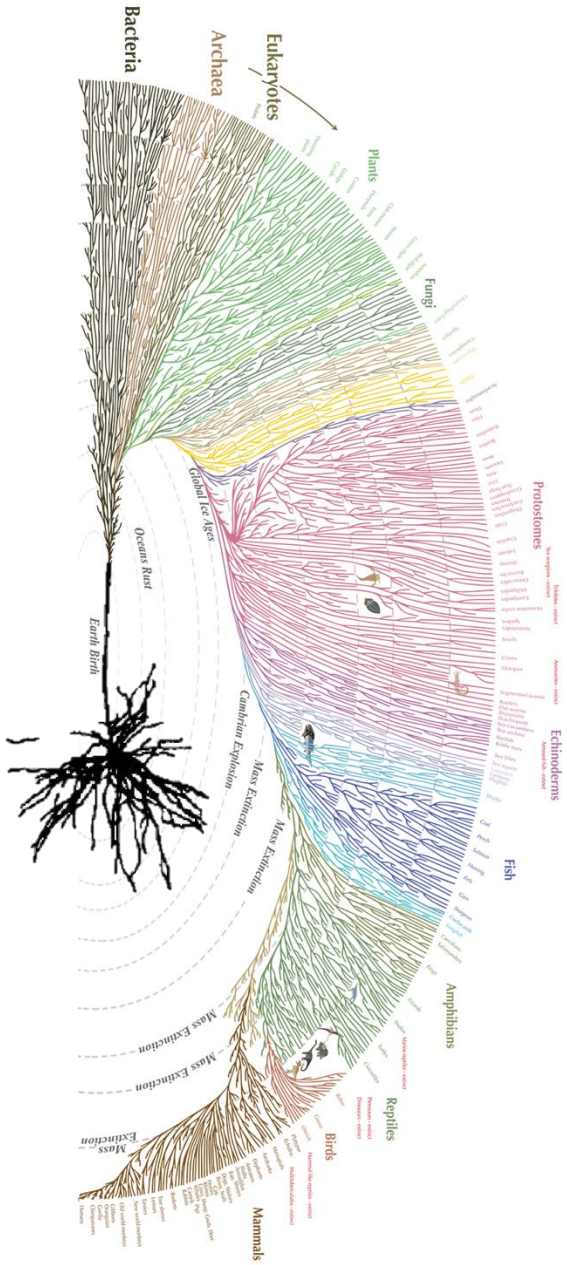
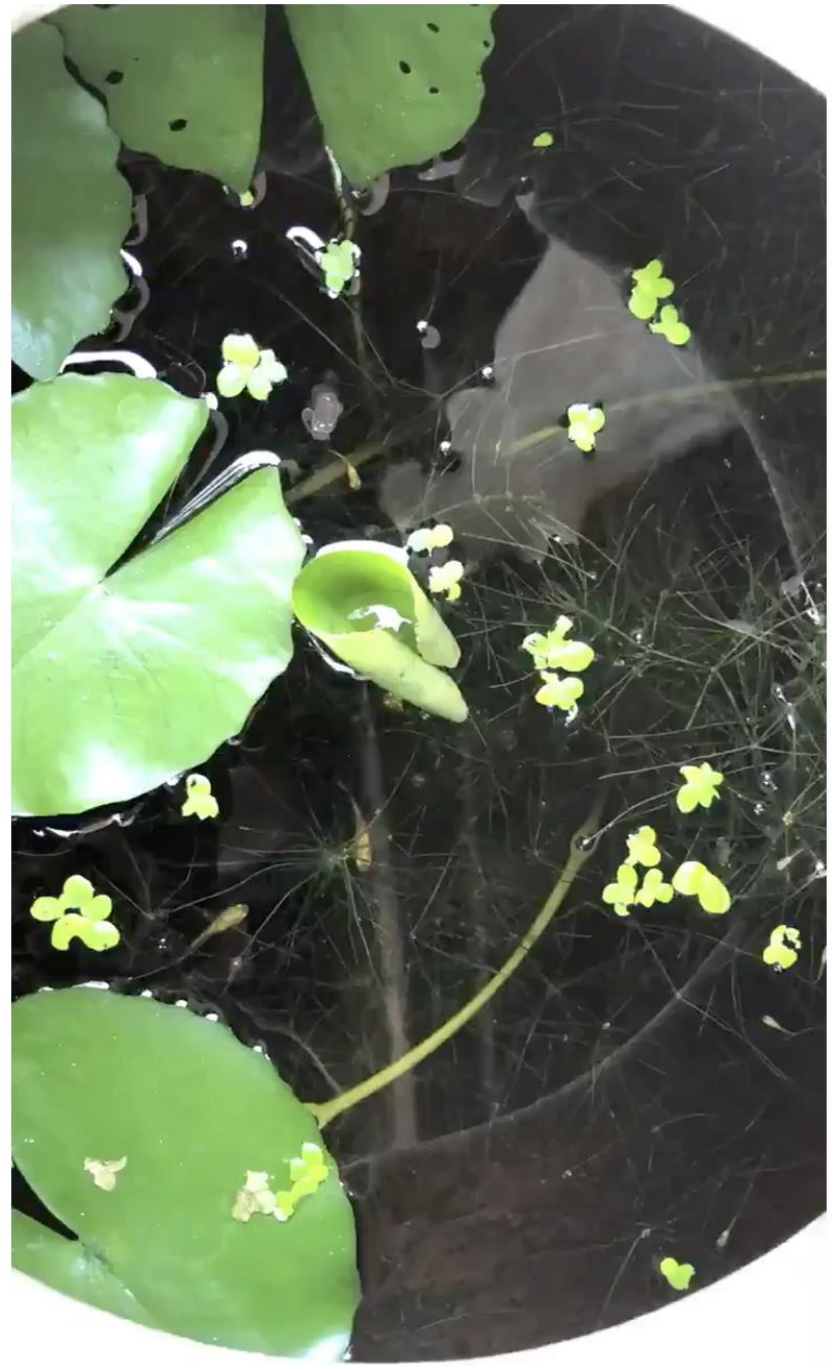
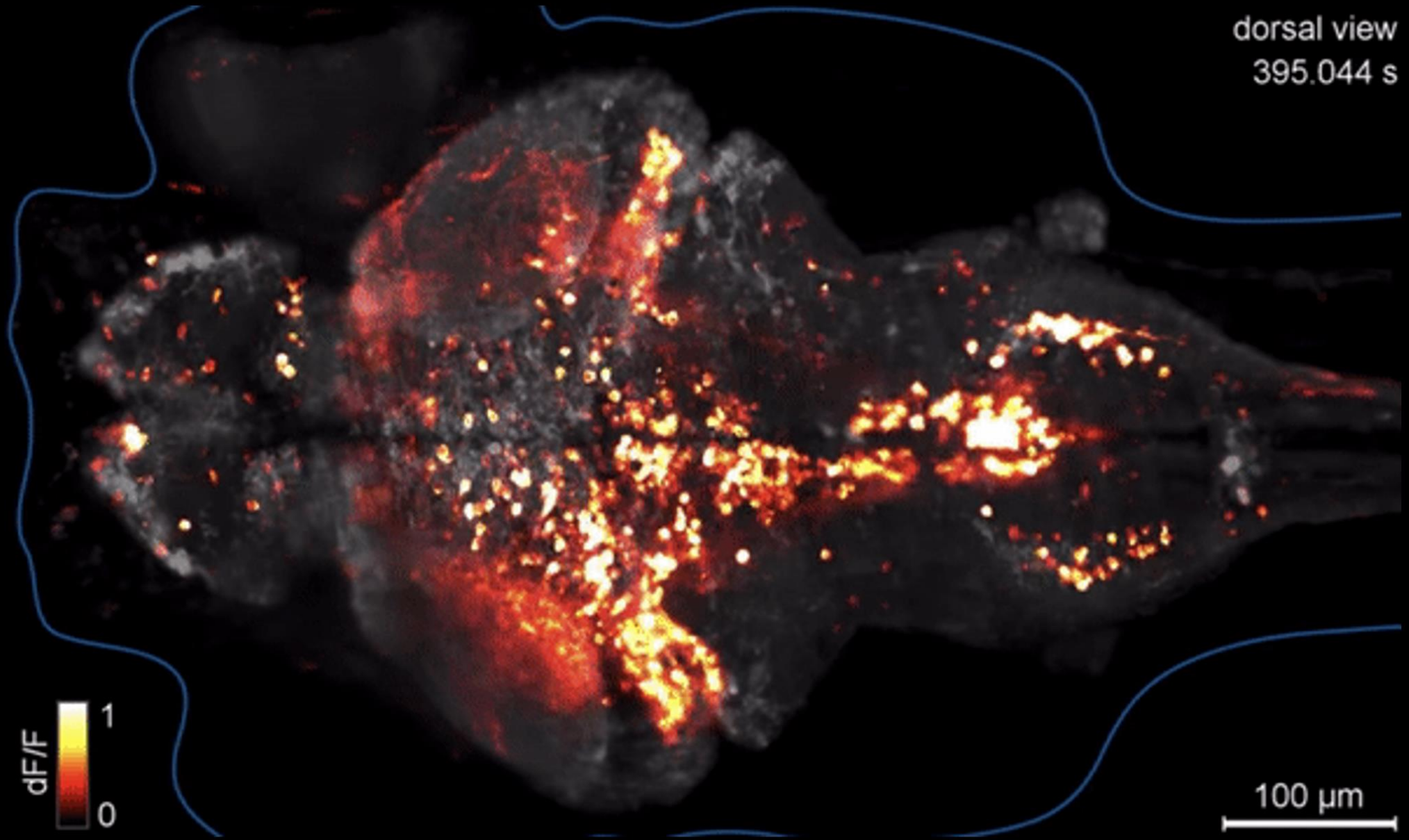


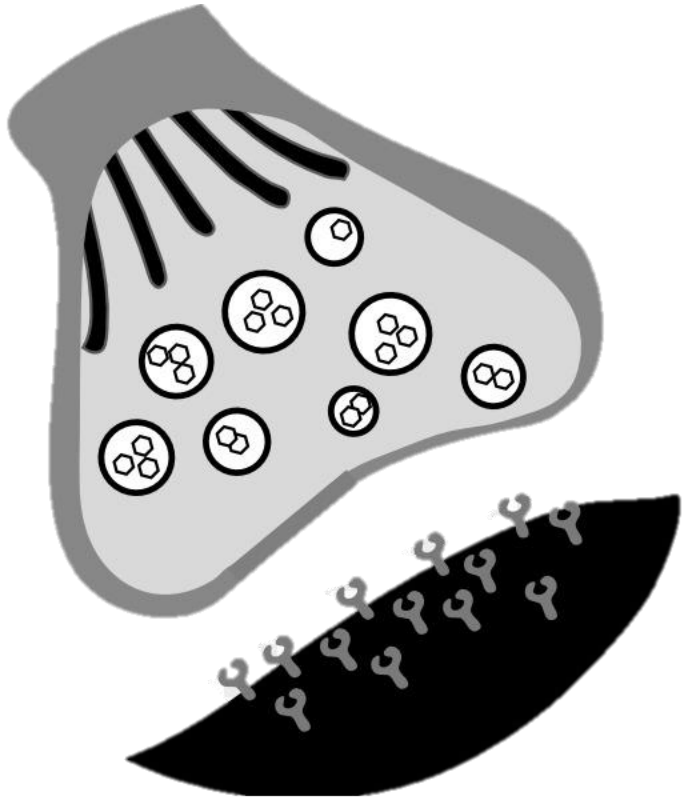
Multiscale Organization of Neuronal Activity Unifies Scale-Dependent Theories of Brain Function

Professor James 'Mac' Shine
University of Sydney, Australia

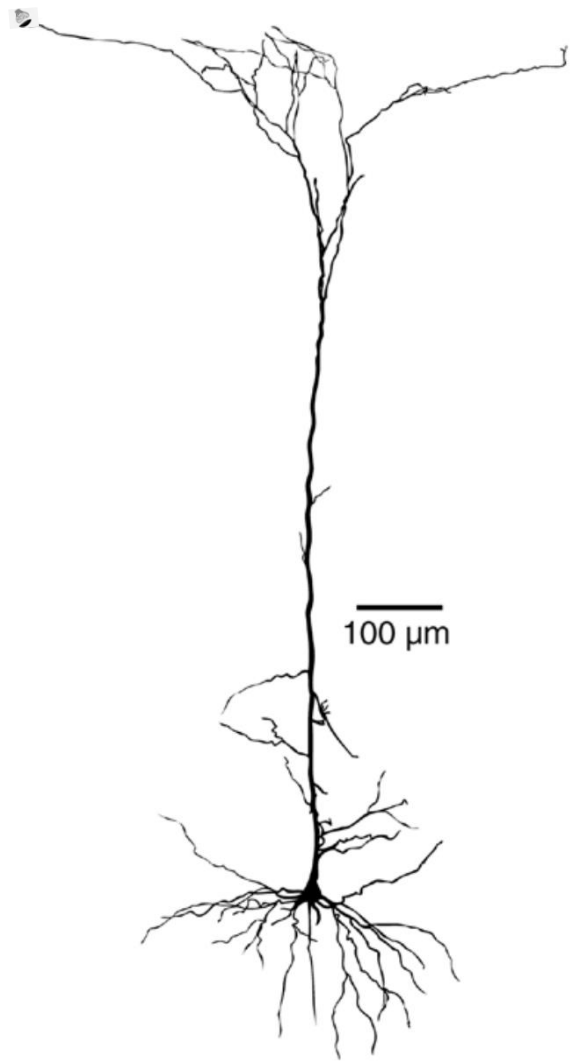
Tues 18th February
FoPM Symposium

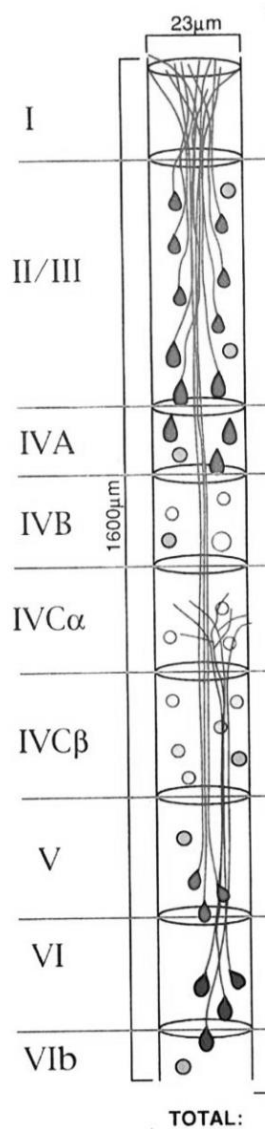



dorsal view
395.044 s
dF/F
1
0
100 µm

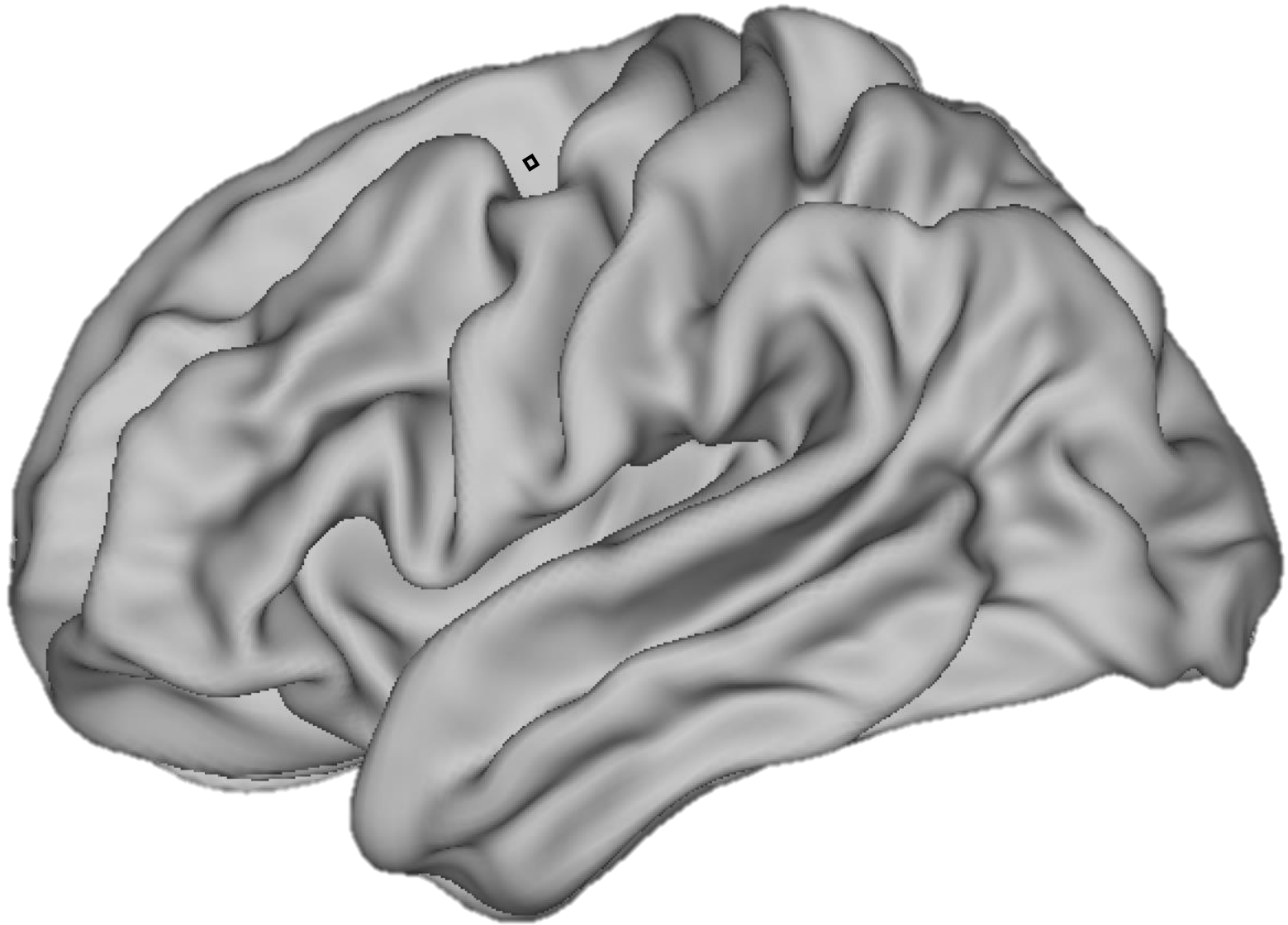


50 µm

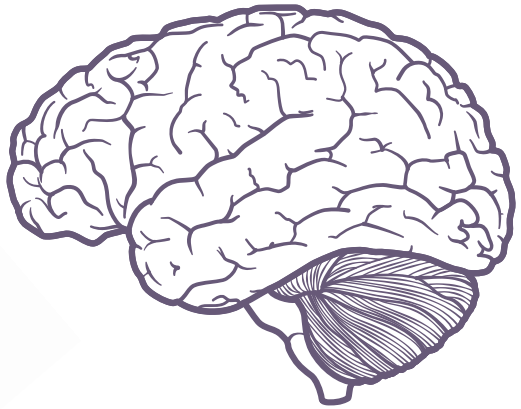

100 µm

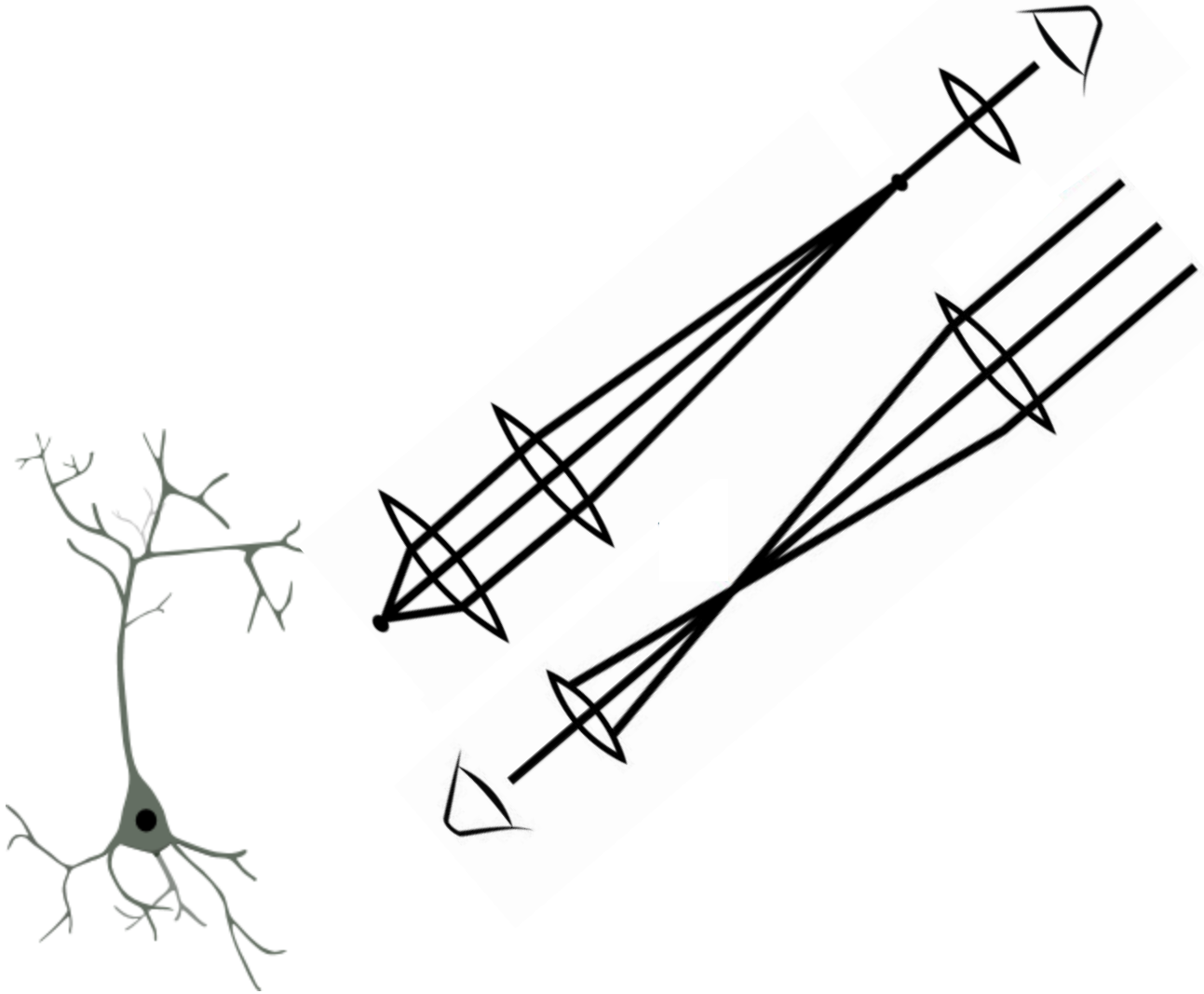


Mountcastle, 1997 *Brain*



Pick a scale…





Brain function

microscale

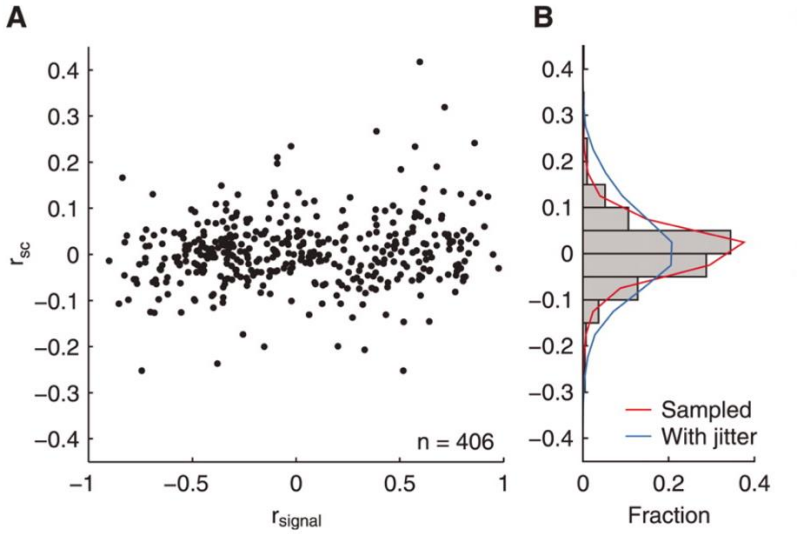
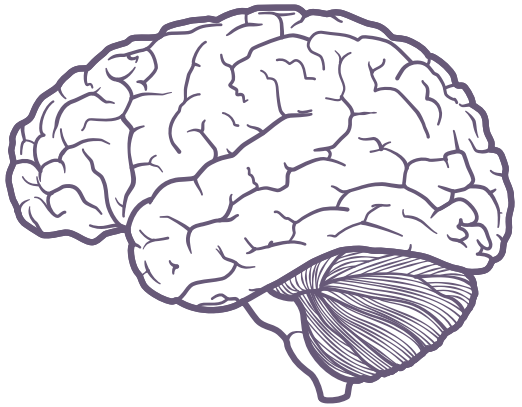
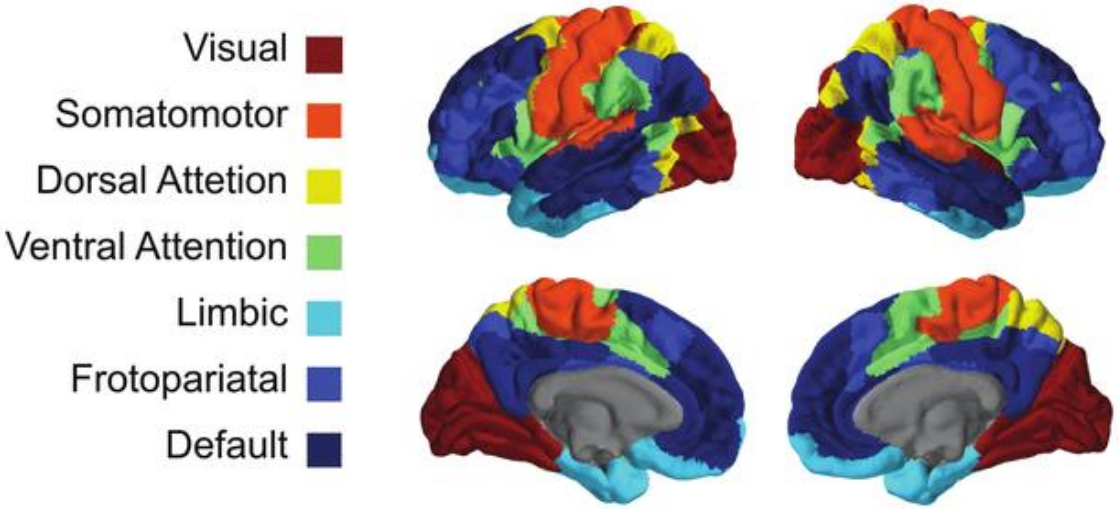


Fig. 2 Spike count correlations of pairs of neurons recorded by the same tetrc
and r_{sc} for all pairs of nearby neurons (both neurons recorded by the same te
(mean ± SEM = 0.005 ± 0.004). Colored lines are distributions obtained by ge

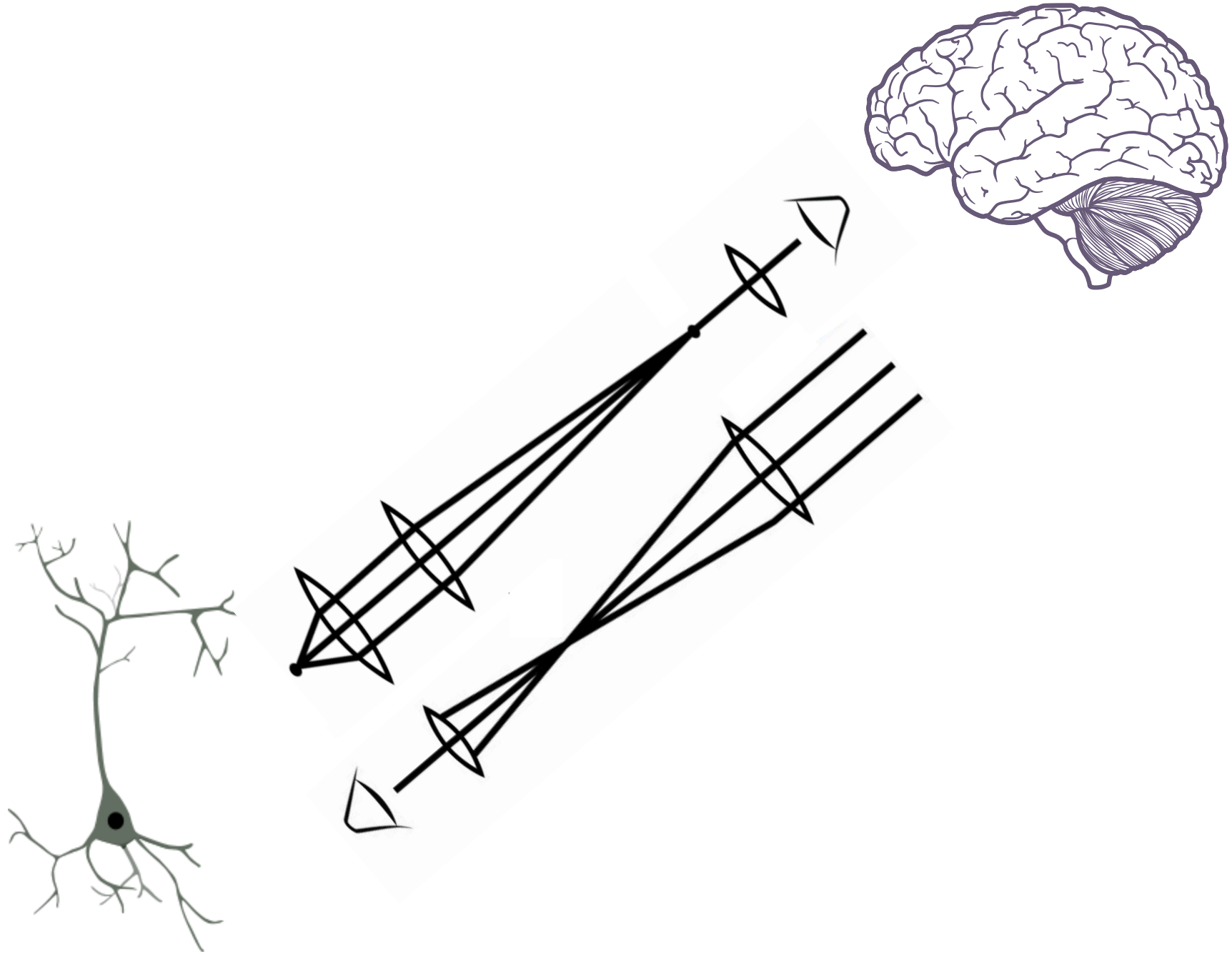
Ecker et al., 2010 *Science*

macroscale





Yeo et al., 2011 *J Neurophysiol.*



Coarse-graining in Physics

Atomic interactions

$$P = \frac{RT}{V-b} - \frac{a}{V^2}$$

→

Fluid dynamics

$$\rho \frac{D\mathbf{u}}{Dt} = -\nabla p + \nabla \cdot \boldsymbol{\tau} + \rho \mathbf{g}$$

Cell

CellPress

Article

Multiscale organization of neuronal activity unifies scale-dependent theories of brain function

Brandon R. Munn,[1,2,8,*] Eli J. Müller,[1,2] Itia Favre-Bulle,[3,4] Ethan Scott,[5] Joseph T. Lizier,[2,6] Michael Breakspear,[7] and James M. Shine[1]

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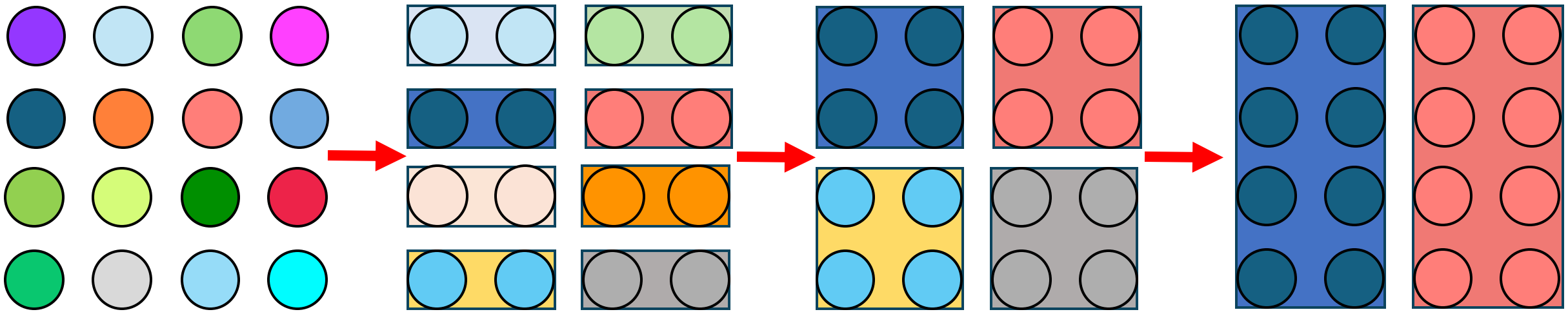
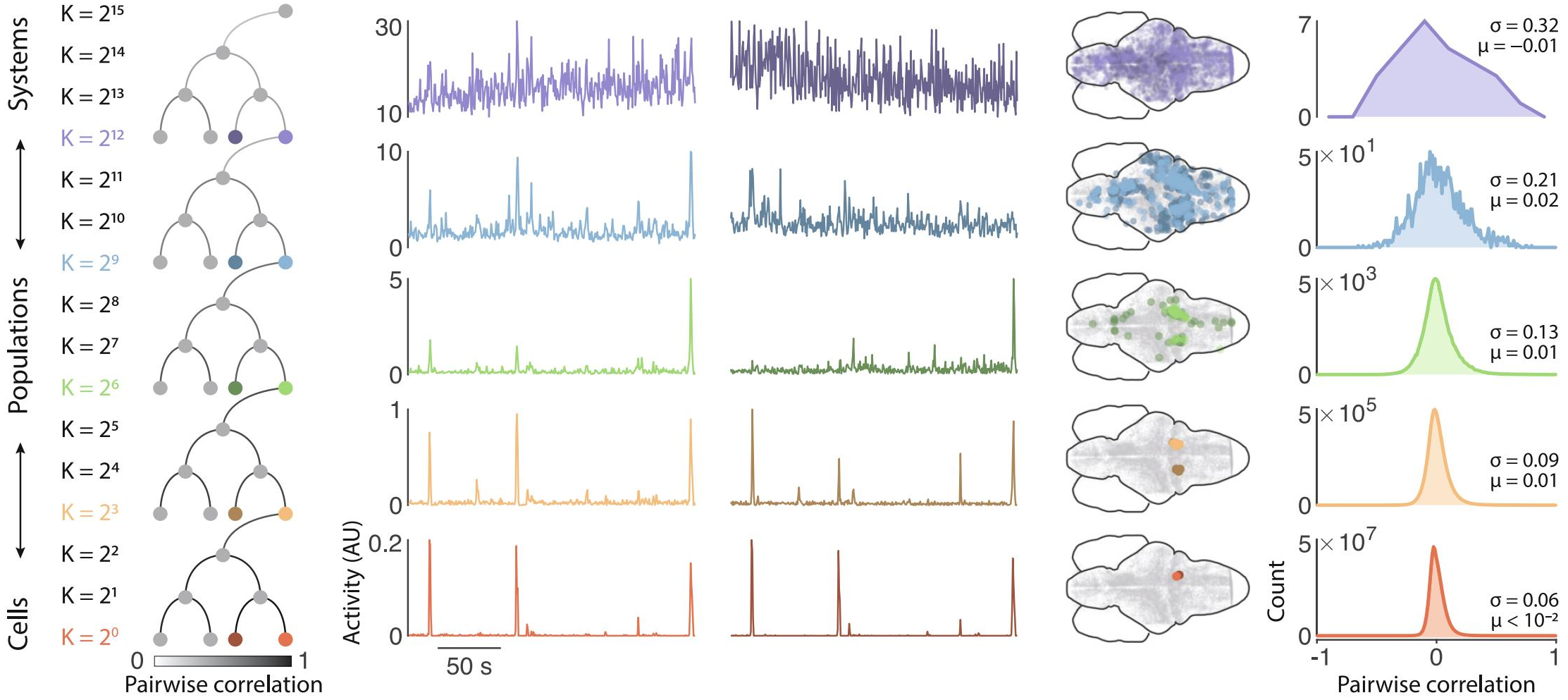
[8]Lead contact
*Correspondence: brandon.munn@sydney.edu.au
https://doi.org/10.1016/j.cell.2024.10.004

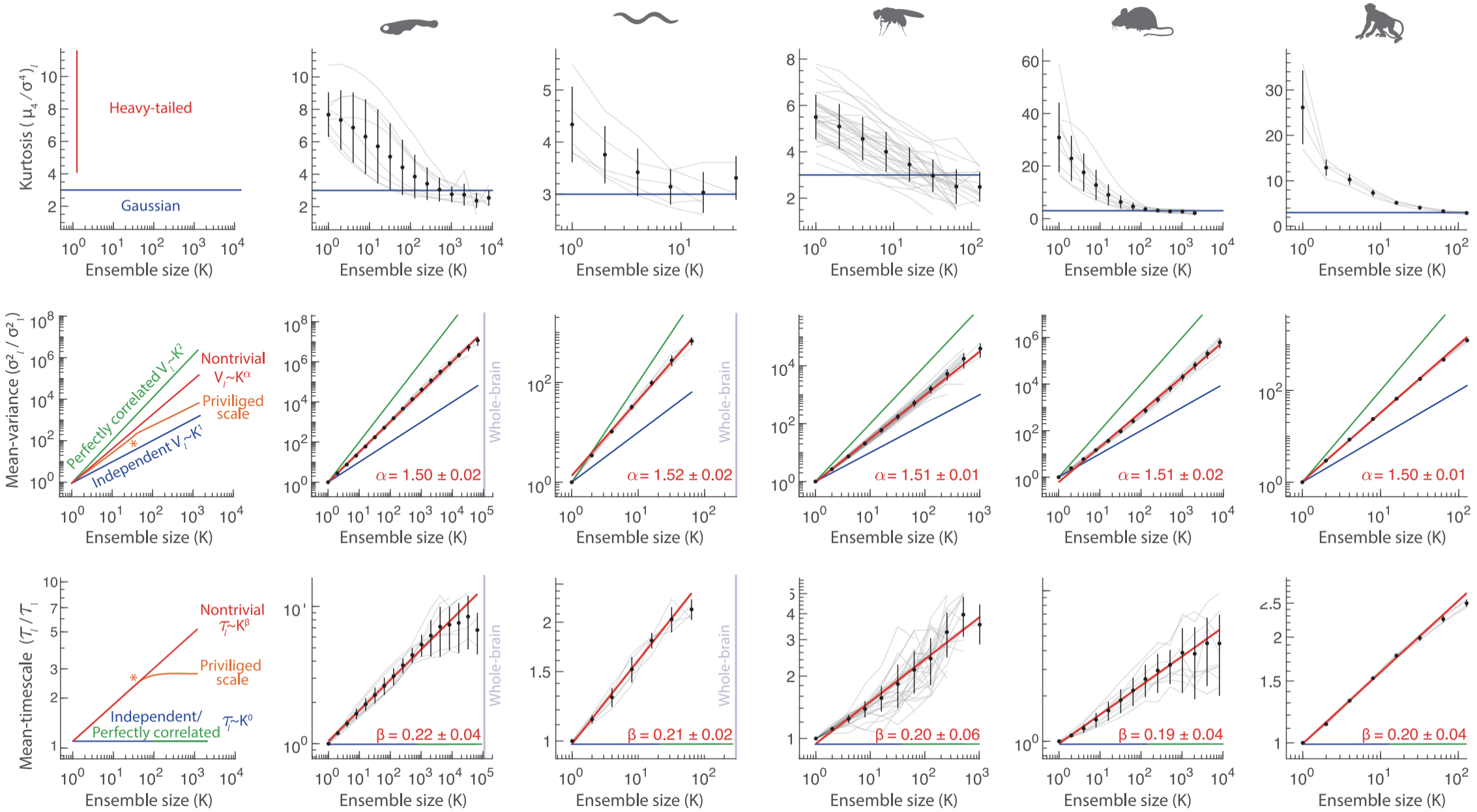
Coarse-graining



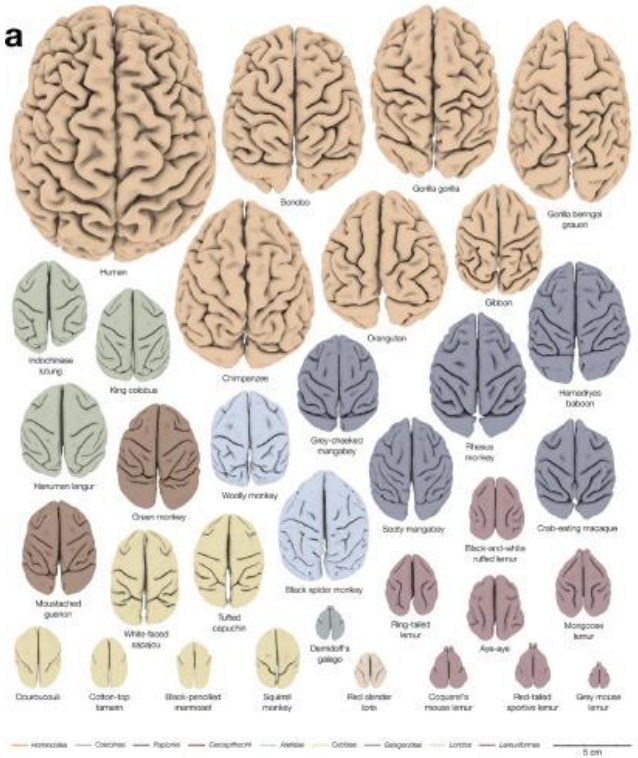
The Importance of Crossing Scales

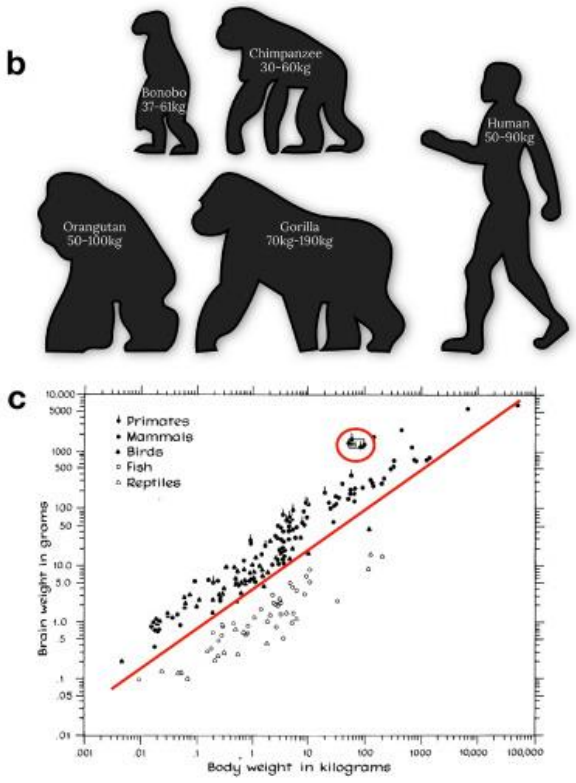


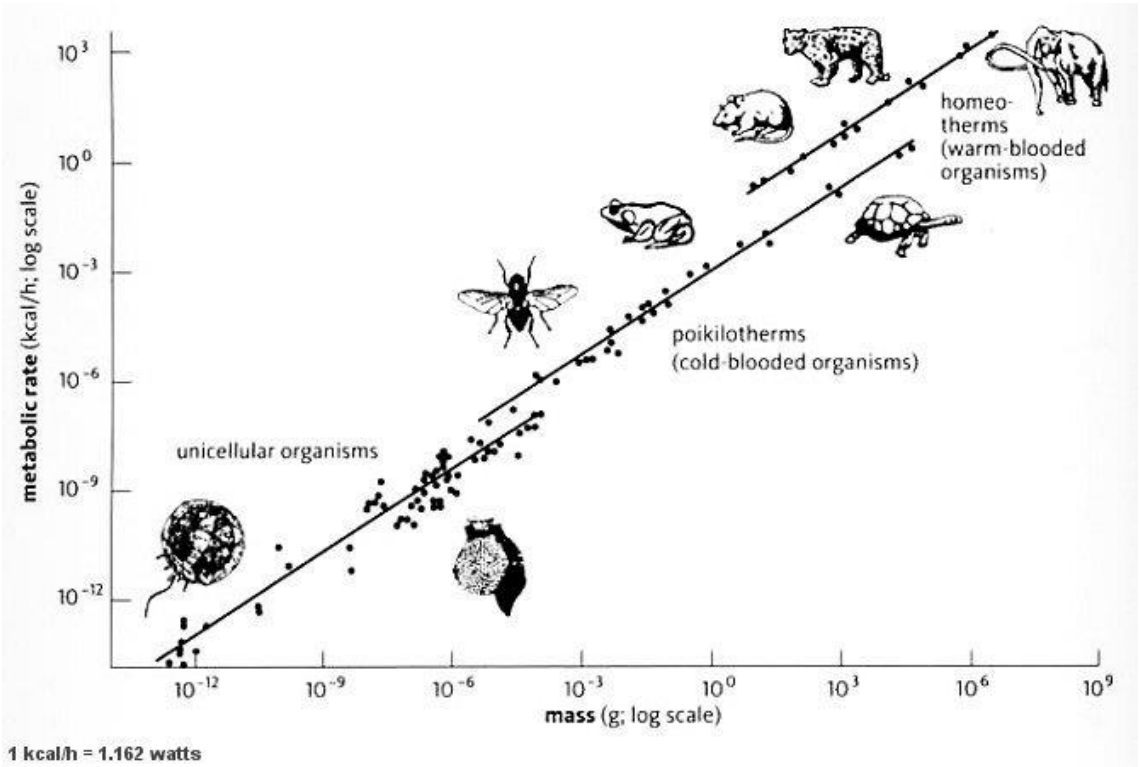
Scale-Independent Signatures



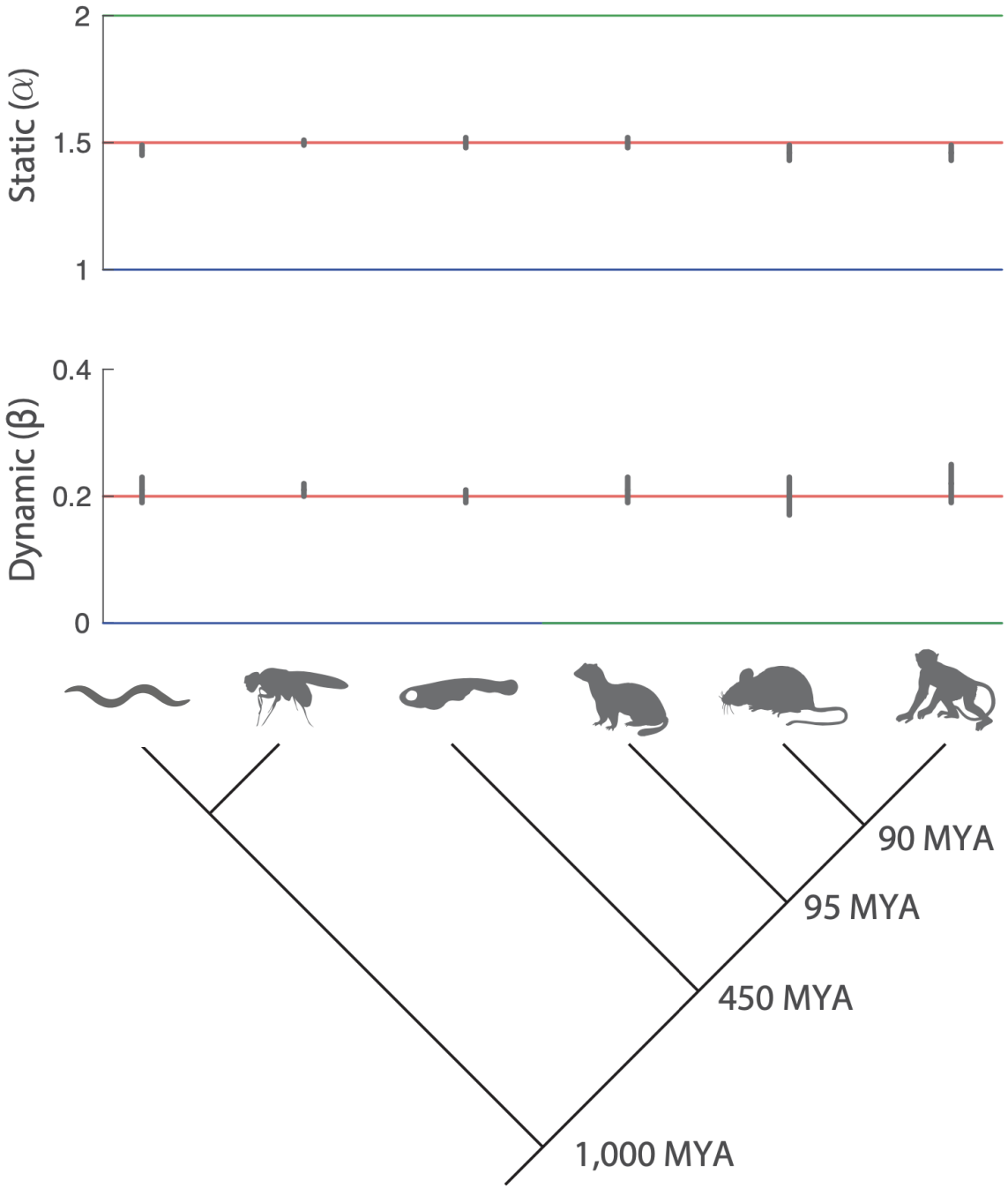
Scaling across phylogeny

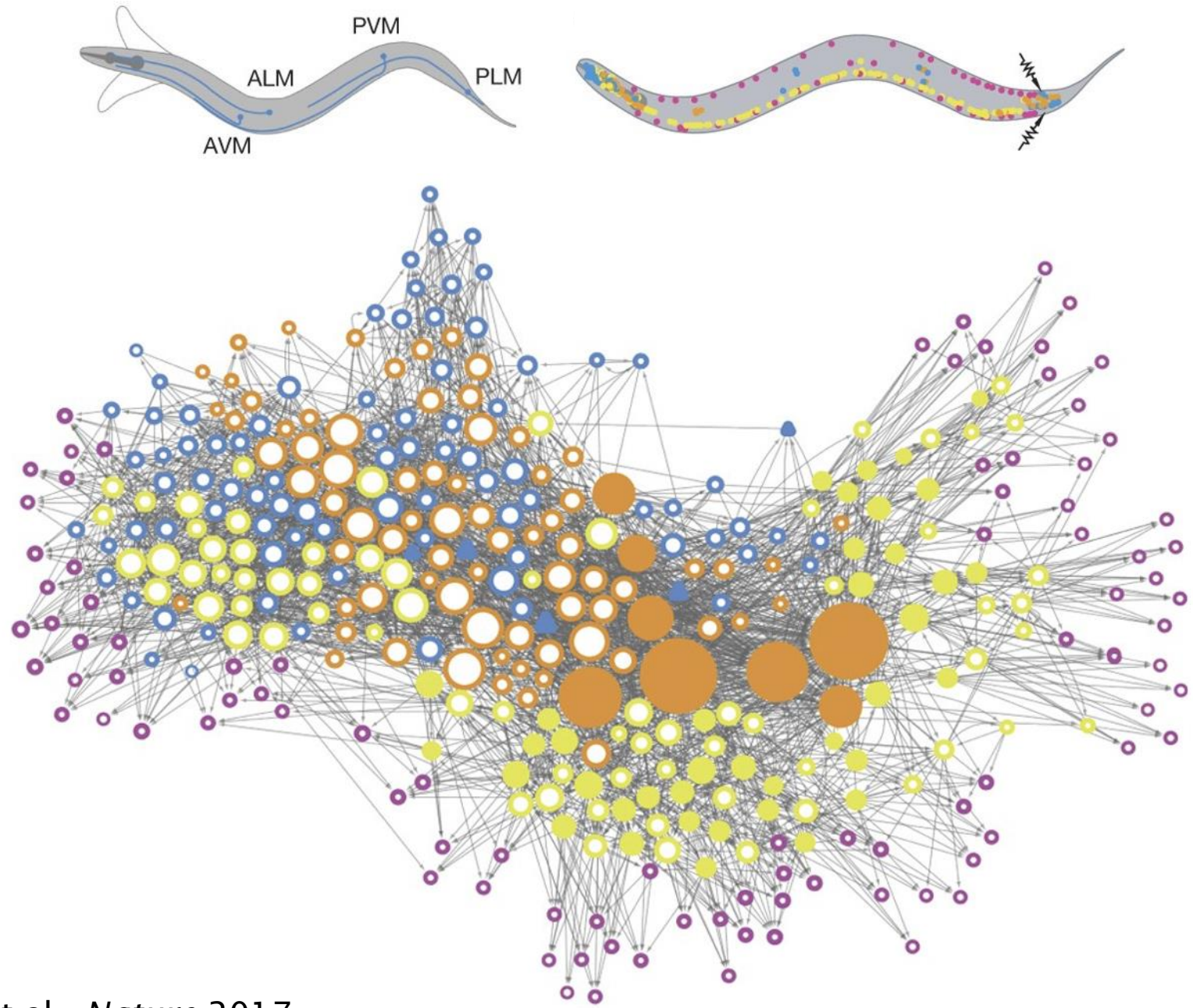


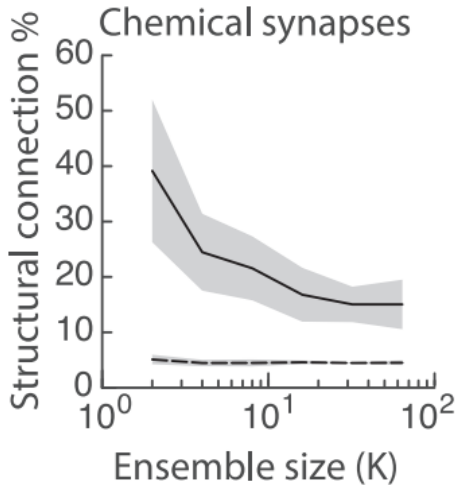


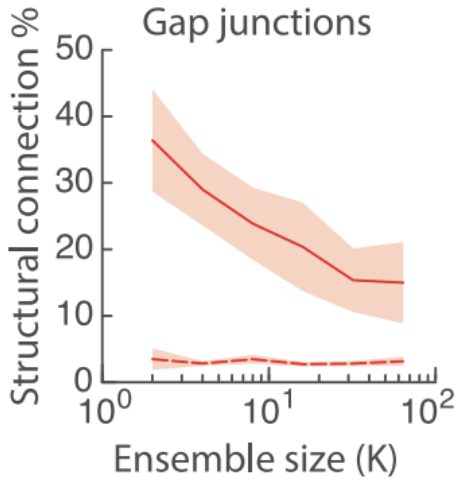


Pagel M. D., Harvey P. H. (1989) *Science*

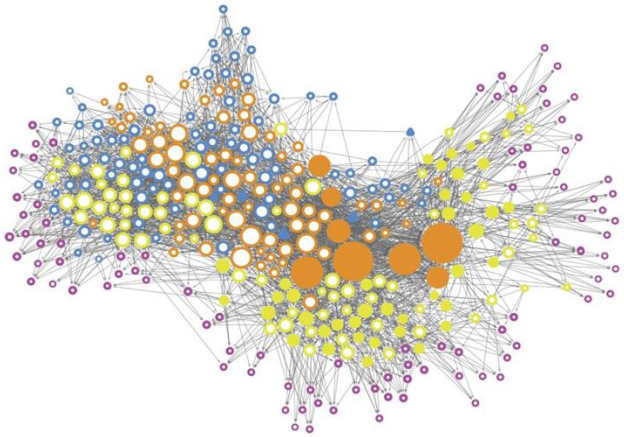

Static (α)
2
1.5
1
Dynamic (β)
0.4
0.2
0
90 MYA
95 MYA
450 MYA
1,000 MYA







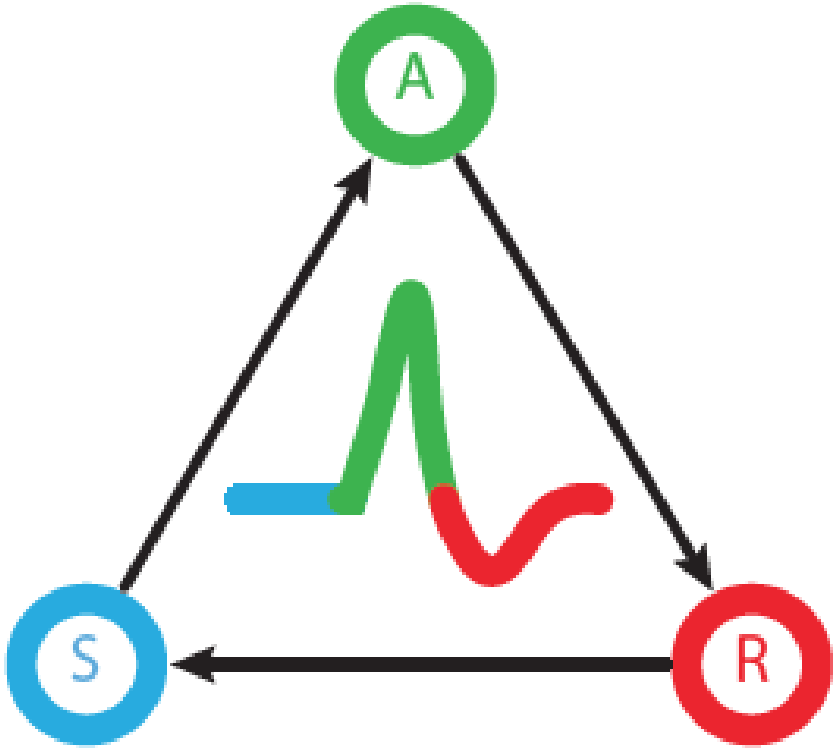
Yan et al., *Nature* 2017



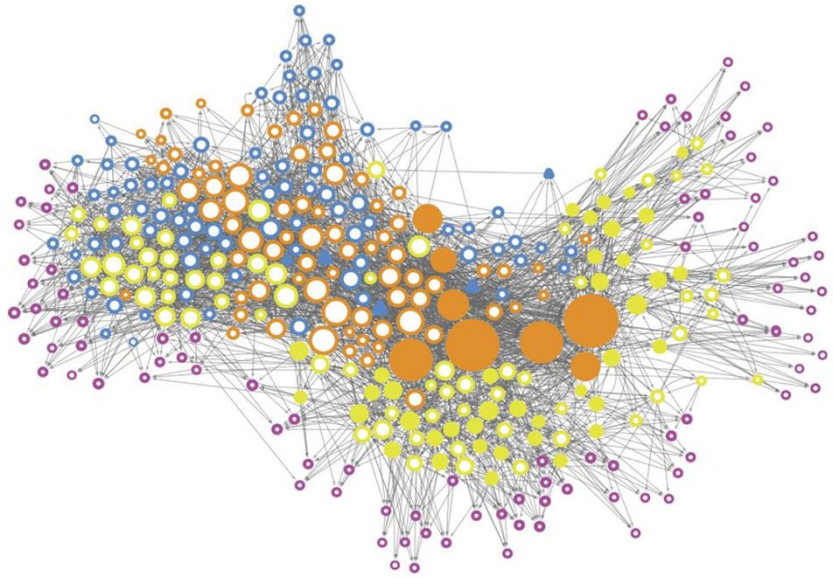
In Silico Test

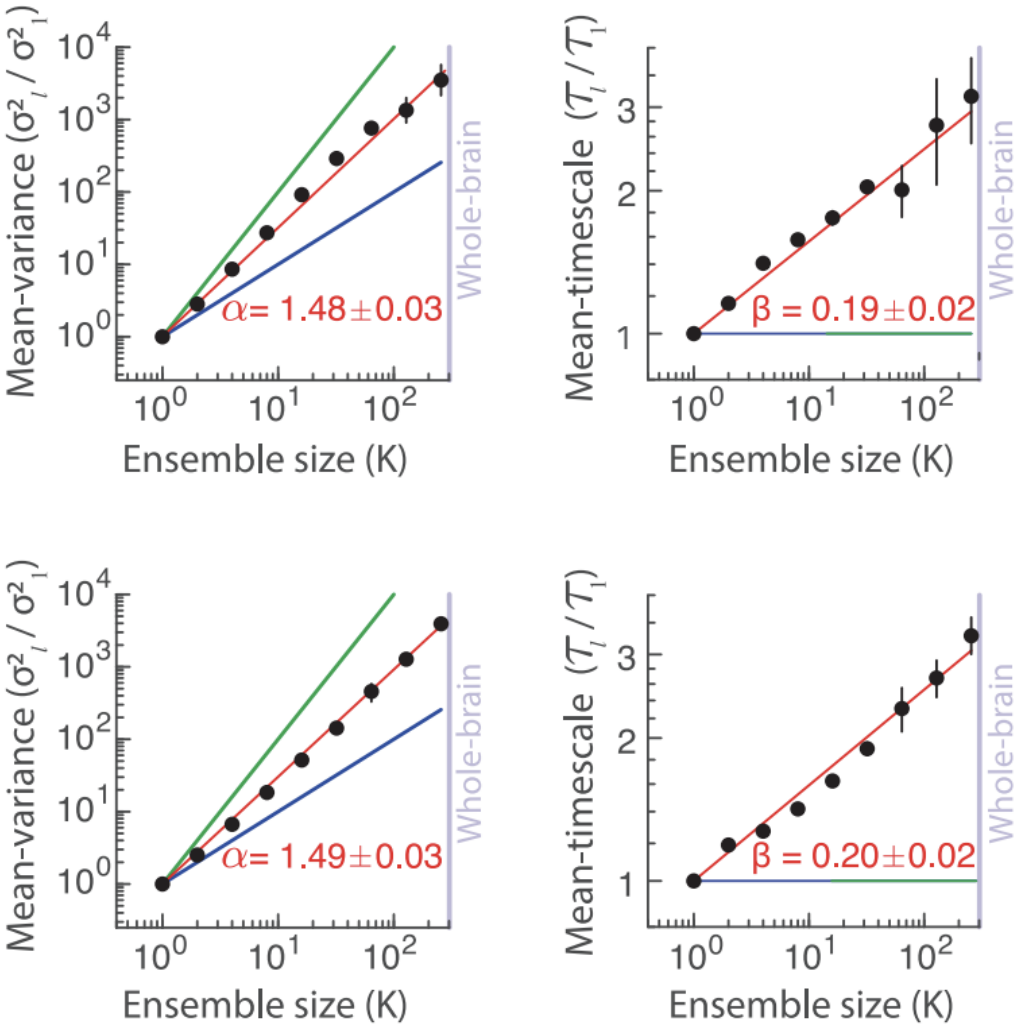
Eli
Müller

Michael
Breakspear



Simple SIR Model Recreates the Observed Scaling Relationships on the *C elegans* Connectome

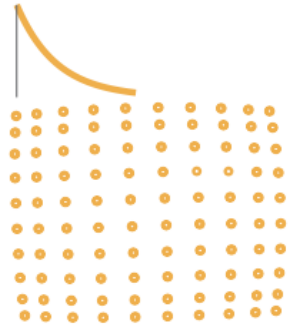




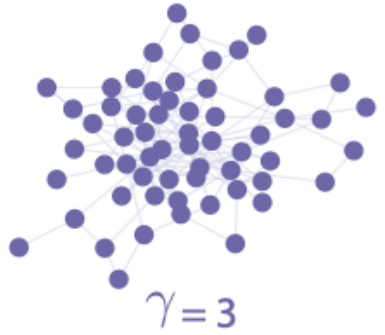
What Kind of Network Could Support This?

Modular

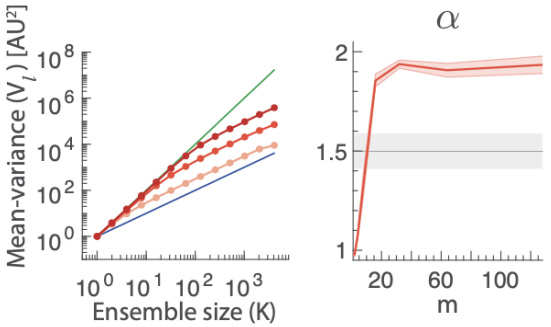
Small-world

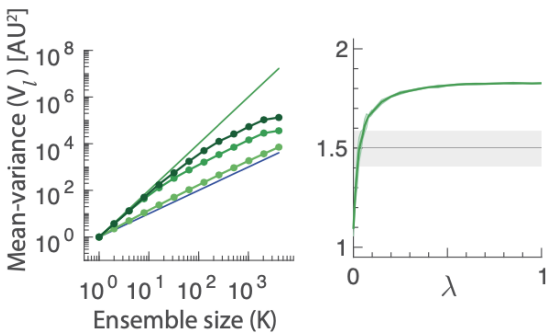


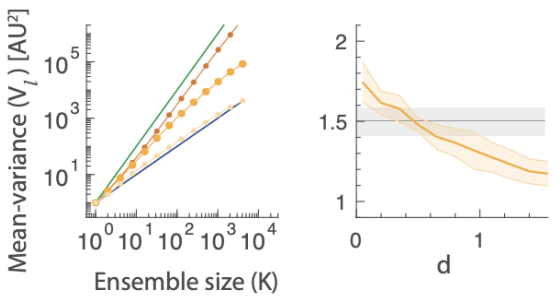
Exponential distance dependence

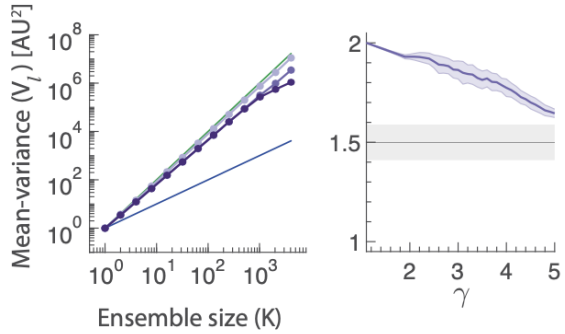


Scale-free degree distributed

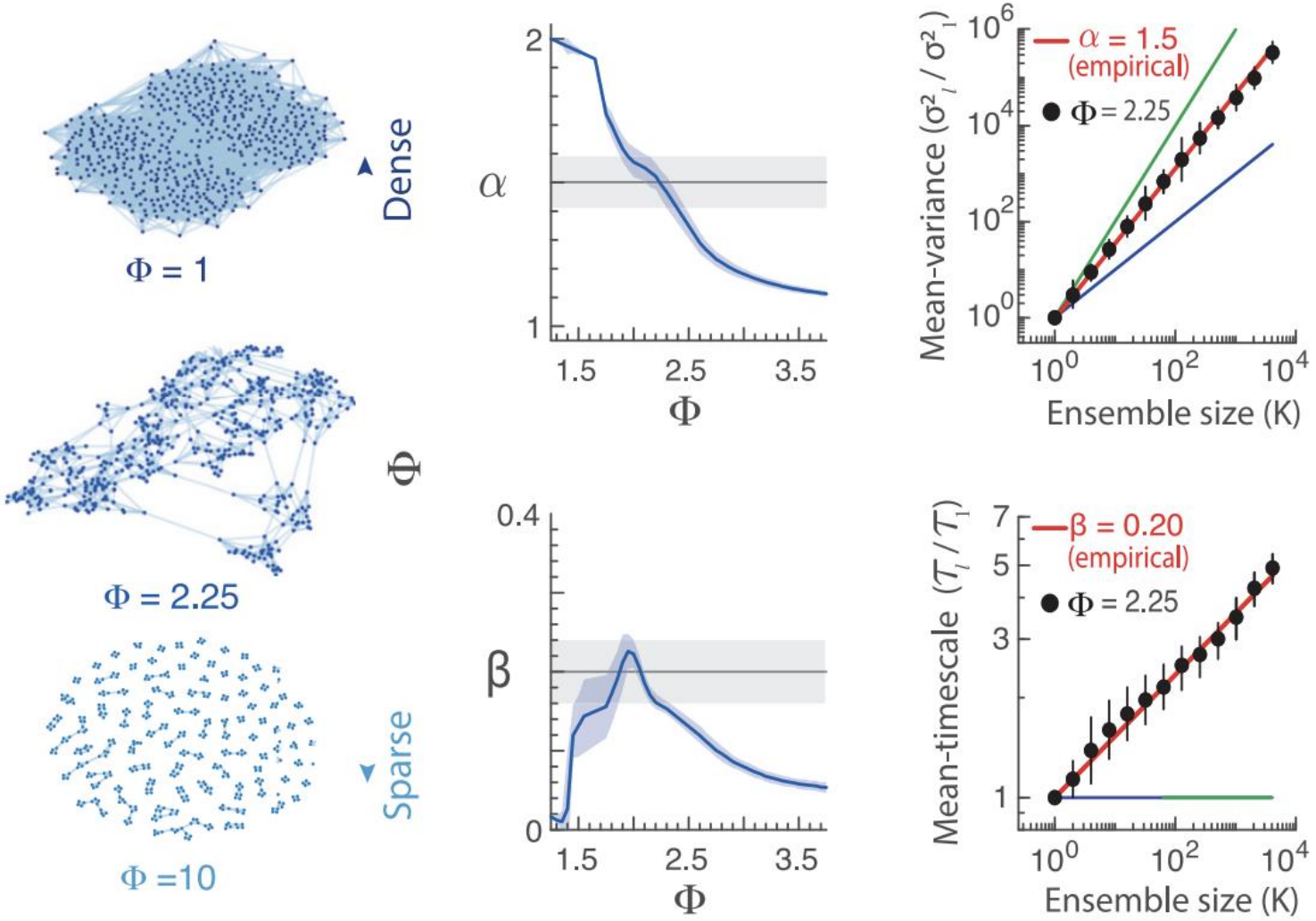




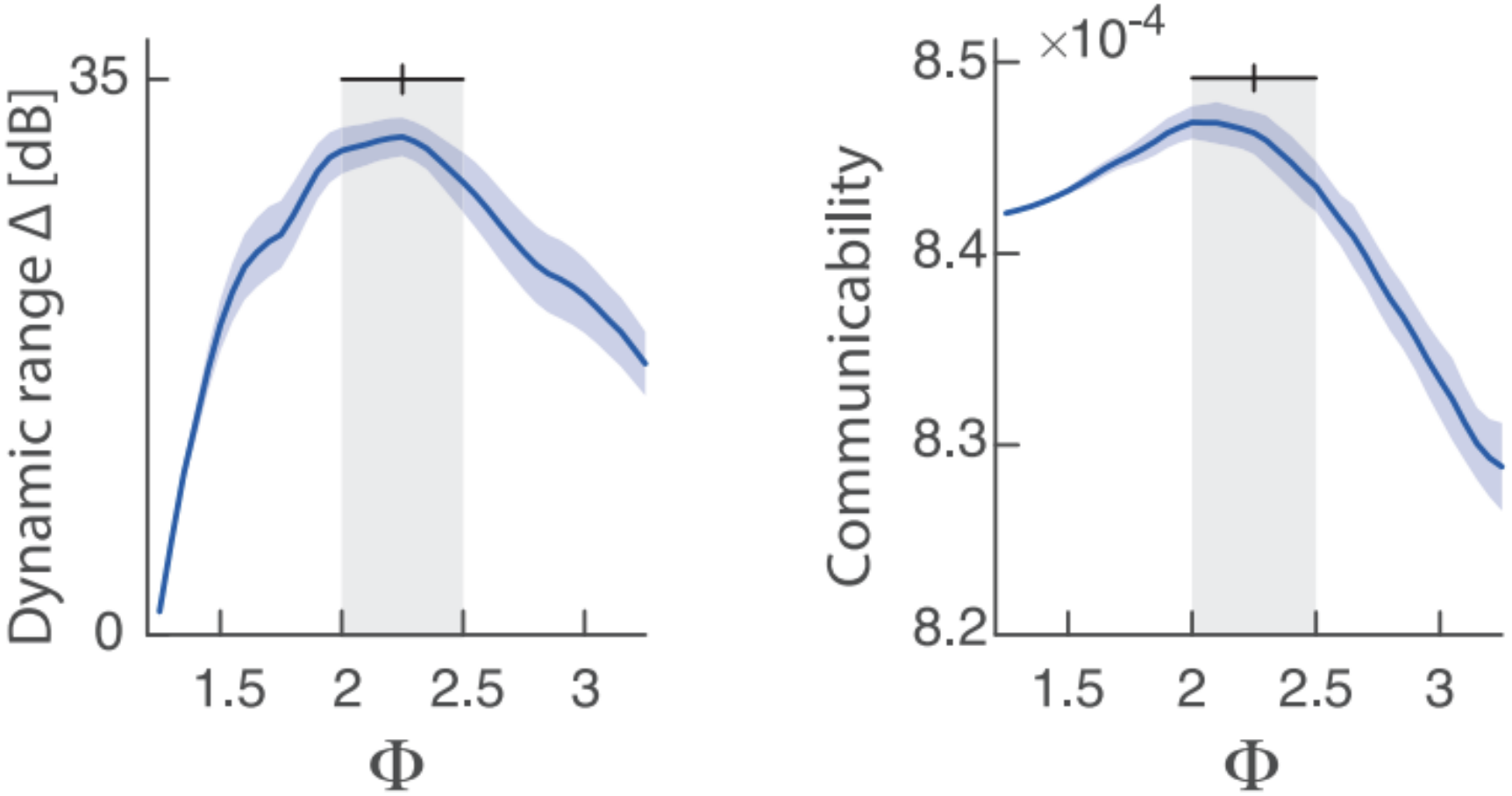




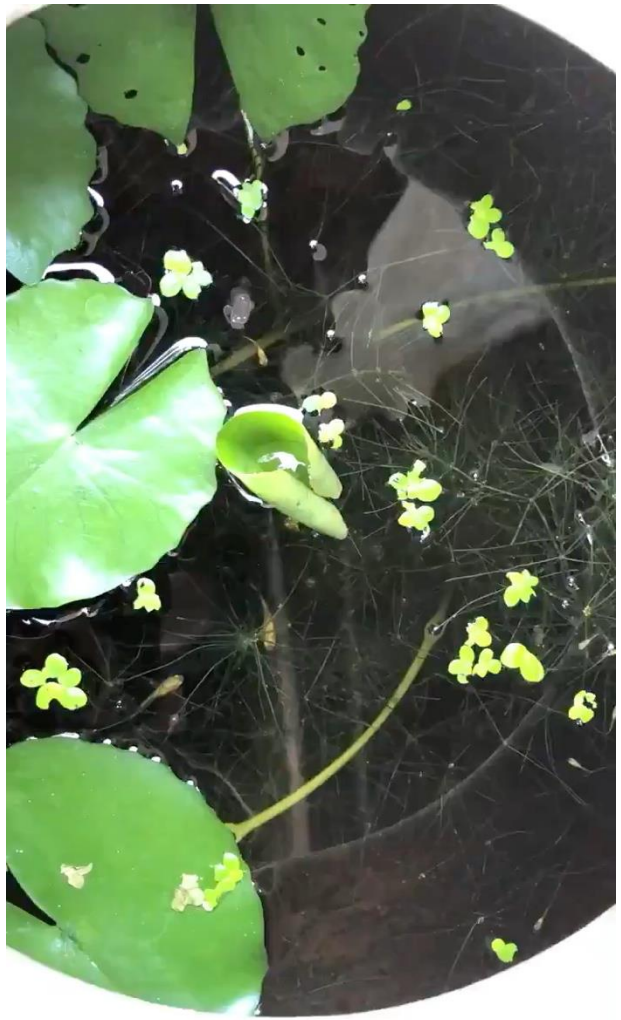
Hierarchical Modular Network Recreates the Same Scaling Relationship

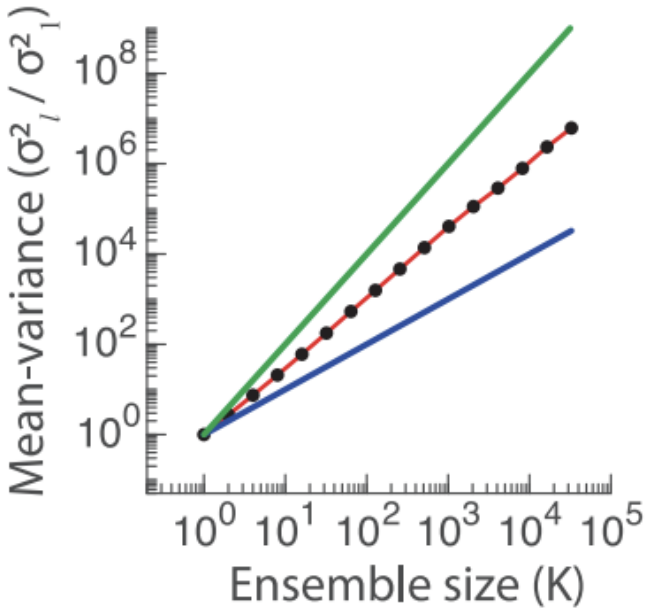


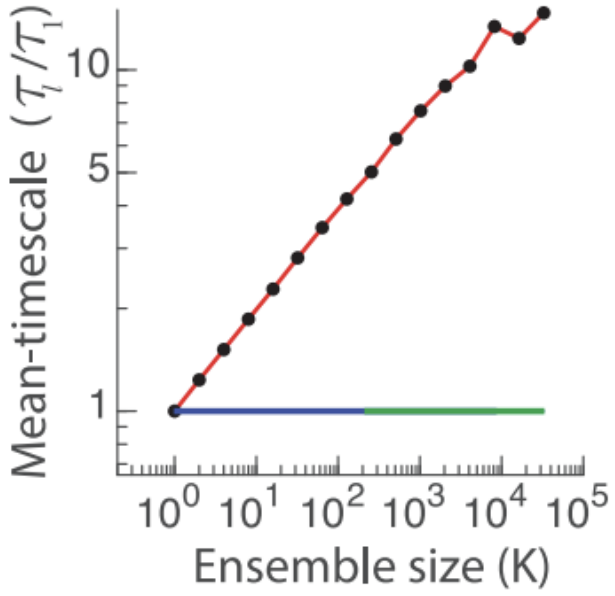
Optimal Information Processing Coincides with Model Parameters that Recreate Scaling



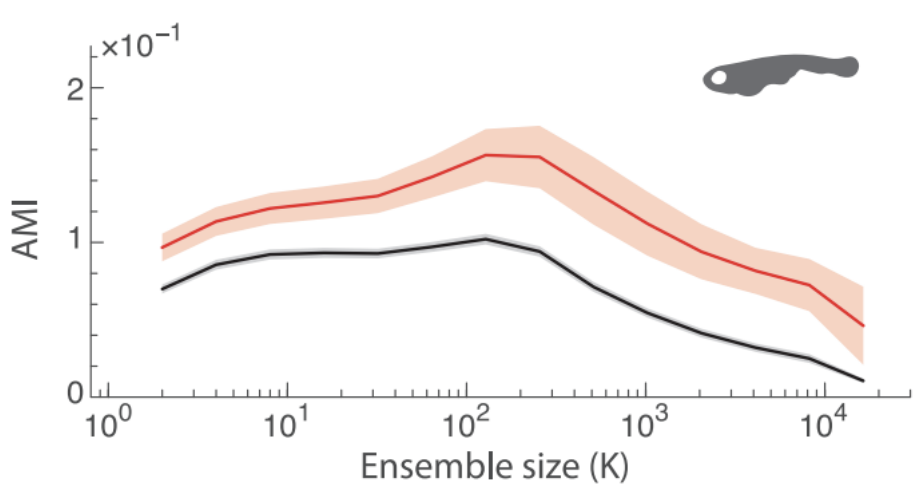
Scaling is Preserved Across Different Tasks

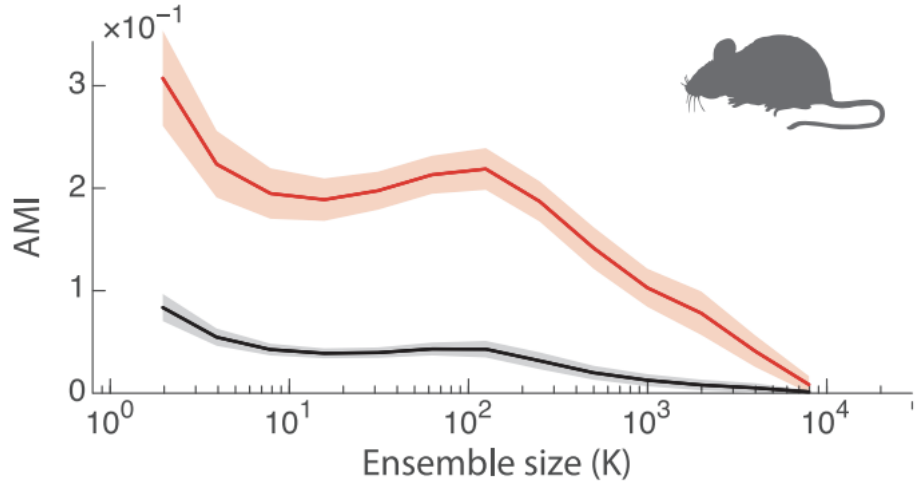


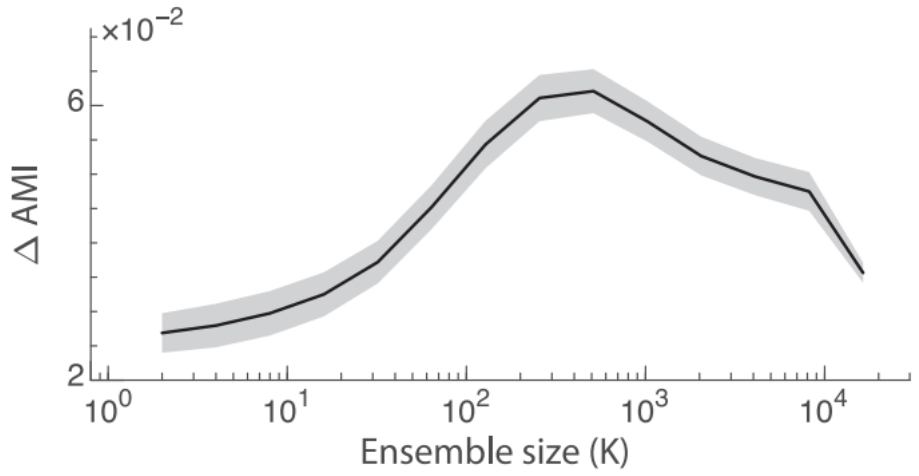


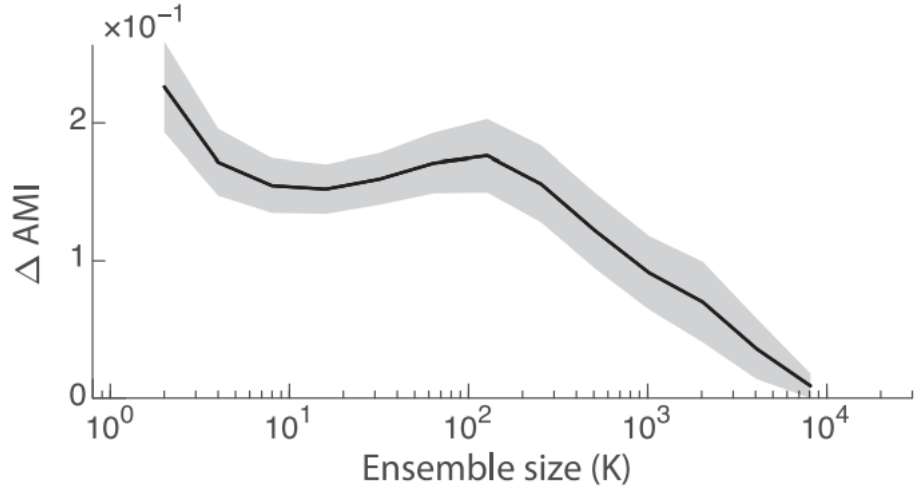


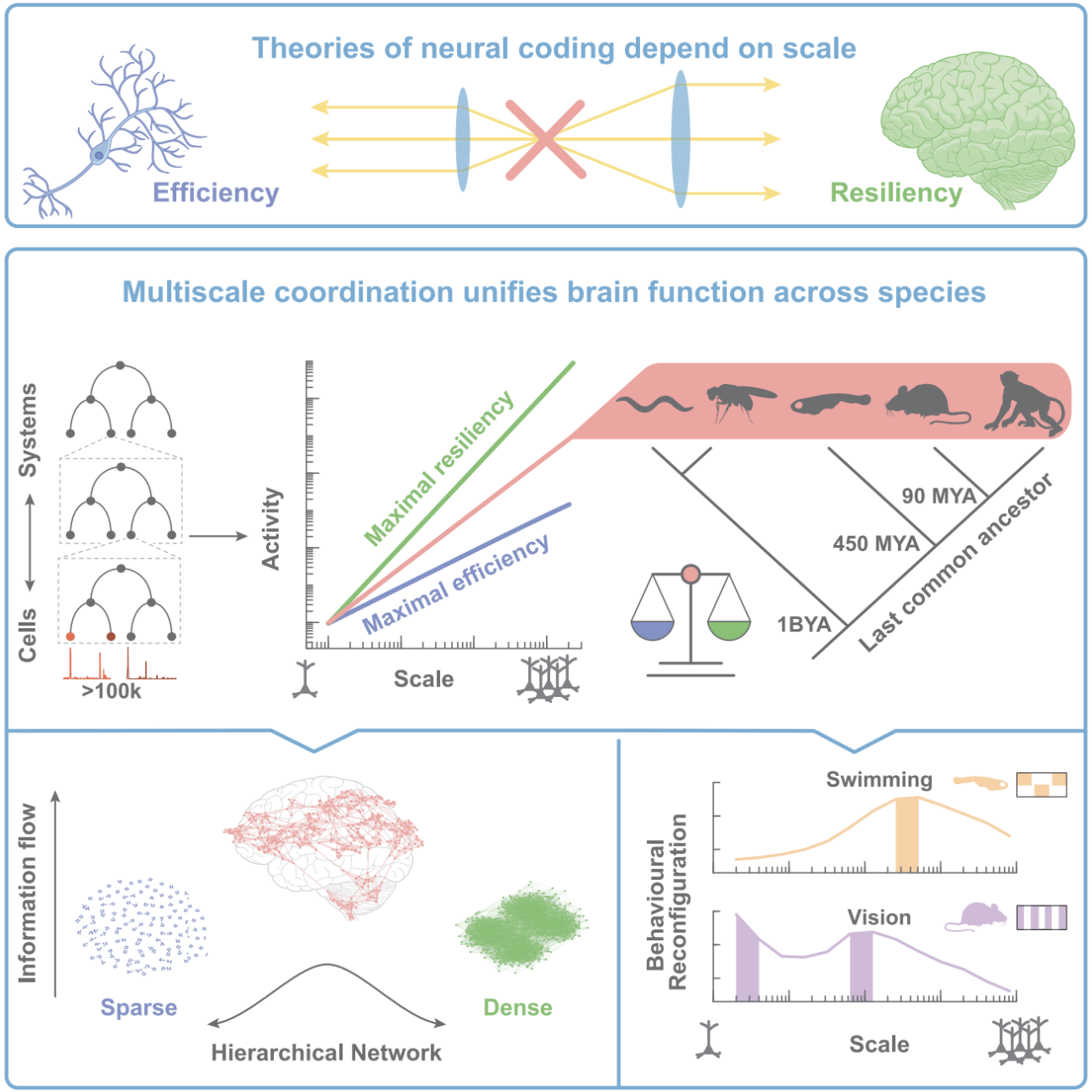
The Scale of Maximal Reconfiguration is not conserved across species



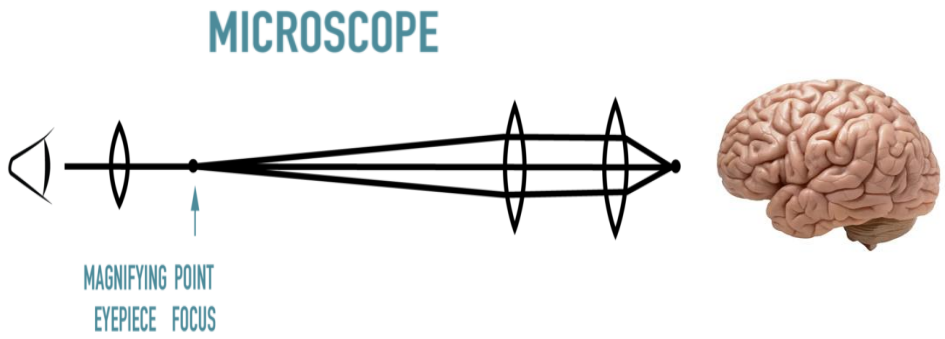


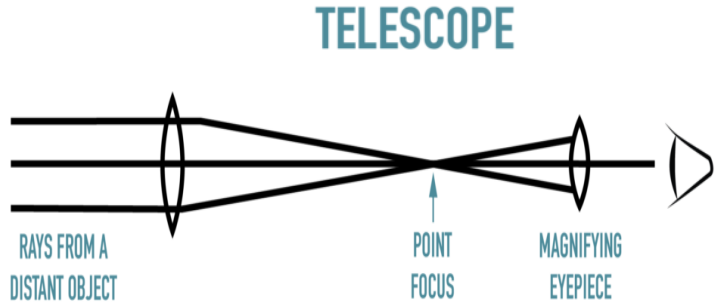


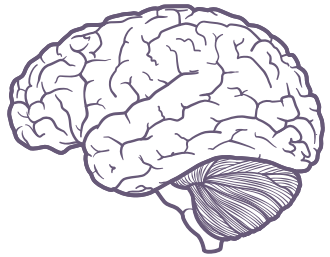


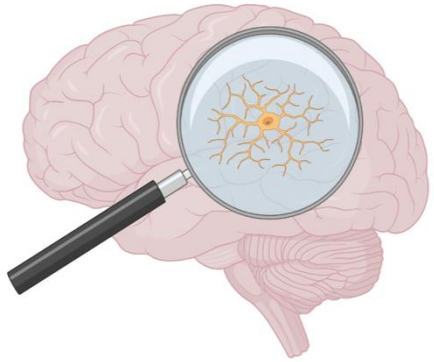

Theories of neural coding depend on scale
Efficiency
Resiliency
Multiscale coordination unifies brain function across species
Systems
Cells
>100k
Activity
Maximal resiliency
Maximal efficiency
Scale
90 MYA
450 MYA
1BYA
Last common ancestor
Information flow
Sparse
Dense
Hierarchical Network
Swimming
Vision
Behavioural Reconfiguration
Scale

The Importance of Crossing Scales

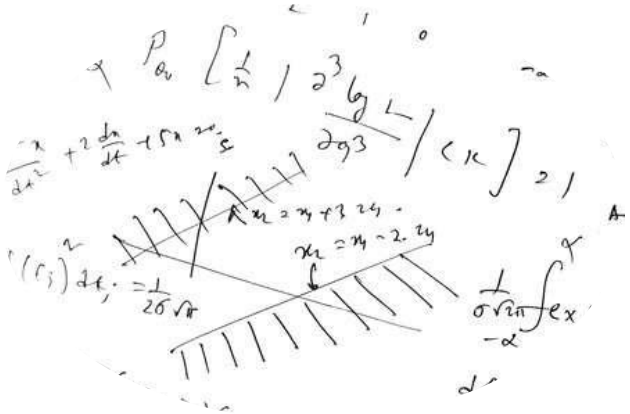








Functional Neurobiology



Computational Modeling

Functional Neuroimaging

Australian Government
National Health and Medical Research Council

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Australian Research Council

The Paper

The Team

Brandon Munn

Eli Müller

Michael Breakspear

Joseph Lizier

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Advancing Understanding of the Human Brain

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