BIOPSYCHOLOGY AND THE FOUNDATIONS OF NEUROSCIENCE

CHAPTER 3
Everything psychological is simultaneously biological.

To think, feel or act without a body would be like running without legs.

We are bio-psycho-social systems. To understand our behavior, we need to study how biological, psychological and social systems interact.
The human brain is the most complex system, natural or man made, in the world.

- About 3 lbs.
- About the size of a grapefruit
- Pinkish/gray in color
- About 100 billion nerve cells
- At a loss rate of 200,000 per day during our adult lives we still end up with over 98% of our brain cells.
Biopsychology

- **Biopsychology**: The specialty in psychology that studies the interaction of biology, behavior and mental processes.
  - The mind thinking about the mind.

- **Neuroscience** is a newer field of study in psychology focusing on the brain and our behavior.
We are born with certain innate abilities, or things we are already programmed to do. But, there are things we must learn.

Evolution is the gradual process of biological change that occurs in a species as it adapts to its environment.
The Role of Evolution

- Evolution has fundamentally shaped psychology because it favors genetic variations that produce adaptive behavior.

The evolutionary process is the link between genetics and behavior.
Natural selection says those individuals best adapted to the environment are more likely to flourish and reproduce; those that are poorly adapted will tend to leave fewer progeny, and their line may die out.

For those individuals whose ancestors had accumulated new traits that allowed them to survive, the result “would be the formation of a new species (Darwin, 1859).”
Natural Selection

- Owl butterfly example
  - [http://www.youtube.com/watch?v=dR_BFmDMRai](http://www.youtube.com/watch?v=dR_BFmDMRai)
There are two main misconceptions about evolution and evolutionary psychology.

1. **Darwin said humans come from monkeys.**
   - In reality he suggests that we had a common ancestor millions of years ago.

2. **Behavior can alter heredity.**
   - People didn’t start growing bigger brains so they could communicate with language, but people who had bigger brains and could communicate had an easier time surviving.
     - As a result, a bigger brain became a dominate trait in humans.
The majority of sciences recognize evolution as a valid theory for more than a century.

Psychology has been slow to accept evolutionary psychology as a psychological theory.

Some psychologists say it puts too much emphasis on nature (biological) and not enough on nurture (learning).
Psychologists agree that genetics play a role in our basic makeup including our temperament, tendency for fears and certain behavior patterns.

Our genetic inheritance is broken into two categories: *genotype* and *phenotype*.
Genotype and Phenotype

- **Genotype**: An organism’s genetic makeup.
  - The blueprint for what an organism is.

- **Phenotype**: An organism’s physical characteristics.
  - This includes the chemistry and “wiring” in our brains.
Heredity and the Environment

- One important thing to remember about heredity is that it never acts alone.

- Heredity always acts in a partnership with the environment, which includes biological influences like nutrition, disease, and stress.
Chromosomes, Genes and DNA

- Every cell in the body carries a complete set of biological instructions for building the organism. We have 23 pairs of chromosomes.

- Each chromosome consists of a long tightly coiled chain of DNA. This DNA holds our unique genetic characteristics.
Genes: A segment of chromosome that encodes the directions for the inherited physical and mental characteristics of an organism.

- Genes are the “words” that make up the organism’s instruction manual.
Chromosomes

- **Chromosomes**: Threadlike structures consisting mostly of DNA, along which the genes are organized.

- Chromosomes are like a string of words in a coded sentence. They also act as “punctuation,” detailing how and when each gene is to be expressed.
Sex Chromosomes

- The two chromosomes responsible for determining a person’s biological sex are represented as either “XX” for femaleness or “XY” for maleness.

- From your mother, you inherit an “X,” essentially leaving your father’s contribution to determine your biological sex, depending on if you inherit an “X” or a “Y.”
Why You Don’t Look Exactly Like Your Siblings

- It is important to remember that you are not exact replicas of your parents.
- You and your siblings probably look similar, but not exactly the same. This is because what you inherit from your parents is a random shuffling of genes.

- This random shuffling and variation is what Darwin viewed as the raw material for evolution.
A Debate for the Future

- This could be a touchy subject, so do not take any arguments personal!

- With some degree of certainty, parents can pick the sex of their child. Within the next 25-30 years, it is expected that parents will be able to pick the components of their child like a Subway sandwich line, adding and deleting certain physical and mental characteristics.

- Is this a good idea?
You Choose…

- In your book on page 69, read the section “Choosing Your Children’s Genes.”
- Then answer these questions on a separate sheet of paper. After you are done, we will discuss and debate.

  1. If you could select 3 genetic traits for your child, what would they be?
  2. If you knew you were a possible carrier for a genetic disorder, would you want to be tested before having children? Why or why not?
  3. Develop an argument supporting genetic manipulation or an argument against genetic manipulation.

- Your response to question #1 can be short. Your answers to questions #2 and #3 should be a paragraph each.
Sports Illustrated Article

- Article in AP Psych Binder
How Your Body Communicates

- Internally, your body has two communication systems. One works quickly, your nervous system, and one works slowly, your endocrine system.
These two systems do not just work in cooperation during stressful situations like a car accident, but also in happier situations, such as when you earn an unexpected “A,” or “fall in love.”
Why Study Them

- These two systems are the biological foundations for all of our thoughts, emotions and behaviors.

- When one of these two systems falters, the result can be a multitude of effects on the brain and mental functions, some mild and some life altering.
Neurons: Our Building Blocks

- Neurons are cells specialized to receive, process and transmit information to other cells.
  - Bundles of neurons are called nerves.

1. Axon
2. Dendrite
3. Motor neuron
4. Bundle of neurons
5. Outer sheath
6. Sensory neurons
7. Blood vessels
3 Types of Neurons

- While neurons can be different sizes and shapes, they all share a similar structure and function in a similar way.

- Neurons are broken into three categories based on their location and function:
  - Sensory Neurons
  - Motor Neurons
  - Interneurons
A neuron exists to perform 3 tasks:

1.) Receive information from the neurons that feed it.
2.) Carry information down its length.
3.) Pass the information on to the next neuron.
Sensory Neurons

- *Sensory neurons*, or *afferent neurons*, act like one-way streets that carry traffic from the sense organs *toward* the brain.

- The sensory neurons communicate all of your sensory experience to the brain, including vision, hearing, taste, touch, smell, pain and balance.
Motor Neurons

- Motor neurons, or efferent neurons, form the one-way routes that transport messages away from the brain to the muscles, organs and glands.
Interneurons

- Sensory and motor neurons do not communicate directly with each other. Instead, they rely on a middle-man.

- *Interneurons*, which make up the majority of our neurons, relay messages from sensory neurons to other interneurons or motor neurons in complex pathways.
What a Neuron Looks Like

- **Axon Terminals**: transmitters
- **Dendrites**: receivers
- **Schwann's Cells**: they make the myelin
- **Node of Ranvier**: myelin sheath
- **Axon**: the conducting fiber
- **Myelin Sheath**: insulating fatty layer that speeds transmission

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How Neurons Work

- The **dendrite**, or “receiver” part of the neuron, which accepts most of the incoming messages.
  - Consists of finely branched fibers.
  - Selectively permeable
How Neurons Work

- Dendrites complete their job by passing the incoming message on to the central part of the neuron called the **soma**.

- The soma, or **cell body**, contains the cell’s nucleus and life-support machinery.

  - The function of the soma is to assess all messages the cell receives and pass on the appropriate information, at the appropriate time.
How a Neuron Works

- When the soma decides to pass-on a message, it sends the message down the **axon**.
- The axon is a single, larger “transmitter” fiber that extends from the soma.
  - This is a one way street
Axon

- The **axon** is the extension of the neuron through which the neural impulses are sent.

- In some neurons, like those of the brain, the axons are very short. In others, like those in the leg, they can reach 3 feet long.
Action Potential

- Information travels along the axon in the form of an electrical charge called the **action potential**.

- The action potential is the “fire” signal of the neuron and causes neurotransmitters to be released by the terminal buttons.
The myelin sheath protects the axon and the electric signal that it is carrying much like the orange plastic coating does on an electrical cord.

The myelin sheath is made up of Schwann cells, which is just a specific type of glial cells.
The axon gets its energy from charged chemicals called ions. In its normal state, the ions have a small negative charge called resting potential.

This negative balance can be easily upset, however. When the cell becomes excited, it triggers the action potential, which reverses the charge and causes the electrical signal to race along the axon.
The neuron is a mini decision maker. It received info from thousands of other neurons-some excitatory (like pushing the gas pedal). Others are inhibitory (like pushing the breaks). If the excitatory signals, minus the inhibitory signals exceed a minimum intensity, called the **absolute threshold**, then action potential is realized.
Refractory Period

- Each action potential is followed by a brief recharging period known as the refractory period.
- After the refractory period, the neuron is capable of another action potential.
  - Much like waiting for the flash to recharge on a disposable camera before you can take another picture.
Once the action potential is released, there is no going back. The axon either “fires” or it does not. This process is called the all-or-none principal.

- How do we detect a gentle touch from a slap? A strong stimulus, like a slap, can trigger more neurons to fire, more often, but not any stronger.
  - Squeezing a trigger harder won’t make the bullet go faster.
Depolarization is the initial movement of the action potential where the action passes from the resting potential in the cell body into the action potential in the axon.
Neural Communication

Cell body end of axon

Direction of neural impulse: toward axon terminals
Neurons do not actually touch each other to pass on information. The gap between neurons is called the **synapse**.

The synapse acts as an electrical insulator, preventing an electrical charge from racing to the next cell.
How Cells Connect

- To pass across the synaptic gap, or synaptic cleft, an electrical message must go through a change in the terminal buttons.

- This change is called **synaptic transmission**, and the electrical charge is turned into a chemical message that flows easily across the synaptic cleft.
How Cells Connect

- In the terminal buttons are small sacs called **synaptic vesicles**. These vesicles contain **neurotransmitters** which are chemicals used in neural communication.

- When the action potential reaches the vesicles, they are ruptured and the transmitters spill out. If they have the right fit, the transmitters fit into the receptors like a key into a lock.
Neural Communication
A Field Trip!!!!

- Now that we have acted out neurons and action potential, we will go look at the neuron models our school has.

- To do this, we will have to take a field trip….

  TO THE BATHROOM

- It just so happens, that toilets are the perfect examples of neurons.
How Does a Neuron Work?

Structure of a Typical Neuron

- Dendrite
- Cell body
- Node of Ranvier
- Axon
- Axon terminal
- Myelin sheath
- Schwann cell
- Nucleus
The chemicals that our bodies produce work as agonists (excite) and antagonists (inhibit). They do this by amplifying or mimicking the sensation of pleasure (agonist), or blocking the absorption of our neurotransmitters (antagonist).

- Agonist-opiates mimic the high produced naturally
- Antagonist-botulin blocks ACh (enables muscle action)
Neural Communication

- Neurotransmitter molecule
- Receptor site on receiving neuron
- Receiving cell membrane
- Agonist mimics neurotransmitter
- Antagonist blocks neurotransmitter
Amongst the vast number of neurons are glial cells. These cells bind the neurons together and help provide insulating covering for the axon.

They act as glue to hold cells together, facilitate communication and potentially play a role in intelligence.
Now we will do a demonstration that will show how neurons work and travel.

Each person needs to stand up and form a “conga line” (you know the awesome dance lines old people love to do at weddings).
### Common Neurotransmitters/Functions

**SOME NEUROTRANSMITTERS AND THEIR FUNCTIONS**

<table>
<thead>
<tr>
<th>Neurotransmitter</th>
<th>Function</th>
<th>Examples of Malfunctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetylcholine (ACh)</td>
<td>Enables muscle action, learning, and memory</td>
<td>Undersupply, as ACh-producing neurons deteriorate, marks Alzheimer’s disease</td>
</tr>
<tr>
<td>Dopamine</td>
<td>Influences movement, learning, attention, and emotion</td>
<td>Excess dopamine receptor activity linked to schizophrenia; starved of dopamine, the brain produces the tremors and decreased mobility of Parkinson’s disease</td>
</tr>
<tr>
<td>Serotonin</td>
<td>Affects mood, hunger, sleep, and arousal</td>
<td>Undersupply linked to depression; Prozac and some other antidepressant drugs raise serotonin levels</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>Helps control alertness and arousal</td>
<td>Undersupply can depress mood</td>
</tr>
<tr>
<td>GABA (gamma-aminobutyric acid)</td>
<td>A major inhibitory neurotransmitter</td>
<td>Undersupply linked to seizures, tremors, and insomnia</td>
</tr>
<tr>
<td>Glutamate</td>
<td>A major excitatory neurotransmitter; involved in memory</td>
<td>Oversupply can overstimulate brain, producing migraines or seizures (which is why some people avoid MSG, monosodium glutamate, in food)</td>
</tr>
</tbody>
</table>
Plasticity

- Neurons have the ability to change and make new connections. This ability is called plasticity.

- This means the nervous system, and especially the brain, has the ability to adapt or modify itself as the result of experience.
Plasticity Video
The Nervous System

- **Interneurons**
  - CNS neurons that internally communicate and intervene between the sensory inputs and motor outputs.

- **Motor Neurons** - *afferent neurons*
  - Neurons that carry outgoing information from the CNS to muscles and glands. Also known as efferent neurons.

- **Sensory Neurons** - *afferent neurons*
  - Neurons that carry incoming information from the PNS to the central nervous system and the brain. Also known as afferent neurons.
The nervous system has 2 major components:

- **Central Nervous System (CNS)**
- ** Peripheral Nervous System (PNS)**.
The Central Nervous System includes the brain and the spinal cord.

They are so important to the human body that they are encased in bone for protection-

- Support for evolutionary psychologists
The Peripheral Nervous System

- The Peripheral Nervous System contains all of the nerves which feed into the brain and spinal cord.
- Any nerves or neurons that feed into the central nervous system

Fig. 2. The human central nervous system, exposed by dissection from the dorsal aspect. Shows the brain, spinal cord and the proximal parts of the spinal nerves.
The Peripheral Nervous System

- **Somatic Nervous System**
  - The division of the peripheral nervous system that controls the body’s skeletal muscles—voluntary movements

- **Autonomic Nervous System**
  - The part of the peripheral nervous system that controls the glands and the muscles of the internal organs (such as the heart)
    - **Sympathetic Nervous System**
      - The division of the autonomic nervous system that arouses the body, mobilizing its energy in stressful situations
    - **Parasympathetic Nervous System**
      - The division of the autonomic nervous system that calms the body, conserving its energy
The Nervous System

**CENTRAL NERVOUS SYSTEM**
- Brain
- Spinal cord

**SYMPATHETIC**
- Dilates pupil
- Stimulates salivation (weakly)
- Relaxes bronchi
- Accelerates heartbeat (strengthens contractions)
- Inhibits activity
- Stimulates glucose release by liver
- Secretion of adrenaline, noradrenaline
- Relaxes bladder
- Stimulates ejaculation in male

**Salivary glands**
- Lungs
- Heart
- Stomach
- Pancreas
- Liver
- Adrenal gland
- Kidney
Reflexes

- Our automatic response to stimuli are reflexes.
  - A simple spinal reflex pathway is composed of a single sensory neuron and a single motor neuron, connected through the spine with an inter neuron.
  - This type of response does not involve the brain, and is often why we feel our body move before we feel the stimuli
    - A warm, headless body could demonstrate a reflex like that produced when hitting the patellar tendon with a hammer.
A. Afferent neuron
B. Efferent neuron
C. Interneuron

Receptors (thermal and pain in the skin)

Effector (biceps brachii muscle)
Divisions of the Nervous System

- Nervous System
  - Peripheral Nervous System (PNS)
    - Autonomic System
      - Sympathetic (Arousing)
    - Somatic System
      - Parasympathetic (Calming)
  - Central Nervous System (CNS)
The Endocrine System

- The endocrine system is the body’s chemical messenger system, that relies on hormones.
  - It involves the endocrine glands: pituitary, thyroid, parathyroid, adrenals, pancreas, ovaries, and testes.

- Hormones are chemical messengers used by the endocrine system. Many hormones are also neurotransmitters.
Working with Other Systems

- Under **normal** (unaroused) conditions, the endocrine system works in parallel with the **parasympathetic** nervous system to sustain our basic body processes.

- In **crisis**, the endocrine system shifts into a new mode to support the **sympathetic** nervous system....it releases epinephrine (adrenalin)
  - Triggers the “fight or flight” response
While the body has a many glands which are important, the most important glad is the **pituitary gland**.  
- Controls all of the responses of the endocrine system.

- The pituitary gland is no larger than a pea, and is located at the base of the brain.
pineal gland

hypothalamus

optic chiasma

pituitary gland
To get a feel for how complex our brains are think about this:

- You could join two eight-studded Lego bricks 24 ways, and six bricks nearly 103 million ways.
- With some 40 billion neurons, each having roughly 10,000 contacts with other neurons, we end up with around 400 trillion synapses.
- A grain of sand size speck of your brain contains 100,000 neurons and one billion synapses.
Neurons cluster into work groups called **neural networks**.

- To understand why this happens, think about why cities exist and how they work.
- Neurons work with those close by to ensure short, fast connections.

The brain learns by modifying certain connections in response to feedback.
For creatures with more complex brains, there are three levels. Creatures with complex brains all share a similar stalk, the brain stem.

- The brain stem is the part of the brain with the longest ancestry
- Even the most simple creatures have this part of the brain

On top of the brain stem, in more evolved creatures, are the limbic system and the cerebral cortex.
The brain stem is made up of four regions: the medulla, the pons, the reticular formation and the thalamus.
The Medulla

- The medulla is the bulge low in the brain stem. It regulates basic body functions including breathing, blood pressure and heart rate.

- The medulla operates on autopilot without our conscious awareness, like most of our brainstem.
The Pons

- The pons is an even larger bulge that sits just above the medulla.

- The pons helps relay signals to the cerebellum that deal with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation and posture.

  - Pons is Latin for bridge, a fitting name since it acts as a “bridge” which connect the brain stem to the cerebellum.
The Reticular Formation

- The reticular formation is a pencil shaped bundle of nerve cells that forms the brain stem’s core.
- One job of the reticular formation is to keep the brain awake and alert.
  - Also is responsible for monitoring incoming sensory messages.
The Thalamus

- The thalamus is at the very top of the brain stem and lays near the center of the brain.

- The thalamus is like the central processing chip of a computer and directs all incoming and outgoing sensory and motor traffic.
  
  - With the exception of smell
Sometimes called the “little brain,” the cerebellum sits at the back of the brain stem and looks like a miniature version of our brain.
- About the size of a baseball

It coordinates with the brain stem and higher parts of the brain to control complex movements we perform without consciously thinking about—walking, dancing, or drinking from a cup.
The Cerebellum

- Acting with the brainstem, the cerebellum controls the most basic functions of movement and life itself.

- Most of the work it does is automatic, and occurs outside our consciousness.
Limbic System

- The limbic system is the middle layer of brain that wraps around the thalamus. Together, the limbic system and the thalamus give humans/mammals the capability for emotions and memory.
The layers of the limbic system not only processes memories and regulate emotions, it is also involved in feelings of pleasure, pain, **fear** and **rage**.

- Cat experiments
- Expands on the more basic functions of the brain stem.
Hippocampus

- One of the two most important parts of the limbic system is the hippocampus.
  - Technically there are two hippocampi and their job is to connect your present with your past memories.
Amygdala

- The second part of the limbic system that is important is the amygdala. Like the hippocampi, the amygdalas’ job relates to memory and emotion.

- It also seems to play the largest role in dealing with feelings of pleasure.
  - Rat studies
Hypothalamus

- A third part of the limbic system is the hypothalamus. It’s function is to analyze the blood flow in your body.
- Specifically regulates body temperature, fluid levels and nutrients.
- When it detects an imbalance, it tells the body how to respond.
- Feeling thirsty or hungry.
When you look at a human brain, the majority of what you see is the cerebral cortex.
Frontal and Parietal Lobes

- **Frontal Lobes:** Portion of the cerebral cortex just behind the forehead.
  - Involves the motor cortex.
  - Involved in making plans and judgment.

- **Parietal Lobes:** Portion of the cerebral cortex at the top of the head.
  - Used for general processing, especially mathematical reasoning.
Temporal and Occipital Lobes

- **Temporal Lobes:** The temporal lobe is involved in auditory processing.
  - It is also heavily involved in semantics both in speech and vision.
  - The temporal lobe contains the hippocampus and is therefore involved in memory formation as well.

- **Occipital Lobes:** Portion of the cerebral cortex just at the back of the brain
  - Responsible for visual functions
Broca’s area and Wernicke’s area
Broca and Wernicke

- **Broca’s Area:** Located in the left frontal lobe.
  - Is involved with expressive language.
  - Damage to this area results in difficulty with spoken language.
  - Area directs muscle movements important to speech production.

- **Wernicke’s Area:** Located in the temporal lobe.
  - Controls receptive language (understands what someone else says.)
Damage to any one of several cortical areas can cause aphasia, or an impaired use of language.

When you read words aloud, the words (1) register in the visual area, (2) are relayed to a second area, the angular gyrus, which transforms them into an auditory code that is (3) received and understood in Werneicke’s area and (4) sent to Broca’s area, which (5) controls the motor cortex as it creates the pronounced word. Depending on which link in the chain is damaged, a different form of aphasia occurs.
Aphasia

1. Visual cortex
   (receives written words as visual stimulation)

2. Angular gyrus
   (transforms visual representations into an auditory code)

3. Wernicke’s area
   (interprets auditory code)

4. Broca’s area
   (controls speech muscles via the motor cortex)

5. Motor cortex
   (word is pronounced)
Damage to Broca’s Area

- When a person experiences brain damage in Broca’s area, the result is often times expressed in difficulty with speech.
  - Common in stroke patients

- Another example of this could be Foreign Accent Syndrome, or FAS.
Motor Cortex

- **Motor Cortex**: An area of the brain at the back of the frontal lobe.
  - In charge of the movement of your body parts.
  - The motor cortex on the right side of your brain controls the movement of the left side of your body, and vice versa.
  - The more intricate the movement for 1 body part, the bigger the section on the motor cortex.

- **Somatosensory Cortex**: The area just behind the motor cortex where your body registers and processes sensations.

- **Association Areas**: Areas that associate various sensory inputs with stored memory.
The Motor Cortex and the Somatosensory Cortex
The Motor Cortex

- Primary motor cortex (M1)
- Foot
- Hip
- Trunk
- Arm
- Hand
- Face
- Tongue
- Larynx
Cerebral Dominance

While both sides of the brain rely on the other half, each hemisphere of the cerebral cortex has specific functions.

**Left Hemisphere**
- Regulation of positive emotions.
- Control of muscles used in speech.
- Control of sequence of movements.
- Spontaneous speaking and writing.
- Memory for words and numbers.
- Understanding speech and writing.

**Right Hemisphere**
- Regulation of negative emotions.
- Response to simple commands.
- Memory for shapes and music.
- Interpreting spatial relationships and visual images.
- Recognition of faces.
Cerebral Dominance

- Keeping in mind that the left side of the brain controls the right side of the body, and vise-versa, we must understand that an injury to the left side of the brain will show bodily symptoms on the right side.

- We also must keep in mind that while each side of the brain may be responsible for certain actions and abilities, the two areas work cooperatively on most tasks.
Hemispheric Differences

- One common misconception is that people can be “right brained” or “left brained.”

- This is another example of pseudo-psychology. In reality we use the both sides of our brain, and the communication between the two halves is important.
  - “Right Brain”/”Left Brain” test
The Splint Brain Procedure

- In the recent past, patients who had severe cases of epilepsy would sometimes be treated with a procedure they called the “split brain.”
- In this procedure they would literally cut the brain in two by cutting the corpus collosum.

[Diagram: The Split Brain Experiment]

“Look at the dot.”

Two words separated by a dot are momentarily projected.

“Point with your left hand to the word you saw.”

“What word did you see?” or

“Art”
For these patients, life changed very little on the service, with the exception of far fewer seizures. Put under certain circumstances, however, the side effects were very clear.
The Endocrine System

- Endocrine System
- The body’s “slow” chemical communication system
- A set of glands that secrete hormones into the bloodstream
Techniques for Studying Human Brain Function and Structure
**EEG (Electroencephalography)**

- **Technique:** Multiple electrodes are pasted to outside of head

- **What it shows:** A single line that charts the summated electrical fields resulting from the activity of billions of neurons
EEG (Electroencephalogram)

- **Advantages**
  - Detects very rapid changes in electrical activity, allowing analysis of stages of cognitive activity

- **Disadvantages**
  - Provides poor spatial resolution of source of electrical activity
**PET** *(Positron Emission Tomography)*

**SPECT** *(Single Photon Emission Computed Tomography)*

- ** Technique:** Positrons and photons are emissions from radioactive substances

- **What it shows:** An image of the amount and localization of any molecules that can be injected in radioactive form, such as neurotransmitters, drugs, tracers for blood flow or glucose use (which indicates specific changes in neuronal activity)
**PET** (Positron Emission Tomography)

**SPECT** (Single Photon Emission Computed Tomography)

- **Advantages**
  - Allows functional and biochemical studies
  - Provides visual image corresponding to anatomy

- **Disadvantages**
  - Requires exposure to low levels of radioactivity
  - Provides spatial resolution better than that of EEG, but poorer than that of MRI
  - Cannot follow rapid changes (faster than 30 seconds)
MRI (Magnetic Resonance Imaging)

- **Technique**: Exposes the brain to magnetic field and measures radio frequency waves

- **What it shows**: Traditional MRI provides high resolution image of brain anatomy, and newer functional images of changes in blood flow (which indicate specific changes in neuronal activity)
Advantages of MRI

- Requires no exposure to radioactivity
- Provides high spatial resolution of anatomical details (<1 mm)
- Provides high temporal resolution (<1/10 of a second)
fMRI—Functional MRI
MEG (Magnetoencephalography)

- **What it shows:** Detects the magnetic fields produced by electrical currents in neurons
  - Detects and localizes brain activity, usually combined with structural image from MRI

- **Advantages**
  - Detects very rapid changes in electrical activity, allowing analysis of stages of cognitive activity
MEG (Magnetoencephalography)

- **Advantages (cont.)**
  - Allows millimeter resolution of electrical activity for surface sources such as cerebral cortex

- **Disadvantages**
  - Poor spatial resolution of brain activity in structures below cortex
  - Equipment is very expensive
Combining a PET Scan and an Magnetic Resonance Imaging