Science, Research, and Theory

• Science is constantly evolving, so it is tentative.
  • **Theories** integrate diverse observations into a complex framework.
  • Example: Amphetamines produce symptoms of schizophrenia, and amphetamines increase activity in dopamine-releasing neurons.

• Theories generate testable hypotheses.
  • Example: Drugs that decrease dopamine activity will improve functioning in schizophrenics.
  • Tests may reveal the need to revise or update a theory as new data becomes available.
Science, Research, and Theory

• **Experimental Research allows for statements of causality**
  - Independent variables- things that can be manipulated by the experimenter.
  - Dependent variables- things that result from independent variables
  - Extraneous variables- uncontrolled influences
  - Not always feasible: may be ethical concerns

• **Correlational study**
  - The researcher determines whether two variables change together, but does not manipulate either of them.
Science, Research, and Theory

Figure 4.2: Correlational Versus Experimental Studies.

(a) Correlational study
- Observed frontal lobe impairment
- A causes B
- B causes A
- Third variable
  Drug use or physical abuse causes both A and B

(b) Experimental study
- Induced frontal lobe impairment
- IV causes DV
- Aggressive behavior
- Confounding variables
  Because the experimenter induces the brain impairment, it is not confounded with drug use or physical abuse
Research Techniques

With the advent of the light microscope, researchers began developing ways to reveal the structures within the nervous system.

Golgi stains may be used to select a small number of neurons to view through a light microscope.

Nissel stains may be used to see the cell bodies of neurons through a light microscope.

2-Deoxyglucose imaging may be used to show if specific neurons are active.
Research Techniques

Figure 4.5: Immunocytochemistry uses dyed antibodies to identify details of cellular components of a neuron.
In situ hybridization uses radioactive complementary DNA, which docks with messenger RNA, to locate gene activity.

Example: Mouritsen focused on the CRY2 cryptochrome (rather than CRY1) because it was constructed outside the retina.
Research Techniques

Figure 4.7: Scanning Electron Microscope

- **Light microscopes:**
  - Cell bodies, dendrites, axons, and large organelles in neurons;
  - Limited capability due to the nature of light.

- **Electron microscopes:**
  - Pass beams of electrons through a thin slice of tissue onto detector;
  - High resolution, magnifying objects up to 250,000 times;
  - Can reveal objects in 3-D (scanning electron microscope).
Research Techniques

Figure 4.8: An Electroencephalograph

- **EEG / electroencephalogram**
  - records the combined activity from many neurons by using multiple electrodes;
  - has good temporal resolution but poor spatial resolution;
  - has been used to diagnose epilepsy & brain tumors, and study sleep and learning.
EEG and Evoked Potentials

Figure 4.9: Evoked Potential Produced by a Novel Tone

• **Evoked potential measurement:**
  - uses a computer to average the EEG over several stimulus presentations;
  - cancels out the “noise” of the brain’s other activity, leaving only the unique response to the stimulus.
A stereotaxic atlas shows the location of key structures on images of a series of brain sections. Helps us figure out exactly where to implant an electrode in 3 dimensions.
Research Techniques

Figure 4.11: A Stereotaxic Instrument

• A stereotaxic instrument is used to place an electrode.
  • An electrode can be used to stimulate neurons or to record their activity.
  • A cannula can be used to introduce chemicals into the brain to observe their effects; or to extract fluids in a procedure called microdialysis.
Research Techniques
Ablation and Lesioning

• Experimental studies with animals provide more control than studies of brain-damaged patients.
• **Ablation** involves the removal of brain tissue, usually via conventional means like a scalpel.
• **Aspiration**: remove tissue via vacuum suction
• **Lesioning** damages neural tissue with heat, electrical current, neurotoxins, or by severing connections.
  • Reversible lesions can be produced by chilling or cooling an area, or by applying certain chemicals.
Research Techniques
See Figure 4.14: Transcranial Magnetic Stimulation

• **Transcranial magnetic stimulation** uses a noninvasive magnetic field and permits excitation or inhibition.

• Has been found to be an effective treatment for depression, and some positive symptoms associated with schizophrenia.
Brain Imaging Techniques
See Figure 4.15 Computed Tomography Scanning Procedure

**CT or computed tomography:**

- A dye is injected into the blood.
- A series of X-rays is made from different angles; the images reflect the density of blood vessels in each area.
- A computer combines the X-rays into a series of horizontal sections of the brain.
- Is one type of imaging technique that will allow us to view ongoing activity.
Brain Imaging Techniques

Figure 4.16: Magnetic Resonance and Diffusion Tensor Imaging

- MRI or magnetic resonance imaging scans work by measuring the radio-frequency waves emitted by the hydrogen atoms when they are subjected to a strong magnetic field.
  - They provide a more detailed view of the brain.
  - They are reasonably fast, inexpensive, and even portable.

SOURCES: Huntington Magnetic Resonance Center Digital Vision (left). Aaron Filer, MD, PhD (right).
Brain Imaging Techniques

• **PET** or **positron emission tomography**
  
  • Injecting radioactive substance into the bloodstream, which is taken up by active parts of the brain.
  
  • Advantages: ability to track changing activity in the brain, fast
  
  • Disadvantages: expensive, requires sophisticated staff, must be near a cyclotron, relatively slow

SOURCE: Photo Researchers
Brain Imaging Techniques

Figure 4.18: An fMRI Scan

- **fMRI** or **functional magnetic resonance imaging**
  - Measures brain activation by detecting the increase in oxygen levels in active structures.
  - Advantages: activity measurement, good spatial resolution and speed, no radioactive substances
  - Disadvantage: expensive, very slow

## Brain Imaging Techniques

Cautions when attempting to interpret results.

<table>
<thead>
<tr>
<th></th>
<th>Misses a great deal of activity due to it’s lower sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET Scans and fMRIs</td>
<td>Test / re-Test reliability is generally quite low</td>
</tr>
<tr>
<td>Controls</td>
<td>Researchers cannot select particular areas of interest to study</td>
</tr>
<tr>
<td></td>
<td>When all is said and done, we cannot be totally confident that what we saw or are seeing is an accurate representation</td>
</tr>
</tbody>
</table>
Investigating Heredity
Genetic Similarities: The Correlational Approach

• **Correlation** is the degree of relationship between two variables, measured on a scale between 1.0 and -1.0.
  • A high positive value (0.5 to 1.0) means that when one variable is high the other tends to be high and vice versa (positive correlation).
  • A high negative value (-1.0 to -0.5) indicates the opposite tendency; when one value is high the other tends to be low (negative correlation).
• A stronger relationship is one approaching -1 or +1.
Investigating Heredity
Family vs. Adoption Studies

• **Family** studies determine how strongly a characteristic is shared among family members.
  • But heredity and environment are confounded, because people who share genes also share environments.

• **Adoption** studies allow us to measure the children’s similarity to their biological parents and to their adoptive parents.
  • Adoption studies are not true experiments.
  • Results (like for IQ) usually suggest that genetics and the environment BOTH contribute to any area of study.
Investigating Heredity

• **In vitro fertilization** can provide greater control of early environmental effects.
  - E.g., low birth weight in babies of smoking mothers was environmental, but antisocial behavior was genetic.

• **Twin studies** assess how similar twins are in some characteristic.
  - Fraternal twins are genetically like any other sibling, result from separately fertilized eggs, and show lower concordance rates than monozygotic twins.
Investigating Heredity

- A useful measure for identifying genetic influence in disorders is the **concordance rate**.
  - The frequency that relatives share a characteristic.
  - The concordance rate for schizophrenia is about 17% in fraternal twins (who share only 50% of their genes), but almost triples to 48% in identical twins (who share 100% of their genes).
## Investigating Heredity

### Table 4.2: Comparison of Relationship Studies

<table>
<thead>
<tr>
<th>Family Study</th>
<th>Adoption Study</th>
<th>Twin Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicates how strongly a characteristic is shared among relatives</td>
<td>Compares adopted children with their adoptive parents and their biological parents</td>
<td>Compares similarity of twins with that of non-twin siblings, or similarity of identical twins with similarity of fraternal twins</td>
</tr>
<tr>
<td>Can show that a characteristic follows family lines, but confounds heredity and environment</td>
<td>Confounding can occur because the adoption variable is not manipulated</td>
<td>Allows comparison of two levels of genetic similarity</td>
</tr>
</tbody>
</table>
Genetic Engineering
The Experimental Approach: removing or adding a gene

- **Genetic engineering** is an experimental technique involving manipulation of genes or their functioning.
- Eliminating a gene
  - In the **Knockout** Technique, a nonfunctioning gene is transferred into embryos, creating organisms without a functioning gene.
  - The **Antisense RNA** procedure injects an animal with complementary RNA, which docks with the gene’s messenger RNA; the cell recognizes this RNA as abnormal and destroys it.
- In a **transgenic** animal (usually a mouse), a gene is inserted into the developing embryo, creating an organism with an extra gene.
Research Techniques
Gene Therapy. Figure 4.1: The Original “Bubble Boy”

• Genetic engineering is finding practical application in gene therapy.
  • Several children treated for Severe Combined Immunodeficiency Disease (the “bubble-boy disease).
  • In 2 children, gene therapy halted the progress of a demyelinating brain disorder.
  • There has been some success in treating Alzheimer’s disease.
• But gene therapy entails risks and raises ethical questions.
Research Ethics
Cardinal Sins of Research... The BIG 2 are...

- **Plagiarism** is the theft of another’s work or ideas.
  - Can be purposeful (taking credit for another’s work), or due to carelessness or lack of knowledge (such as not citing where information came from)

- **Fabrication** (faking results) is more serious than plagiarism because it introduces erroneous information into the body of scientific knowledge.
  - University of Pennsylvania social psychologist (Dr. Has Uri Simonsohn) devised a statistical method to detect suspicious patterns in research data.

For discussion:
http://news.sciencemag.org/education/2012/06/fraud-detection-method-called-credible-used-instrument-medieval-torture
Research Ethics
Protecting the Welfare of Research Participants / Human Research

- **Informed consent** means that the individual voluntarily agrees to participate after receiving information about any risks, discomfort, or other adverse effects that might occur.

- **Deception** involves:
  - failing to reveal the exact purpose of the research;
  - failing to reveal what will happen during the study; or
  - actively misinforming the participants.

- Deception is considered acceptable only when:
  - the value of the study justifies it;
  - alternative procedures are not available; and
  - the individuals are correctly informed afterward.
Research Ethics
See Figure 4.21: Protecting Welfare of Research Participants / Animal Research

• Nonhuman animals have important advantages.
  • They live in a controlled environment, have a homogeneous history of experience, a briefer development and shorter lifespan.

• Activists have raised concern about animal research... and they have made some headway
  • More work is now done using computer simulations and tissue cultures.
  • The number of animals being used has steadily declined.

• Animal care and use guidelines have been strengthened and monitoring has been increased.
  • In 2011, NIH suspended all new research on chimpanzees until new standards are met.
Genetic Engineering
See Figure 4.23: Injecting Stem Cells into Damaged Nervous System

- Sources for embryonic stem cells are limited
- Policies for stem cell research vary from country to country, and change over time
- Involves injecting stem cells (before differentiation) into damaged parts of the brain/spinal cord
- Cells presumably differentiate and form new structures in the brain
  - Some patients have developed leukemia or tumors
  - Stem cells have migrated to other areas.
Research Ethics

• In spite of its promise, gene therapy has raised ethical concerns.
  • It has led to at least one death.
  • There is some concern that gene therapy could affect reproductive cells and change the genome of offspring.
  • Some believe that gene therapy will be used for purposes other than disease treatment, such as enhancing strength, beauty, or intellect.
  • One clinic offers parents the chance to “design” their babies.