

THE HUMAN CONNECTOME

A STRUCTURAL DESCRIPTION OF THE HUMAN BRAIN

BY OLAF SPORNS, GIULIO TONONI, ROLF KÖTTER

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ALEX SHARATA

WHAT IS A CONNECTOME?

(QUICK REFRESHER...)

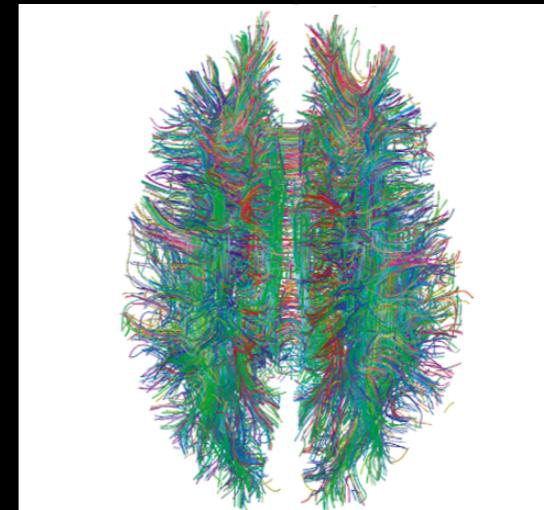
connectome [kuh-nek-tohm] /noun/

- a comprehensive map of neural elements and connections in the brain, and may be thought of as its “wiring diagram”

SUMMARY

- The brain is highly complex
- **Network** of connections is still unknown
 - Some DBs of **large-scale** anatomical connections exist, but there's no **connection matrix** for humans
- Proposing a **research strategy** —> first draft of connectome

OPPORTUNITY

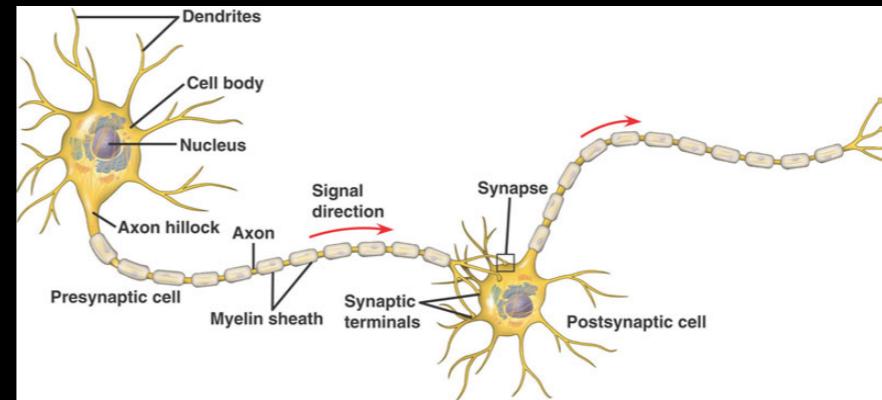


- Opportunity to assemble the first draft of human connectome
- Could help answer the question: **how does the (human) brain really work?**
 - Insights on structure-function mappings in the brain
 - Neuroinformatics resource with many applications
- Analogous to the human genome (but arguably much more complex)
- Still virtually no information on **finer connectivity patterns**

CHALLENGE OF COMPILING THE HUMAN CONNECTOME

- Lack of coordinated efforts (at the time...)
 - No standardized data format or public database
- No existing connection matrix
- The human brain is highly complex - distinct levels
- Individual variability in connection patterns
- First drafting of the connectome will be resource intensive

ACTION

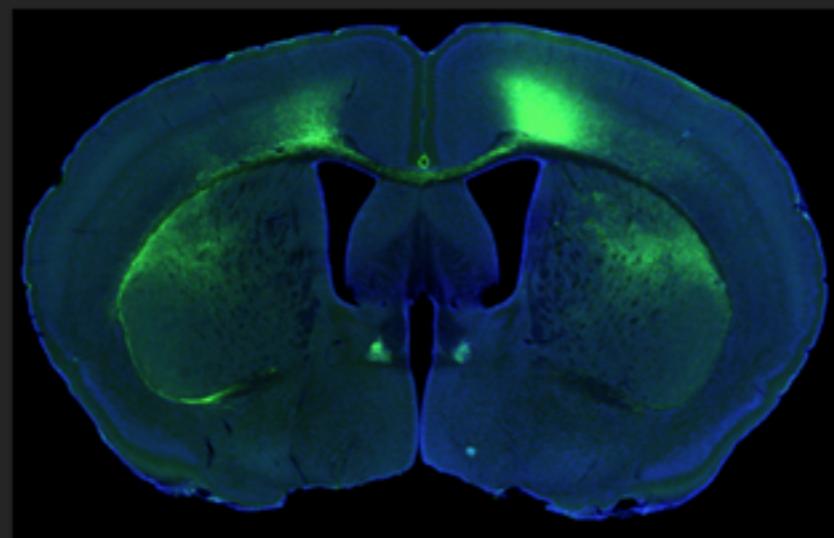


- Assembling the human connectome... a many stepped process
 - Define a level of **scale** —> consider different **approaches** —> assess potential experimental **approaches** and limitations —> evaluate **impact**

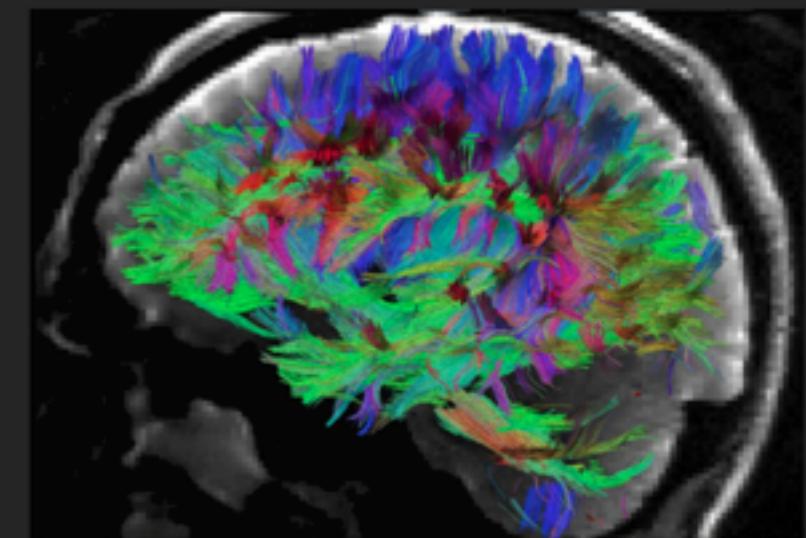
microscale: connections of individual neurons



mesoscale: projection of a set of neurons

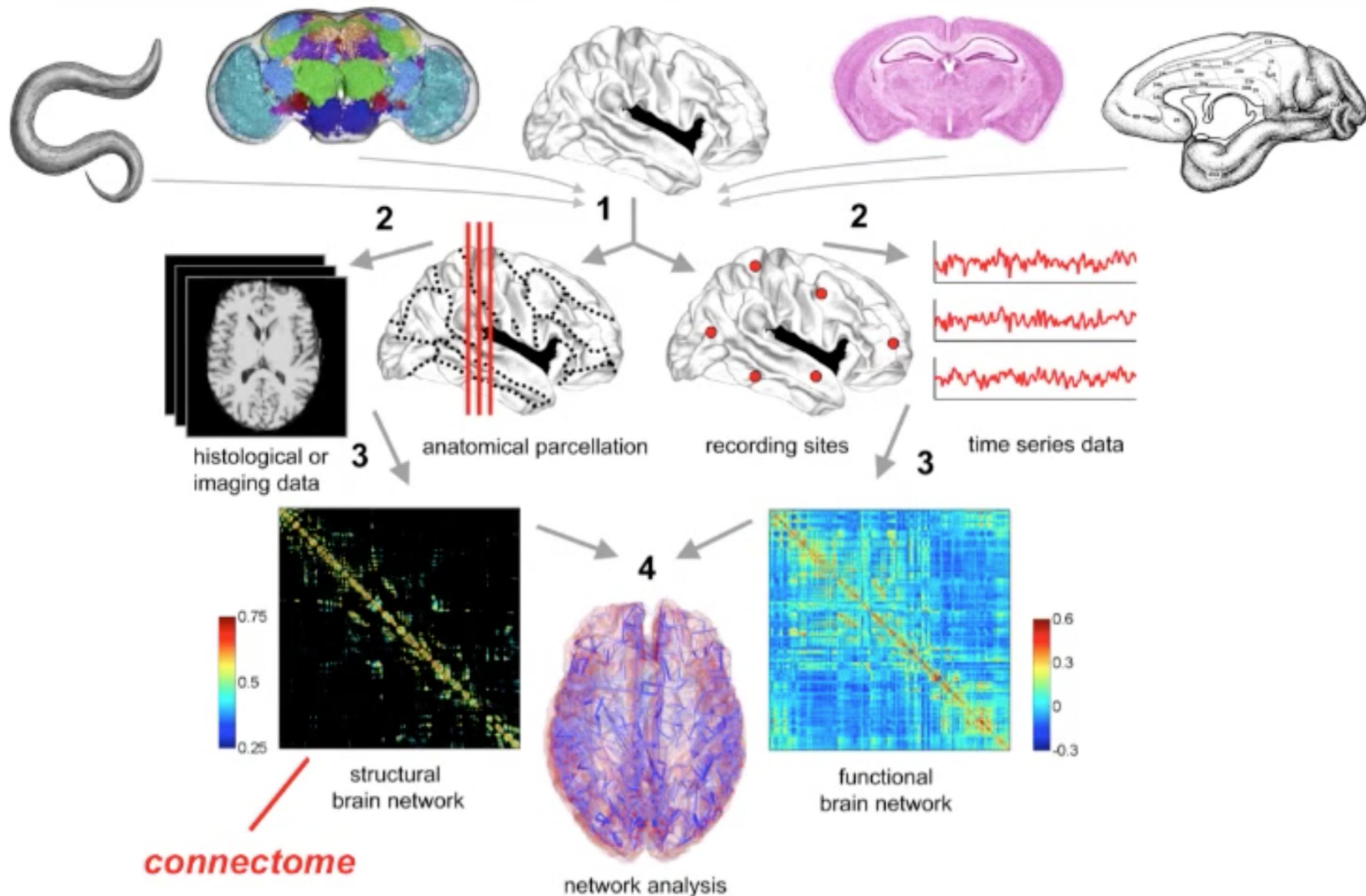


macroscale: traces of many neuron sets



Brain Connectivity

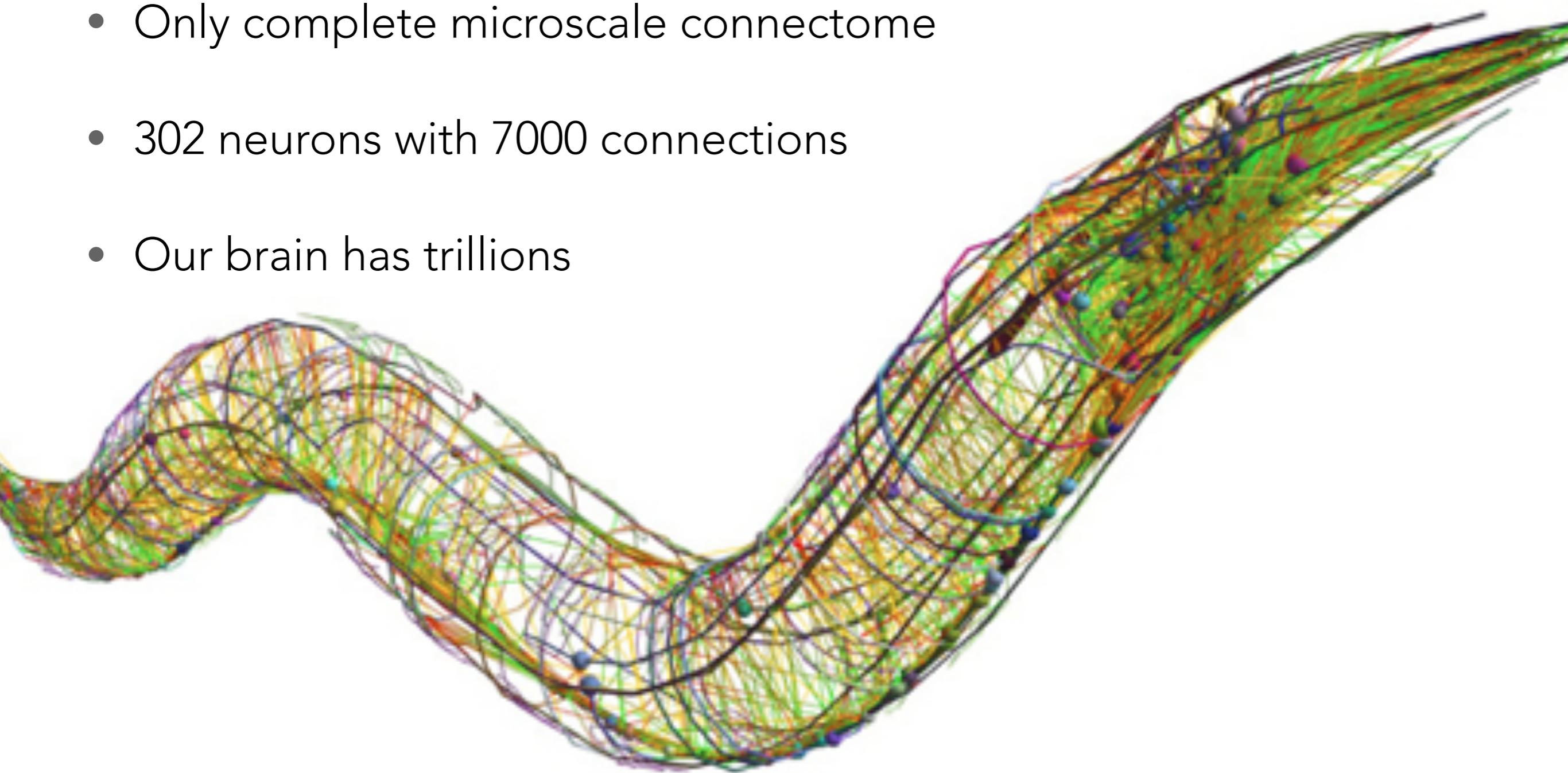
Extraction of Brain Networks from Empirical Data



THE OPENWORM PROJECT

THE C. ELEGANS CONNECTOME

- Only complete microscale connectome
- 302 neurons with 7000 connections
- Our brain has trillions



RESOLUTION

- 5 steps toward the human connectome
- How can we leverage the potential of the connectome to drive results? (mapping of structures → functions)
- Central motivating hypothesis regarding the pattern of **elements** and **connections**
- Can help us understand: language, cognitive function, network structure, brain imaging, brain damage and recovery, and neurodegenerative diseases

FUTURE WORK

- The Human Connectome Project
- Cataloging all functional activity maps in a brain
 - April 2013: Obama announces BRAIN initiative
- Possibly assembling the human connectome at the microscale (level of single neurons — 10^{11} of them)
- Leverage the connectome along with other brain mapping databases and computational methods
 - —> **Capitalizing** on its full potential

DISCUSSION

PROS

- Ability to identify new insights and knowledge about the brain and how it functions
- Drive advances in artificial intelligence, cognitive neuroscience, and neuropsychology
- Help understand the mind and its diseases (much like the human genome did)
- so much more...

CONS

- Tremendously large sets of data
- Took ~12 years to map the connectome of a worm (humans are way more complex)
- Disparate data formats — no consensus among researchers
- Computationally and resource intensive process
- \$300MM/year for 10 years (budget for Human Connectome Project)

