



## Bi/CNS/NB 150: Neuroscience

MWF 11-12  
Discussions Thurs pm  
cns.caltech.edu/bi150

Ralph Adolphs  
Henry Lester

Jaron Colas  
Mason McGill  
Jonathan Liu  
Cynthia Chai

## What is Neuroscience?

- the study of the nervous system

1. Development (developmental neurobiology)
2. Cells and their function (cellular and molecular neurobiology)
3. Brain regions/circuits and their function (systems neuroscience)
4. Thinking (cognitive neuroscience, psychology)
5. Neurodegenerative diseases, Stroke (Neurology)
6. Mental illness (Psychiatry)
7. Consciousness (Philosophy)
8. General functional principles (cognitive science, theoretical neuroscience)

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## Neuroscience at Caltech 2015: BBE

*Drosophila* genetics: Zinn, Hay, Stathopoulos  
 Transplantation in chicks, frogs, zebrafish: Bronner  
 Visualization & imaging: Stathopoulos  
 Optogenetics: Gradinaru, Oka  
 Synapse function and memory: Kennedy  
*C. elegans* genetics: Sternberg  
 Ion channels, addiction, disease: Lester  
 How flies fly: Dickinson  
 Gut, brain, and immune system: Mazmanian  
 Cognitive neuroscience in humans: Adolphs, Shimojo  
 Salt and thirst in rodents: Oka  
 Evolution, vision in primates: Allman  
 High-level vision in monkeys: Tsao  
 Neural prosthetics, monkeys: Andersen  
 Cognitive neuroscience, vision: Shimojo  
 Zebrafish genetics: Prober  
 Circuits and behavior in flies and mice: Anderson, Meister, Hong  
 Circuits for learning and memory in rodents: Siapas

## Who are you?

9 Seniors  
 11 Juniors  
 6 Sophomores  
 0 Frosh  
 3 Grads

## 2014

10 Seniors  
 20 Juniors  
 7 Sophomores  
 0 Frosh  
 8 Grads

3

4

## Discussion sections

All in KK101, Thursday afternoons

Section 1 (Th 2-2:55, Cynthia): 5 people

Section 2 (Th 3-3:55, Mason): 14 people

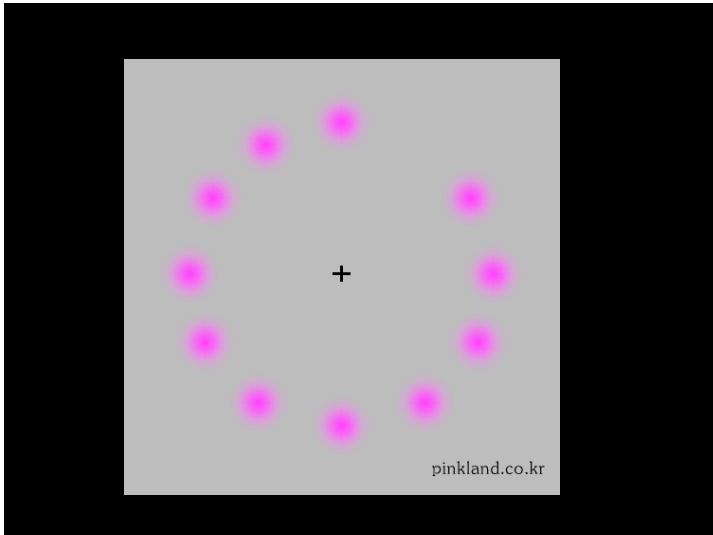
Section 3 (Th 4-4:55, Jaron): 4 people

Section 4 (Th 7-7:55, John): 6 people

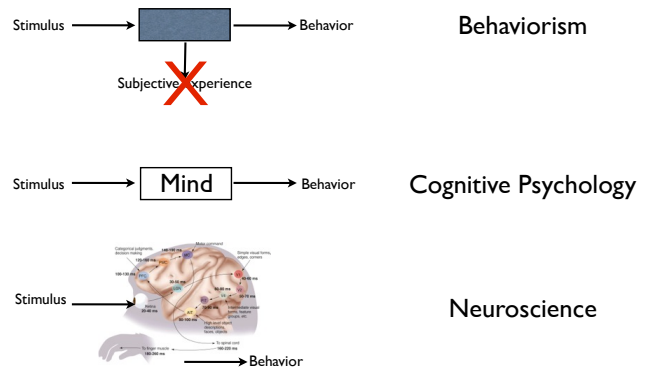
## Two reasons to study the brain

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$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

## Neuroscience

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

Astronomy

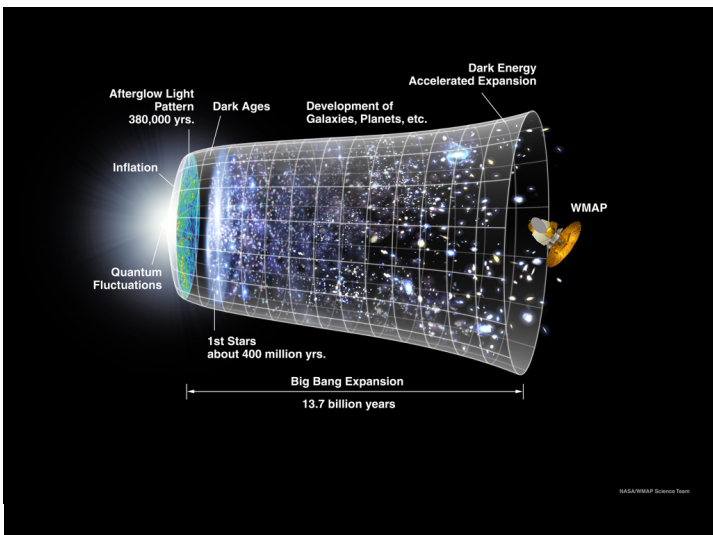
Chemistry

Biology

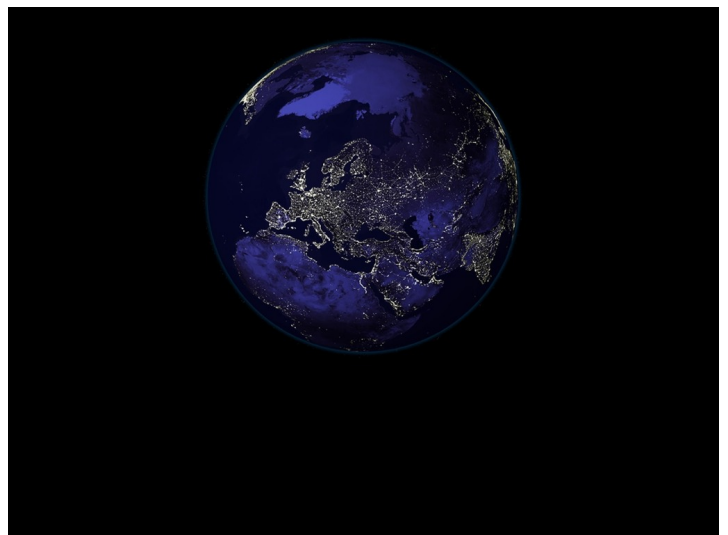
Psychology

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11



12



"As humans, we can identify galaxies light years away, study particles smaller than an atom but we still haven't unlocked the mystery of the 3 pounds of matter that sits between our ears...."

## Textbook

"Principles of Neural Science"

Fifth Edition, 2013

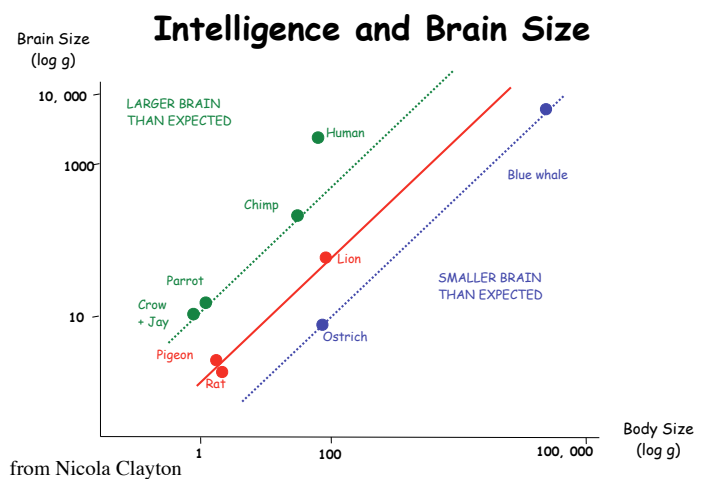
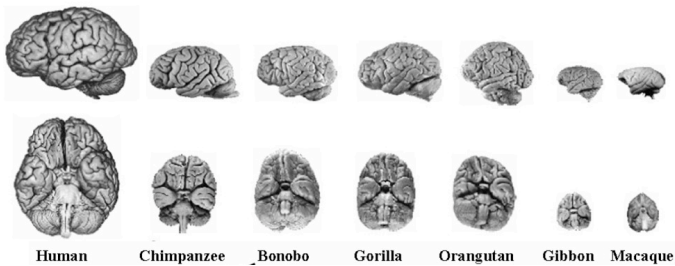
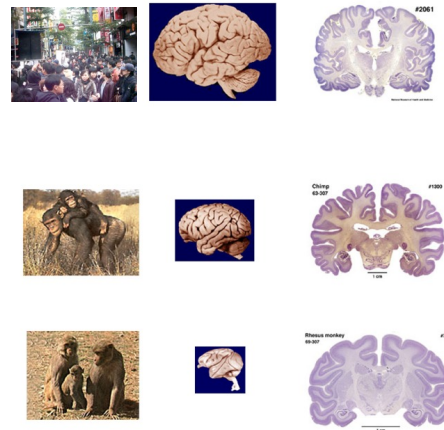
Kandel, Schwartz, Jessell, Siegelbaum, Hudspeth, eds.

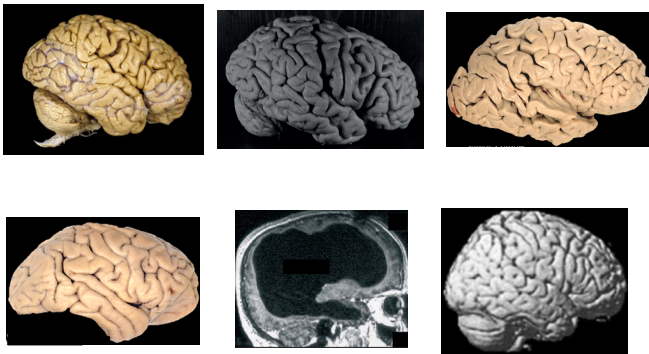
"The last frontier of the biological sciences -- the ultimate challenge -- is to understand the biological basis of consciousness and the brain processes by which we feel, act, learn and remember."

(First sentence, Chapter 1)

We emphasize these points from Kandel in Bi/CNS 150

Read			Lecture
1: pp 5-10	Introduction	Brains evolved All higher animals have brains Neurons across species look remarkably similar How these neurons are connected differs A hallmark of brains is complexity Human brains are large and wrinkly and have large frontal cortex	Sept 28 (today)
15: 337-344	Anatomy	The nervous system can be subdivided into regions The brain is a tube The brain floats in your skull NS = PNS + CNS ANS = PNS + CNS = sympathetic + parasympathetic Sensorimotor cortices are topographically organized	Sept 30 (Weds)
	Discussion section	Real human brains	Oct 1 (Thurs)
52: 1165-1185 53: 1187-1194 53: 1218-1227	Development	Most of the complexity of the brain comes from development It is impossible to create an adult human brain without development There are relatively simple developmental rules Development = genes + environment	Oct 2 (Fri)





## Complexity of the human brain

~85 billion neurons (roughly same as glia)  
 $>10^{14}$  synapses ( $\sim 10^6$  /s during 1<sup>st</sup> 2 yr of life)

Thousands of neuronal types  
 (there are more than in any other type of tissue)

Brain architecture determined partly by genetics

However, much of the brain is sculpted by experience

19

20

## Complexity of the human brain

20,000 neurons per mm<sup>3</sup>  
 4 km axons per mm<sup>3</sup>  
 2-4 mm cortical thickness  
 $10^9$  synapses under a square mm

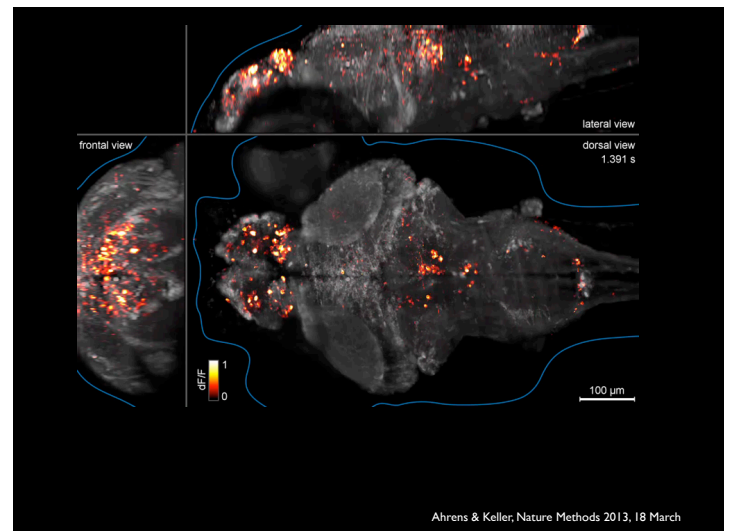
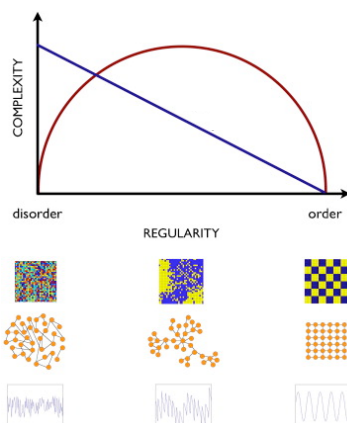
## Complexity of the human brain

~85 billion neurons (roughly same as glia)  
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Very, very large number of ensembles  
 Unbounded number of mental states?

21

22



23

24

Brains evolved (but brains like ours may have only evolved once)  
All higher animals have brains

Neurons across species look remarkably similar  
How these neurons are connected differs

A hallmark of brains is complexity  
Human brains are large and wrinkly and have large frontal cortex

Some brain weights: humans = 1400g, chimps = 400g, monkey = 100g.  
Bigger brains are smarter, but this relationship is not very reliable

Brains have 85B neurons and  $10^{14}$  synapses, allowing for a huge number of combinatorial patterns

Please attend class. Videos are intended as supplementary material, not primary material.

There will be Quizzes on 1/3 of the lectures.  
These Quizzes account for 10% of your grade and are EASY points.  
The Quizzes focus on the preceding lectures.

Exams and problem sets will cover lectures and book readings.  
The most important points in lectures will be emphasized.  
The most important pages in the book will be assigned.

Do NOT consult previous problem sets or exams.

Questions from Quizzes may reappear in the Problem Sets or future Quizzes.  
Questions from Problem Sets may reappear in exams.

<http://www.cns.caltech.edu/bi150/index.html>