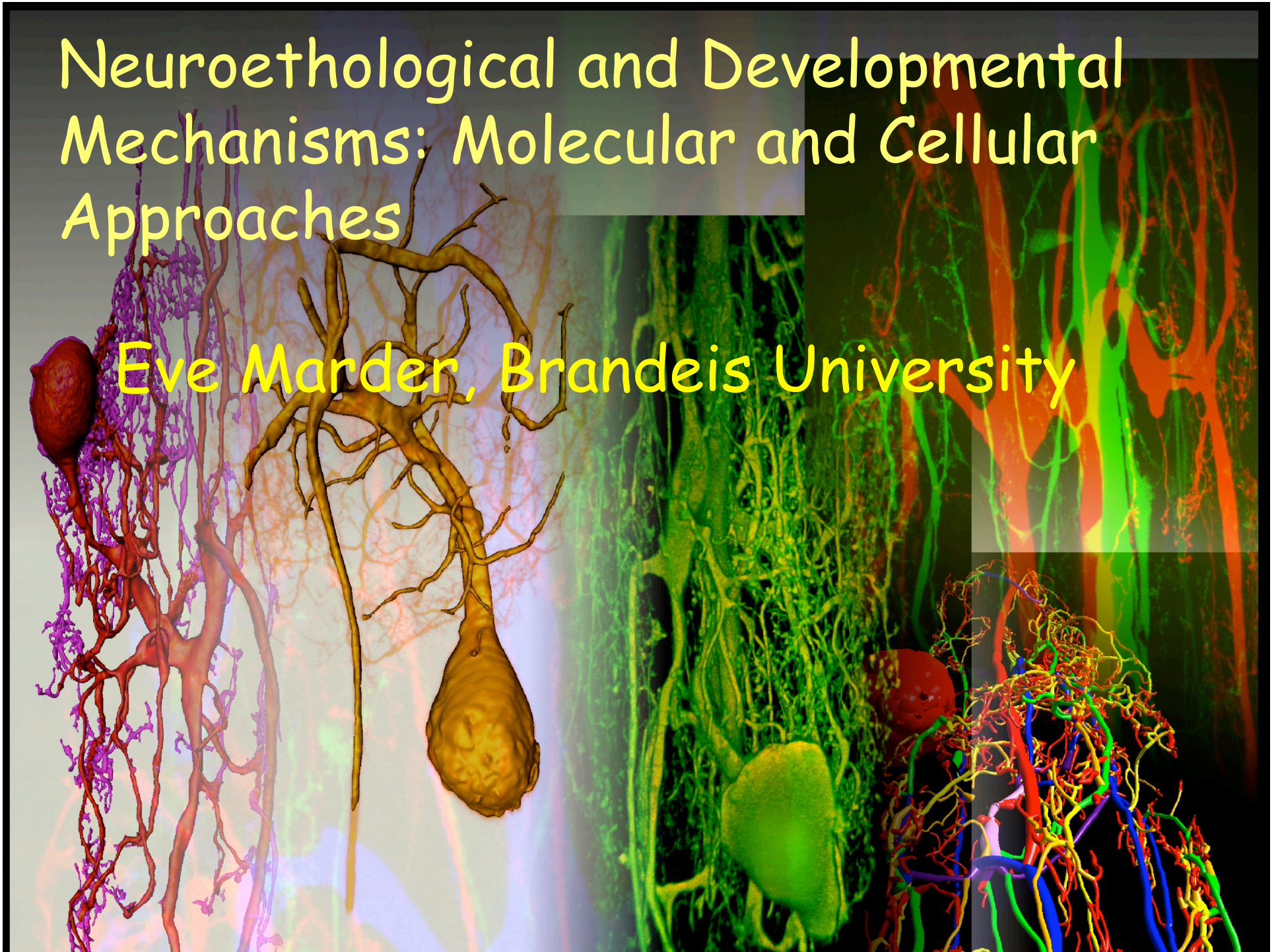


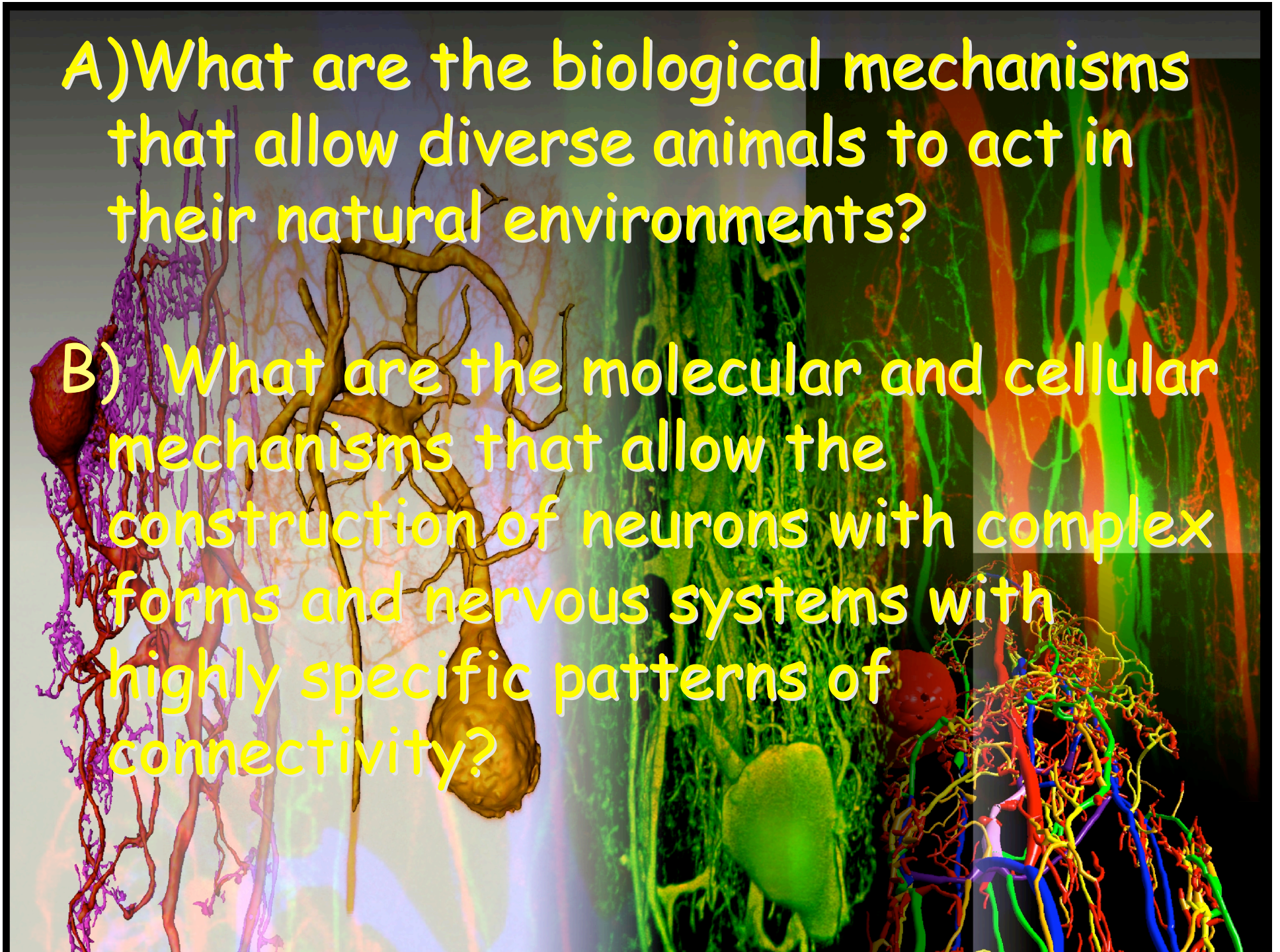
# Neuroethological and Developmental Mechanisms: Molecular and Cellular Approaches

Eve Marder, Brandeis University



A) What are the biological mechanisms that allow diverse animals to act in their natural environments?

B) What are the molecular and cellular mechanisms that allow the construction of neurons with complex forms and nervous systems with highly specific patterns of connectivity?



Evolution and  
behavior in  
natural  
environments

Picture courtesy  
of Larry Wangh



Evolution has given us myriad forms, in body plan and in nervous system design, including animals with remarkable specializations for living in extreme environments.... electric fish signal in murky waters, desert ants navigate faithfully, penguins share the care of young, etc etc etc etc etc etc etc etc



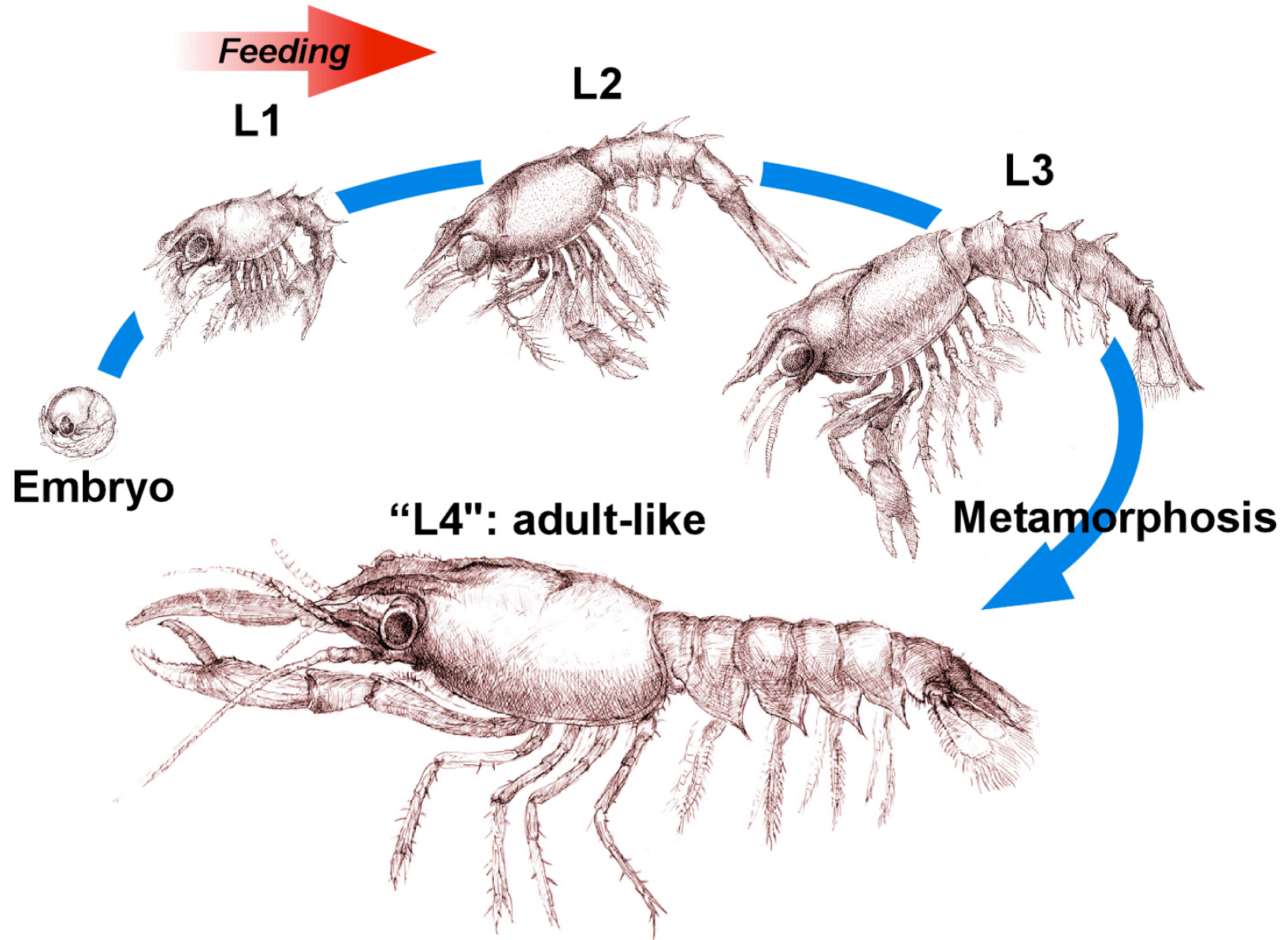
The push toward the consolidation of neuroscience research into the study of only genetic organisms runs the risk that we lose our ability to understand how evolution has influenced behavior. Animal diversity represents an enormous opportunity for understanding nervous system development and function.



There are new opportunities to interface with the ecology, evolution, and behavior as we explore how animals interact with each other in their natural settings.



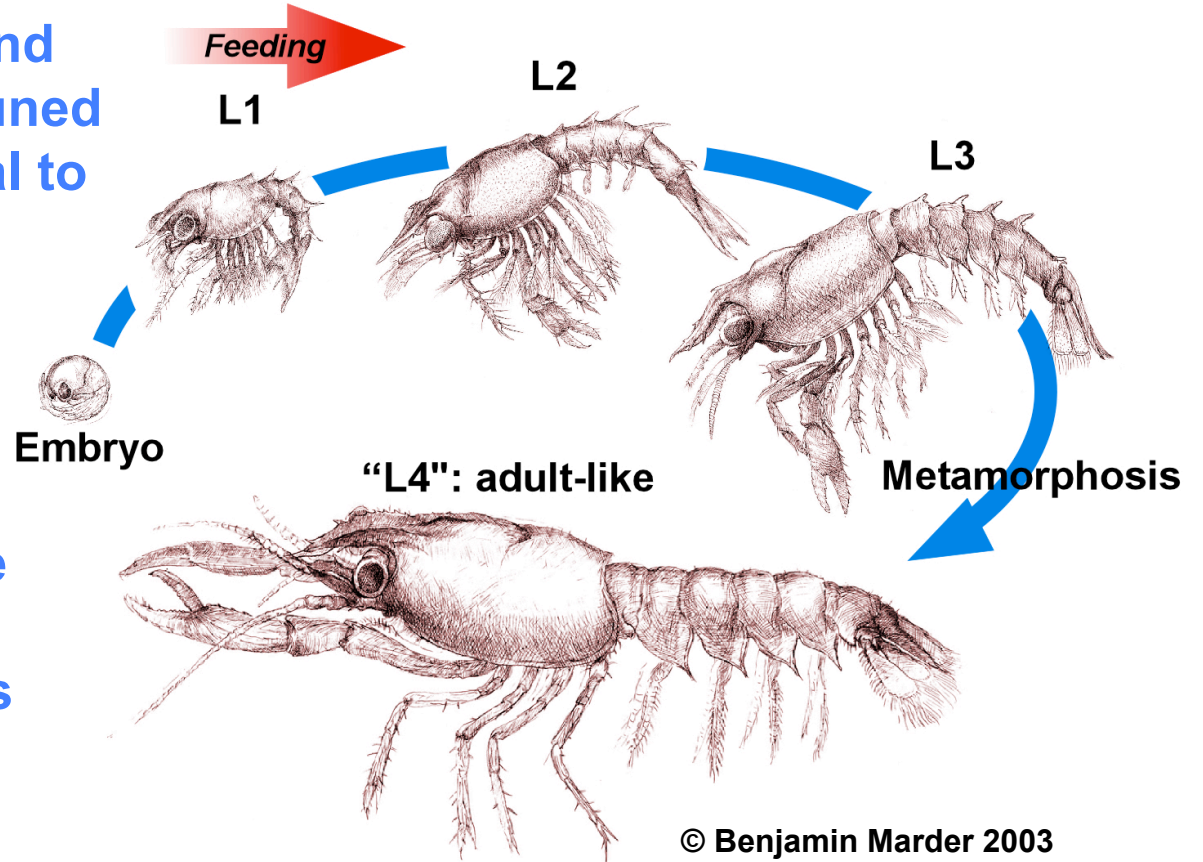
# Animals develop in a complex world



# Understanding nervous system development requires characterizing molecules and processes:

- a) Axon outgrowth and pathfinding
- b) Determination of cell identity
- c) Construction of an appropriate wiring diagram
- d) Ensuring that synaptic and intrinsic properties are tuned well enough for the animal to function in its natural environment

- e) How experience and epigenetic mechanisms interact with genetics in the construction and maintenance of the nervous system

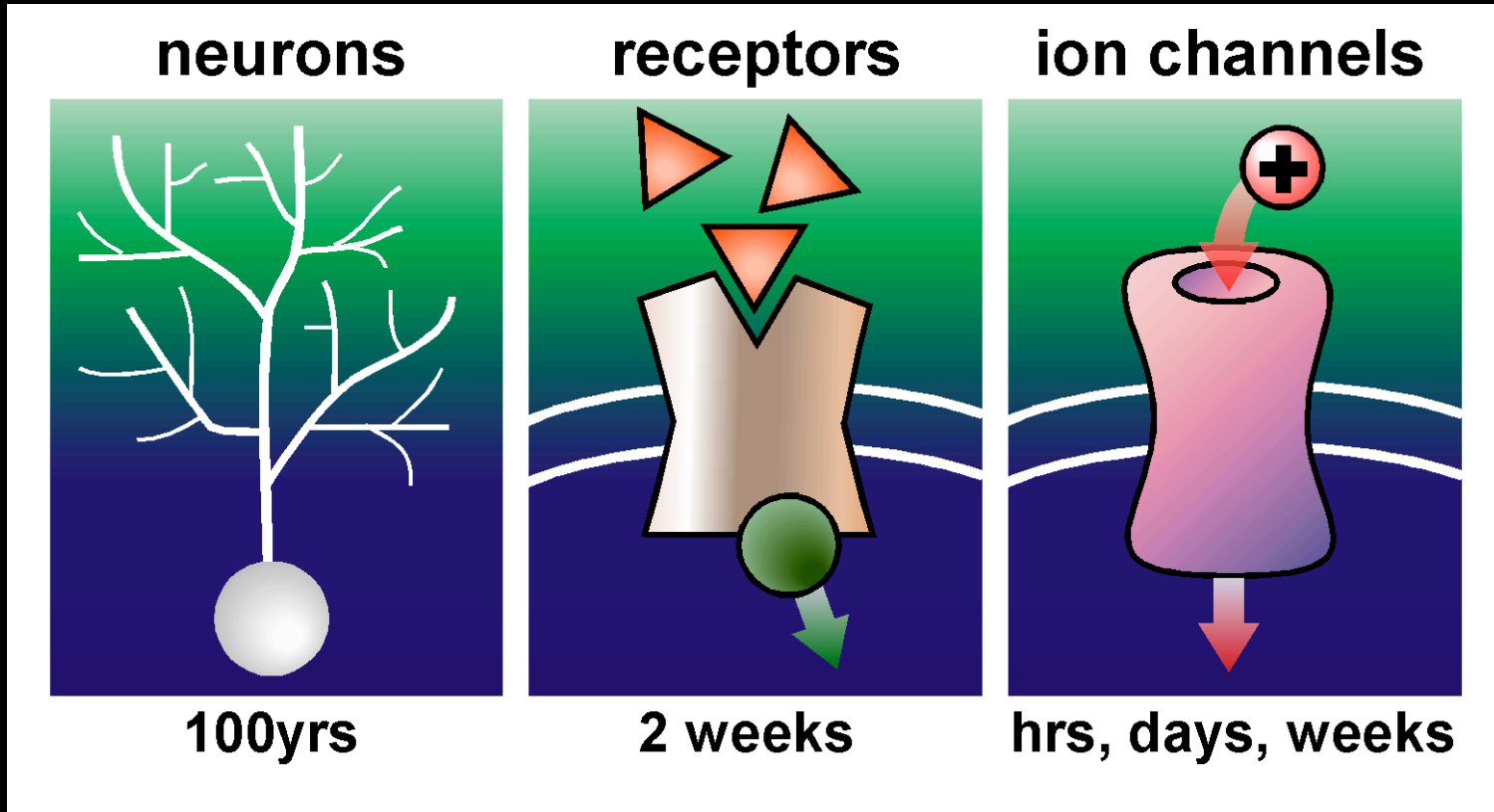




# Specification of cell identity is a necessary precursor to circuit analysis

- Sounds simple, in fact extremely difficult...
- Needs new methods to look at the correlated expression of molecules, anatomical form and connectivity during development and as a function of experience
- Single neuron expression profiling and proteomics

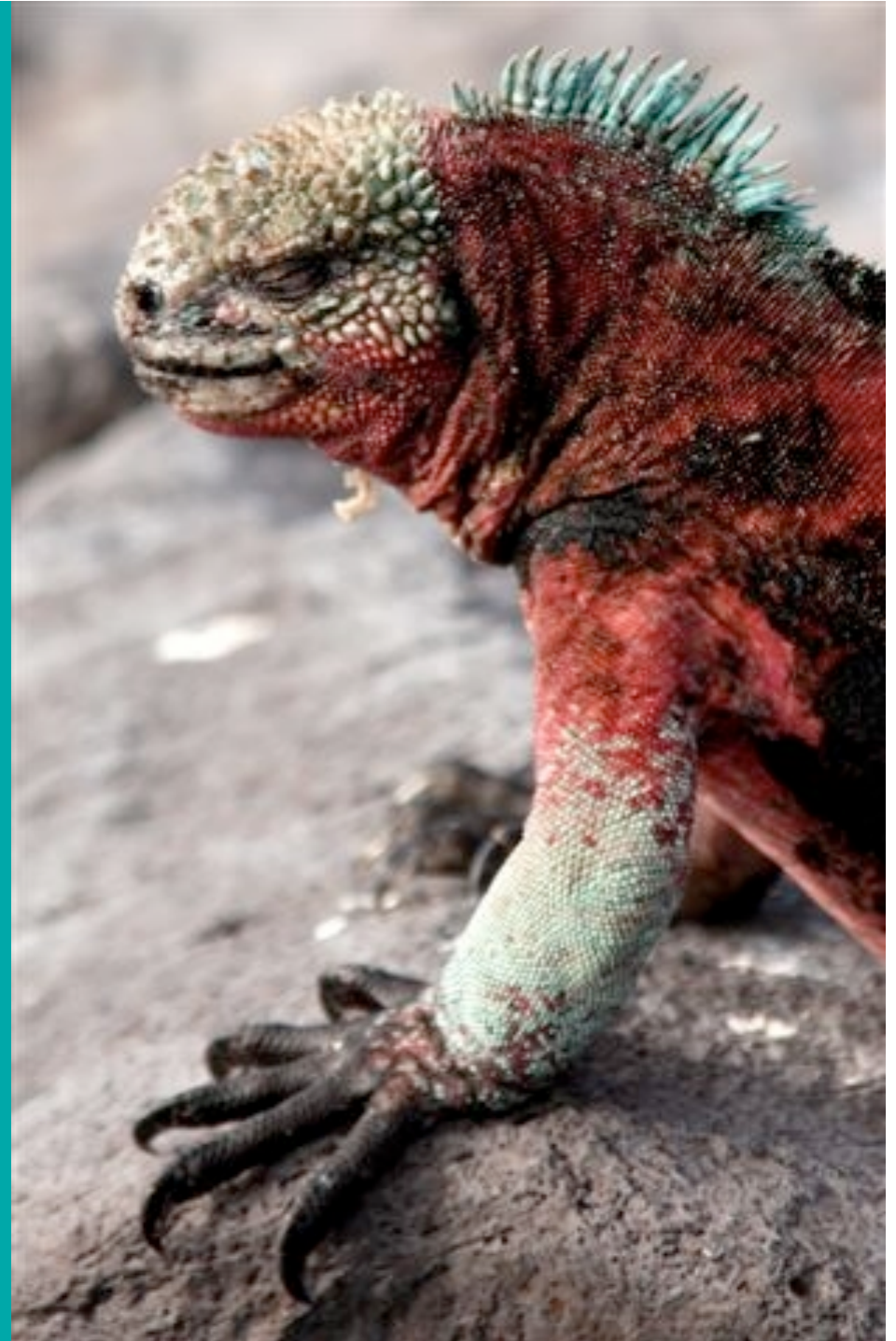
-The components of functional circuits are not static, but are constantly turning over rapidly during the lifetime of a neuron



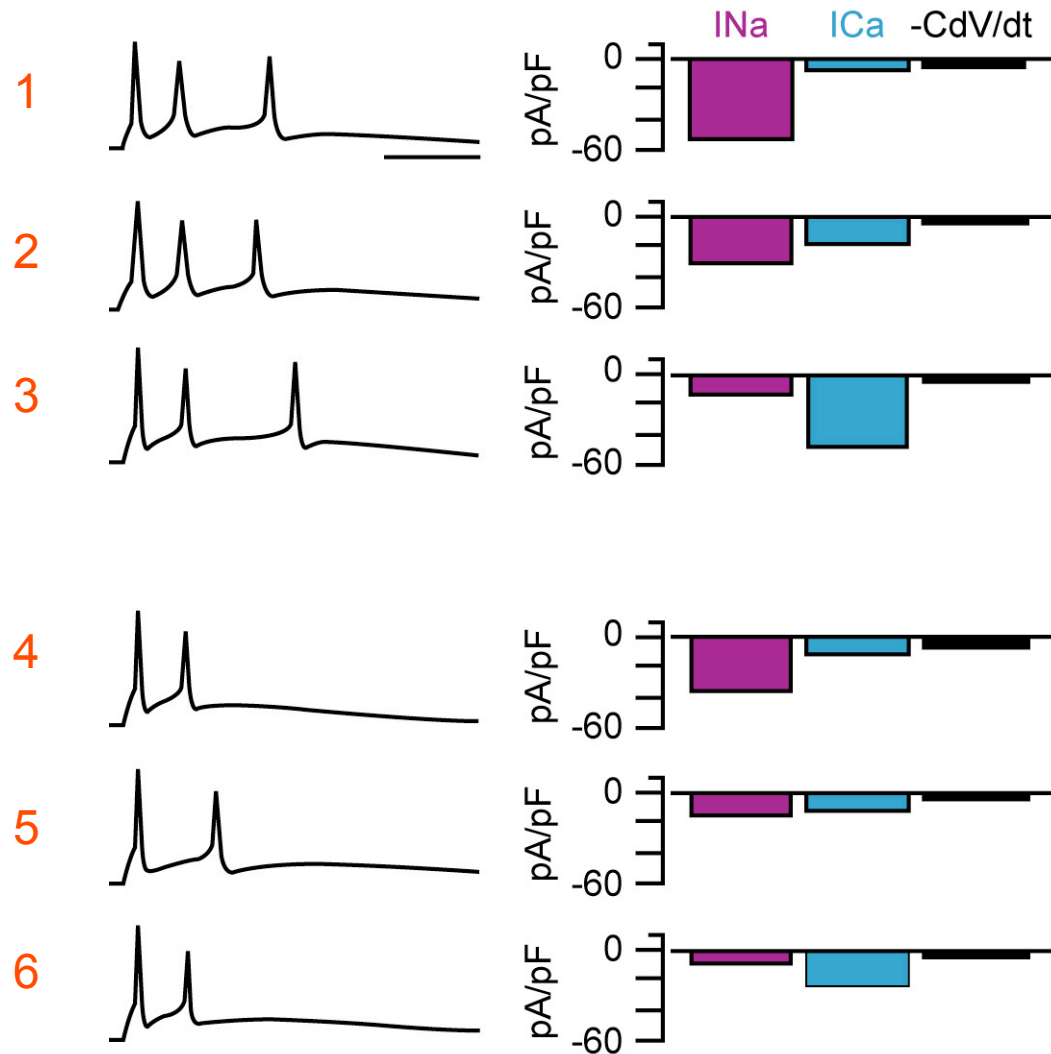
-How is function maintained while the nervous system is constantly rebuilding itself?

Determine the contribution of genetic noise to noise in network function

- Phenotypic variability can arise from stochastic variations in gene expression
- When does this variability have consequences for network function?

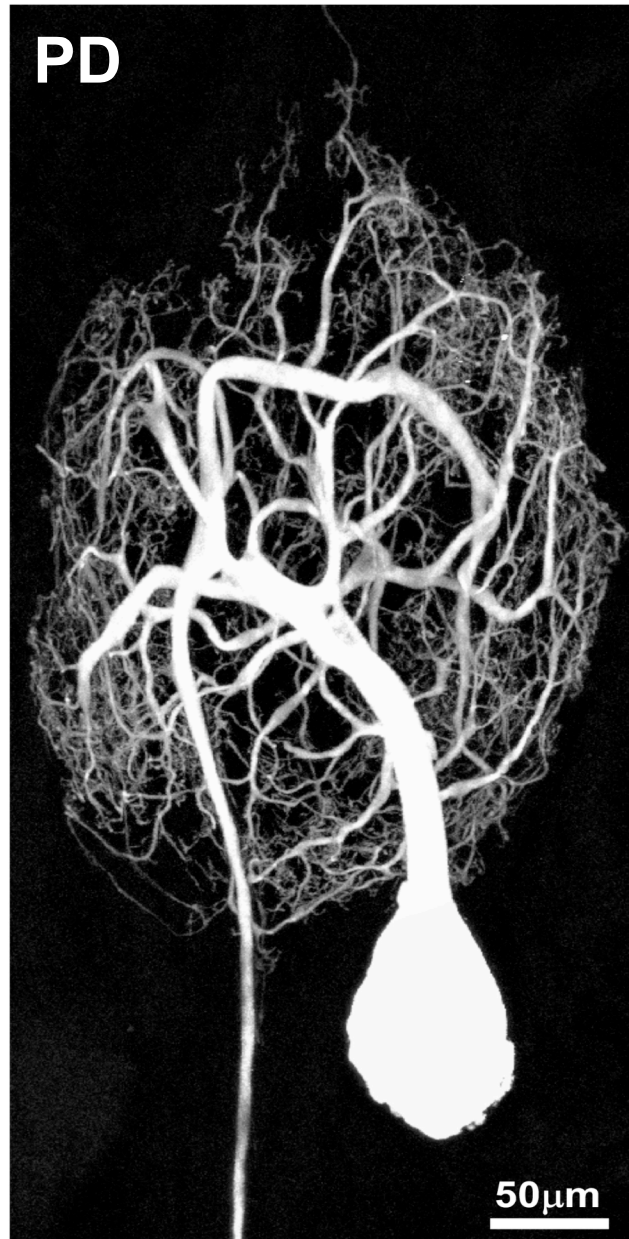


# Cerebellar Purkinje Cells with Similar Behavior and Different Underlying Ratio of Conductances



Swensen &  
Bean, 2005

Neurons are complex structures. Much of the intracellular signaling that is important for neuronal function takes place under conditions that require a new biochemistry: Anchored molecules and very small spaces may require entirely new methods...Monte Carlo simulations, etc



Bucher & Taylor, 2004

**Need new ways of collecting and analyzing data of all kinds**

**Need new ways of studying nervous systems in more natural settings**

**Need new ways to perturb biochemical and molecular pathways, neurons and networks in real time, during development and behavior.**

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