Questions
(1) What are the building blocks of the brain?
(2) How do they work?
(3) How are things in the environment, such as faces, trees, or houses, represented in the brain?
(4) How is the brain organized?
(5) What methods do we have to study the link between neurobiology and human behavior?
Caption: A portion of the brain that has been treated with Golgi stains shows the shapes of a few neurons. The arrow points to a neuron’s cell body. The thin lines are dendrites or axons.

Caption: Basic components of the neuron. The one on the left contains a receptor, which is specialized to receive information from the environment (in this case, pressure that would occur from being touched on the skin). This neuron synapses on the neuron on the right, which has a cell body instead of a receptor.
How do neurons talk to each other?

- Neurons talk to each like a computer does.
- Neurons talk to each other by sending electrical signals.

**How so?**

A neuron is immersed in liquid rich in ions (molecules that carry electrical charge).

**Ion?**

- An ion is an atom or group of bonded atoms which have lost or gained one or more electrons, making them negatively or positively charged.
- A negatively charged ion has more electrons in its electron shells than it has protons in its nuclei.
- A positively charged ion has fewer electrons than protons.

**Atom?**

- An atom is the smallest particle still characterizing a chemical element; it is composed of various subatomic particles.
- Electrons have a negative charge; they are the least heavy (i.e., massive) of the three types of basic particles.
- Protons have a positive charge with a free mass about 1836 times more than electrons.
- Neutrons have no charge, have a free mass about 1839 times the mass of electrons.

* (Wikipedia.org)

Neurons talk to each other electronically by sending signals (+ or – signals).

Neurons are not directly attached but are connected indirectly at a juncture called “synapse.”

**WHY?**
When an electric signal reaches at the end of the axon of a neuron, that neuron releases “neurotransmitters.”

Dendrites collect electrical signals from other neurons. Dendrites forward these signals to the axon of that neuron.

Visual perception

- What is the difference between (a) & (b)?
- What is going on in your head when you see (a) versus when you see (b)?

• Demo
• Neuroanimator

• [Q 3] How are things in the environment, such as faces, trees, or houses, represented in the brain?
How about this?
• When you see the square, what’s going on?
• How do you find out?

What’s going on?

In terms of the activity of neurons, what is the difference between A and B?
Any guess?

A

B

Measuring the electrical activity of a neuron directly by inserting a thin needle into animal brains.
The frequency of action potential is correlated with the intensity of the stimulus.

Different neurons respond to different characteristics of stimuli:
- E.g., color, shapes, brightness, faces, artifacts, so on.
- There are bunch of neurons that respond to specific physical characteristics of stimuli.
- Q: the reason why we can communicate, think, solve problems, get angry, sing, walk, so on is because neurons are responding (sending electric signals).

Specificity coding vs. Distributed coding
- How are objects represented in the visual system?
- Think about human faces. Every face is different. So do we need an infinite number of neurons to represent individual faces?
- A single neuron responds to each face?

Combinations of neurons can express lots of different faces

Caption: How faces could be coded by specificity coding. Each face causes one specialized neuron to respond.
• (4) How is the brain organized?

Cognition in the Brain: Cerebral Cortex and Other Structures

– From Principles of Neural Science by Kandel, Schwartz, & Jessell

Visit Brain Atlas:
http://www.med.harvard.edu/AANLIB/home.html

Cerebral Cortex and Localization of Function

– The cerebral cortex is related to cognitive functioning.
– It is anatomically divided into four lobes.
– It is organized in layers (1- to 3-millimeter).
– The layers organize inputs and outputs

– From Principles of Neural Science by Kandel, Schwartz, & Jessell
Chimpanzee vs. Human

Cerebral Cortex Principles

- Localization of function
  - Specific mental processes are correlated with discrete regions of the brain
  - Each lobe of the brain has specialized functions
- Hemispheric Specialization
  - Left and right hemispheres of the brain do different things.

Lobes of the Cerebral Cortex

- Frontal lobe
  - Motor processes and higher cognition
- Parietal lobe
  - Somatosensory processing, attention
- Temporal lobe
  - Auditory processing, language comprehension, visual memory
- Occipital lobe
  - Visual processing
Primary projection areas and their topological organization

Essay question

- 1 paragraph
  - Specific mental processes are correlated with discrete regions of the brain. Each lobe of the brain has specialized functions. What does this tell you in terms of how the human brain evolved?

- CogLab
- Brain asymmetry
  - Do the CogLab brain asymmetry experiment.
  - Pay attention to the manipulations (independent variables) they employed.
**Summary**

- The mechanism of neurons is relatively uniform.
- A neuron consists of dendrites, a cell body and an axon.
- Neurons are not directly attached but are indirectly connected by synapses.
- One neuron sends an electrical signal to another neuron by releasing neurotransmitters.
- Some neurons send excitatory signals (+); others send inhibitory signals (-).

**What does this tell?**

- Our mental activities (cognition) can be examined by the activity of neurons.
  - When we are perceiving something, some neurons are firing.
  - When we are thinking, some neurons are firing.

(5) What methods do we have to study the link between neurobiology and human behavior?

- Single cell recording
- EEG/ERP (Event related potential / evoked potentials)
- PET (Positron Emission Tomography)
- fMRI (functional Magnetic Resonance Imaging)
- TMS (Transcranial magnetic stimulation)

**Event-Related Potentials (ERP)**

- Electroencephalograms (EEG)
  - Are recordings or the electrical activity (frequency and intensity) of the living brain.

- Event-related potential (ERP)
  - Is the record of a small in the brain’s electrical activity.
  - EEG waves are averaged over a large number of trials.
Biofeedback / Neurofeedback

Neurofeedback and autism

http://www.youtube.com/watch?v=JpKcbh7_710

Metabolic imaging

- Trace metabolic changes
  - E.g., increased consumption of glucose and oxygen in a particular area of the brain.
• Visit
• http://www.functionalmri.org/
• http://defiant.ssc.uwo.ca/Jody_web/fmri4dummies.htm

fMRI Setup

fMRI Experiment Stages: Prep
1) Prepare subject
   • Consent form
   • Safety screening
   • Instructions
2) Shimming
   • Putting body in magnetic field makes it non-uniform
   • Adjust 3 orthogonal weak magnets to make magnetic field as homogenous as possible
3) Sagittals
   Take images along the midline to use to plan slices

fMRI Experiment Stages: Anatomicals
4) Take anatomical (T1) images
   • High-resolution images (e.g., 1x1x2.5 mm)
   • 3D data: 3 spatial dimensions, sampled at one point in time
   • 64 anatomical slices takes ~5 minutes

MRI
Source: Kandel et al., 1994
PET (Normal resting pattern)  
Source: Kandel et al., 1994

PET (visual & auditory stimulation)  
Source: Kandel et al., 1994

• Demonstration  
• fMRI and mind reading (10 min)  
  • http://www.youtube.com/watch?v=Cwda7YWK0W

TMS  
• Transcranial magnetic stimulation  
  – Disrupt the electrical activity of neurons in a targeted area by a strong magnetic field (4:15)  
  – http://www.youtube.com/watch?v=XJtNPqCj-iA

ERP, PET, fMRI, &TMS  
• Subjects carry out some psychological tasks (e.g., solving problems)  
• Trace neural activities of the brain.  
• Identify the brain location in which the psychological function takes place.  
• Bridge psychological functions and their brain locations.