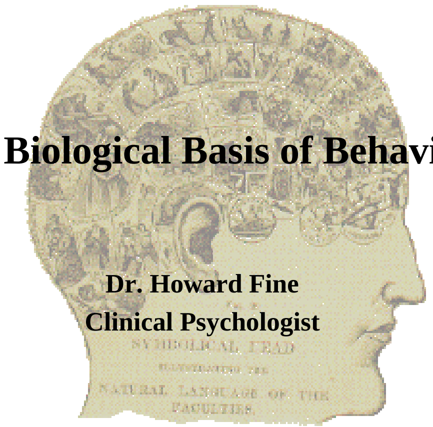
# The Biological Basis of Behavior

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**Clinical Psychologist**



## Why should Psychologists be interested in biology?



## Introduction

- Psychologists are interested in Biology *not* for its sake but for what it can tell them about behaviour and mental processes.

**Relationship between Psychology and Biology**

1. The kind of behaviour of which an animal species is capable of depends very much on the kind of *body* it possess (Wings Vs. Skilled manipulation)
2. The possession of a specialised body is of little use unless the NS is able to control it (evolution).

   Therefore, the kind of behaviour of which a species is capable is determined by the kind of *nervous system* it possesses….



## Introduction 2

**Relationship between Psychology and Biology**

3. The kind of nervous system also determines the extent and the nature of the learning of which a species is capable.
   - i.e. ***phylogenetic - evolutionary***
   – NS becomes more complex and behaviour becomes increasingly the product of learning and environmental influence, distinct from instinct and other innate, genetically determined factors.

# Why study the nervous system?

Furthers our understanding of causes and treatments of nervous disorders:

- Multiple Sclerosis
- Alzheimer's Disease
- Schizophrenia
- Depression
- Sleep disorders (e.g., apnea)
- Childhood disorders (e.g., autism)



# The Nervous System

- The NS consists of:

  Brain

  Spinal Cord

- Allows the body to co-ordinate its physical and physiological functioning efficiently and largely automatically.



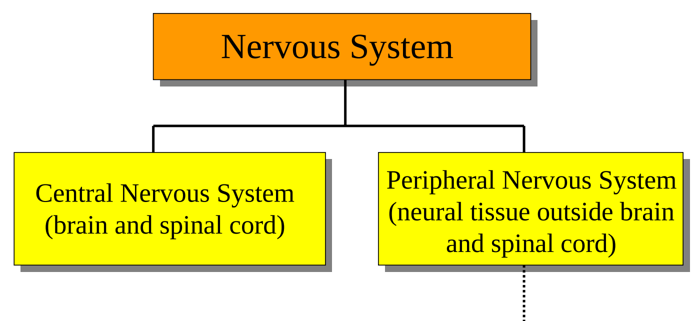
# Structure & Function

- The NS is often divided into three sections (not completely separate) :

1. The Central Nervous System (CNS) - Brain and spinal cord
2. The Peripheral Nervous System (PNS) – network of neural fibres
3. The Autonomic Nervous System (ANS) – Glands and nerve cells controlling body state (mood, emotion).



# Organisation of the Nervous System



Peripheral Nervous System (neural tissue outside brain and spinal cord)

- Somatic nervous system (sensory and motor nerves, voluntary)
- Autonomic nervous system (internal systems, involuntary)
  - Sympathetic division (arousal - “fight or flight”)
  - Parasympathetic division (“returns body to normal”)



# Neurons: The Messengers

- The NS consists of between 10 – 12 billion ***neurons*** (nerve cells) – the basic structural units of the NS.
- Approximately 80% of all neurons are found in the brain, particularly the cerebral cortex (the topmost outer layer).
- Neurons have many of the same features as other cells
  - Nucleus
  - Cytoplasm
  - Cell membrane
- What makes neurons unique is their shape and function

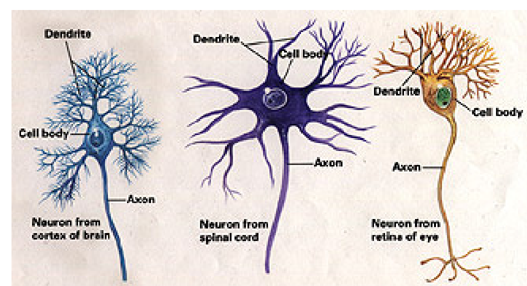


# Types of Neurons

- **Sensory neurons**
  - Carry information from receptors to CNS via dorsal root
  - Also referred to as *afferent*
- **Motor neurons**
  - Carry information from CNS to muscles and glands via ventral root
  - Also referred to as *efferent*
- **Interneurons**
  - Connecting neurons to neurons integrating the activity of sensory and motor neurons (97% of total neurons in the CNS).
  - Also called *Connectors*



# Variations in Neurons

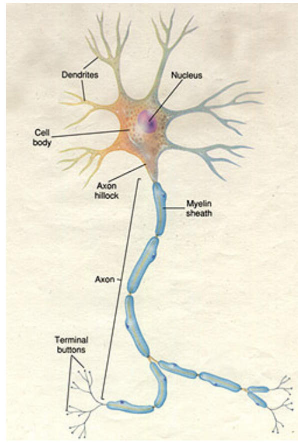



No two neurons are identical, though share same basic structure

# Prototypical Neuron

This illustration represents a prototypical (i.e., idealized) neuron. Dendrites receive incoming information, nerve impulses are transmitted down the axon, and the terminal buttons release neurotransmitters which stimulate other cells.

-Cell body (soma)
- Dendrites
- Nucleus
- Axon
- Myelin sheath
- Nodes of Ranvier
- Arborizations
- Terminal buttons

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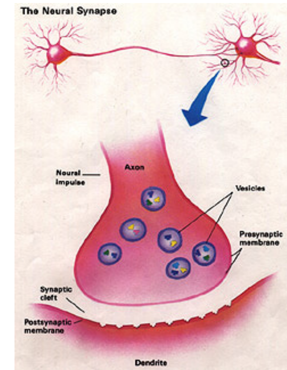
# Making Connections

This enlarged terminal button shows the small sacks or "vesicles" which contain neurotransmitters. When neurotransmitters are released, they float across a tiny gap called the "synapse" (also called the synaptic cleft) between the terminal button and the next cell.

- Vesicles
- Neurotransmitters
- Synapse
- Receptor sites

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# Glial Cells

- ***Glial*** cells ('glue') are smaller than neurons and ten times more numerous, supplying nutrients and structural support.
- Cells that insulate and support neurons
- Create the myelin sheath
- Serve as "phagocytes" (i.e., consume destroyed tissue following neural injury)
- Provide nourishment
- Prevent harmful substances from entering the brain
- "Schwann cells" are the same as glial cells in the PNS

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# Communication by Neurons

You may ask, "how do neurons communicate information?"

- Nerve impulses
- Neurotransmitters

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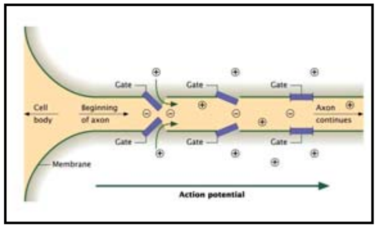
# The Neural Impulse

At its "resting potential," the presence of positively charged sodium ions (Na+) outside the cell membrane make the neuron slightly more negative inside the cell than outside. When the neuron is stimulated sufficiently and reaches its “threshold of excitation,” the membrane becomes more porous, allowing the Na+ to rush inside the cell. That event causes a change in polarity called "depolarization" which makes the inside of the neuron more positive than the outside. That process occurs down the entire axon - called the "action potential" - until it reaches the terminal buttons. The Na+ begins to be immediately pumped back outside the cell. During this "refractory period," the neuron is ordinarily unable to transmit another impulse. Once the Na+ has been removed from inside the cell, the neuron returns to its initial resting potential.




- “Absolute” refractory period
  - Period immediately after an action potential when another action potential cannot occur
- “Relative” refractory period
  - Period following absolute refractory period when a neuron will only respond to stronger than normal stimulation

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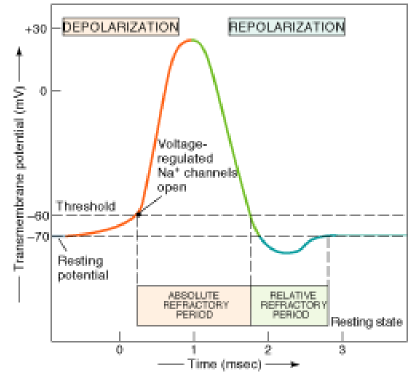
# Life-Cycle of a Neural Impulse

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# The Neural Impulse

- Graded Potentials
  - Slight, temporary changes in membrane potential caused by stimulation insufficient to depolarize neuron
  - Many “subthreshold” stimulations must usually be added together to produce depolarization (a process known as *summation*)
- All-or-None Law
  - A neuron either fires or it does not
  - When it does fire, it will always produce an impulse of the same strength

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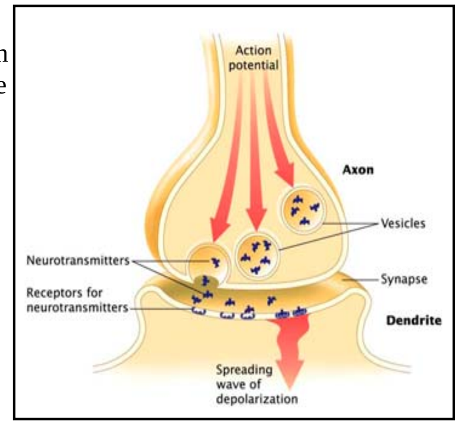
# Communication Between Neurons

Small sacs called “vesicles” release neurotransmitters when the action potential reaches the terminal buttons. Neurotransmitters cross the synapse (synaptic cleft) and attach themselves to receptor sites on the next cell.

Depending on the type of receptor site, the next cell will be excited, making it more likely to transmit a nerve impulse, or it will be inhibited, making it less likely to transmit a nerve impulse.

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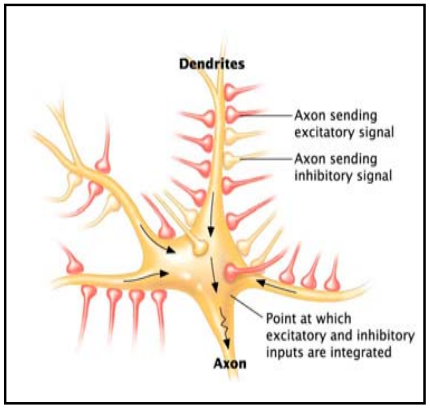
## Excitation and Inhibition

The above illustrates how many terminal buttons from many neurons simultaneously excite or inhibit another neuron. In actuality, one neuron may receive stimulation from as many as 1,000 other neurons.

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## Some Well-Known Neurotransmitters

- Acetylcholine (ACh)
  - Released at the neuromuscular junction
  - Plays an important role in arousal and attention
  - Loss of ACh producing cells is linked to Alzheimer's Disease
- Dopamine
  - Implicated in schizophrenia
  - Plays a role in learning, memory, and emotions
  - Loss of dopamine-producing cells causes symptoms of Parkinson's Disease

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## Some Well-Known Neurotransmitters

- Serotonin
  - Found throughout the brain
  - Appears to sets an "emotional tone"
  - Low serotonin levels are implicated in depression
- Endorphins
  - Reduce pain by inhibiting or "turning down" neurons that transmit pain information

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## Psychopharmacology

Have you ever wondered how drugs work?

- Most psychoactive drugs (and toxins) work by blocking or enhancing synaptic transmission
- Botulism
  - Blocks release of ACh at the neuromuscular junction, causing paralysis
  - "Botox" is botulism toxin used to prevent facial muscles from making wrinkles

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# Psychopharmacology

- Curare
  - Can stun or kill prey quickly
  - Blocks ACh receptors causing paralysis
- Antipsychotic medications
  - Block dopamine receptors
  - Reduces schizophrenic hallucinations
- Caffeine
  - Increases the release of excitatory neurotransmitters by blocking the inhibitory neurotransmitter *adenosine*

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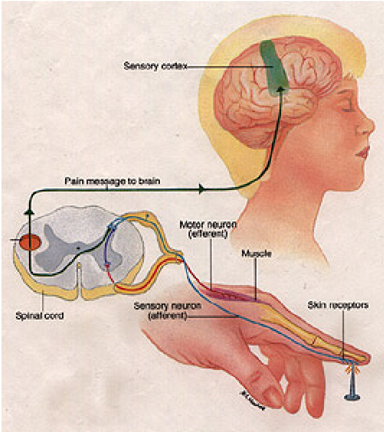
# The Reflex Arc

This illustration depicts a simple example of how communication occurs in the nervous system. Sensory (afferent) neurons detect stimulation and send a signal to the spinal cord where the information is passed on to an interneuron (within the spinal cord) and another neuron to the brain. The interneuron relays the message to a motor (efferent) neuron which signals the muscle to contract and move the finger. A short time later, the brain finally receives the signal and you become aware of the pain. Note the afferent, inter-, and efferent neurons have a myelin sheath on their axons which allow impulses to travel much faster than the unmyelinated axon to the sensory cortex in the brain. It is for that reason the reflex was completed before the brain recognized the pain.

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# Tools for Studying the Nervous System

- Ablation
  - Destruction of portions of brain; examine resulting deficits
  - While typically used on animals, some individuals have been studied following accidents (e.g., strokes, head injury) or surgery (e.g., split-brain patients)
- Brain Stimulation
  - Administer small electrical current or chemicals to different areas of the brain (e.g., Penfield)
- Microelectrode Recording
  - Very small electrodes inserted into individual neurons
  - Used to study activity of a single neuron

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# Tools for Studying the Nervous System

- EEG imaging
  - Electrical activity on the scalp from millions of neurons is used to produce a continuous picture of activity in the brain
- Computerized Axial Tomography (CAT-scan)
  - Uses X-rays to create a 3-dimensional image of the brain

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## Tools for Studying the Nervous System

- Positron Emission Tomography (PET scan) and Single Photon Emission Computed Tomography (SPECT)
  - Radioactive tracer injected in blood stream allowing detection of greater areas of blood flow in brain
- Functional Magnetic Resonance Imaging (fMRI)
  - Radio waves passed through brain causes the iron in hemoglobin to produce a small magnetic field. Greater magnetic signals indicate greater neural activity

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## Central Nervous System (CNS)

Brain and spinal cord

Nerves - bundles of axons

Nuclei - bundles of cell bodies within CNS

Ganglia - bundles of cell bodies outside CNS

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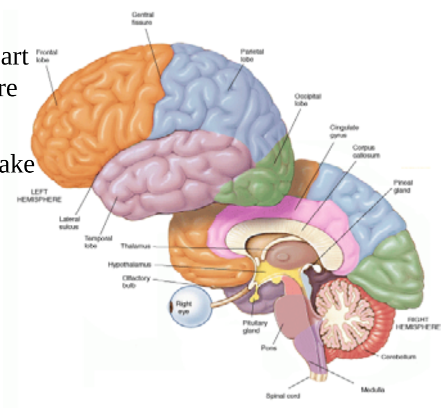
## The Brain – The Central Core

- Medulla
  - Controls breathing, heart rate, and blood pressure
- Pons
  - Maintains the sleep-wake cycle
- Cerebellum
  - Coordinates body's movements

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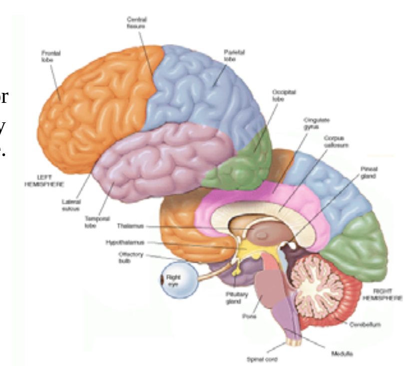
## The Brain – The Central Core

- Thalamus
  - Relays information from sensory receptors to the brain
- Hypothalamus
  - Influences motivated behavior
  - Regulates hunger, thirst, body temperature, and sexual drive.
  - Directly involved in emotional behavior
- Reticular formation
  - Network of neurons found throughout the brain
  - Serves to alert and arouse higher brain in response to incoming information



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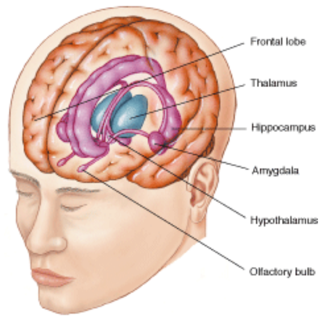
# The Brain – The Limbic System

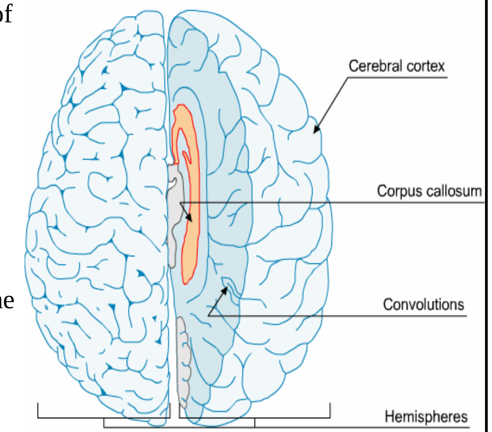
- Ring of structures located between the central core and the cerebral hemispheres
- Important to learning and emotional behavior
  - Hippocampus essential in formation of new memories
  - Amygdala, together with the hippocampus, is important for regulating emotions






# Cerebral Cortex

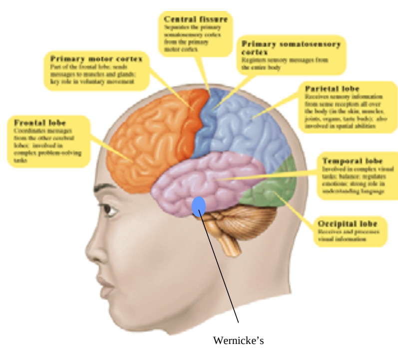
- The outermost covering of the brain is called the Cerebral Cortex. This is the largest part of the brain. It is the wrinkled outer layer controlling 'higher' mental process that enhance learning, memory, thought and language. To fit inside the skull the cerebral cortex has intricate folds called convolutions.






# The Cerebral Cortex

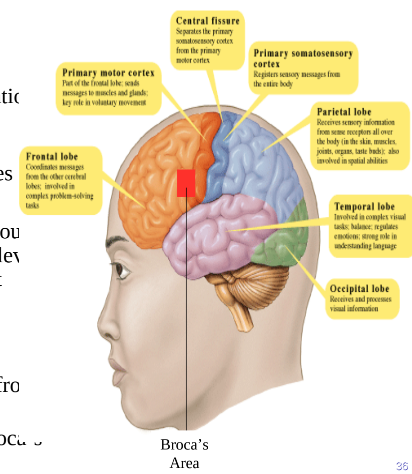
- Temporal lobe
  - Receives and processes auditory information
  - Language processing (Wernicke's Area)
  - Involved in balance, some emotions and motivations
  - Complex visual tasks such as face recognition
- Occipital lobe
  - Receives and processes visual information





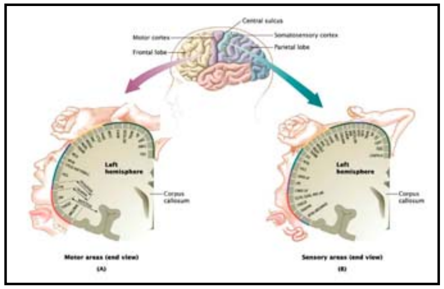

# The Cerebral Cortex

- Parietal lobe
  - Receives sensory informatic from body - "primary somatosensory cortex"
  - Involved in spatial abilities
- Frontal lobe
  - Primarily responsible for ou ability to conduct higher-lev processes such as abstract thinking
  - Includes "primary motor cortex"
  - Coordinates information fro other lobes
  - Language processing (Broca's Area)



# Motor and Sensory Cortex

The amount of tissue in the motor cortex and somatosensory cortex devoted to movement and touch is directly related to the degree of fine motor activity and body sensitivity to touch in that area. Notice those capable of the greatest degree of fine motor activity and the most sensitive areas of the body (i.e., tongue, face, and hands) are represented by the greatest proportion of cortex.



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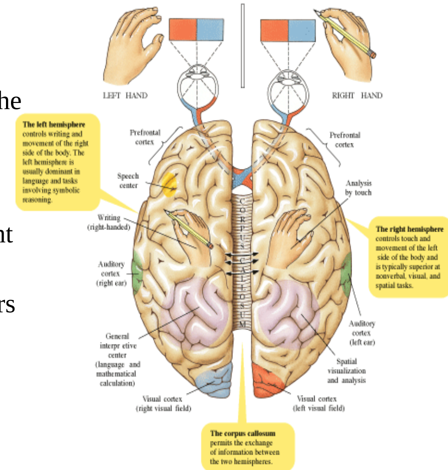
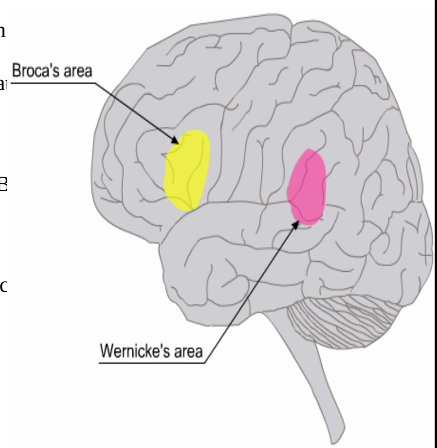
# Hemispheric Specialization

- Corpus Callosum
  - Fibers that connect the two hemispheres
  - Allow close communication between left and right hemisphere
- Each hemisphere appears to specialize in certain functions




# Broca's and Wernicke's Area

- Two language centres located in left hemisphere.
- Paul Broca (1861), observed tha TBI in **left frontal damage** presented with **speech difficulties**.
- Carl Wernicke (1874), found TB to **left temporal lobe** lost the ability to **comprehend speech**.
- Therefore language disorders (aphasias), demonstrate 2 distinc cortical centres for language:
- Broca's area = **expressive** difficulties such as sequencing and producing language.
- Wernicke's area = **expressive** difficulties such as sequencing and producing language.

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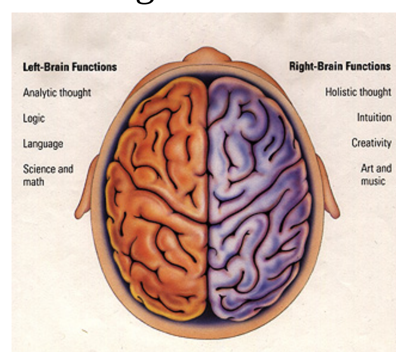
# Left- and Right-Brain Thinking




Both cerebral hemispheres are always active. However, there is a greater concentration of activity in the left or right hemisphere depending on the type of task.

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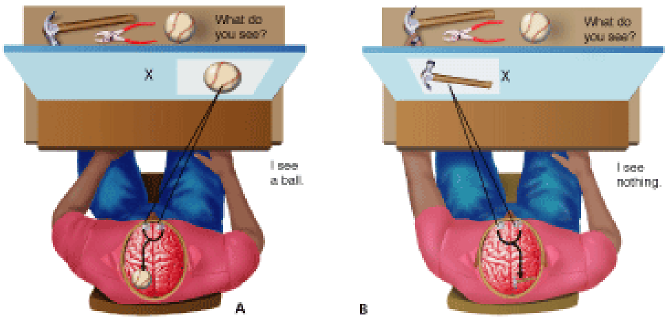
## Split-Brain Research

- Much information about functions of each hemisphere has come from studying split-brain patients

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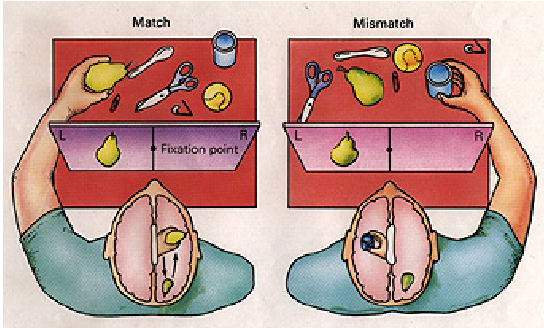
## Split-Brain Difficulties




Patients who have had the corpus callosum severed (i.e., "split-brain") provide unique insights into the functioning of the brain. For example, since information in one hemisphere is not shared with the other hemisphere, patients can identify an object with one hand, but cannot identify the same object with the opposite hand.

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## Neural Plasticity

- The brain can be changed structurally and chemically by experience
- Rat studies show that an “enriched” environment leads to larger neurons with more connections
- Has also been shown in humans
- Recent research has uncovered evidence of neurogenesis, or the production of new brain cells, in human brains

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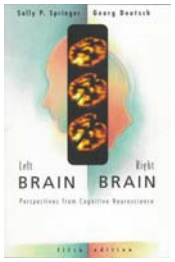
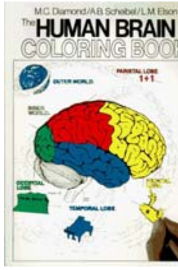
## Suggested Reading





- Deutch, G. & Springer, S. (1997). ***Left Brain, Right Brain : Perspectives from cognitive neuroscience***. Worth Publishers.
- Diamond, M.C. & Scheibel, A.B. (1986). ***The Human Brain Coloring Book***. Collins.
- Rosenzweig, M. R. (1999) ***Biological Psychology : An introduction to behavioural, cognitive, and clinical neuroscience.*** (2nd Ed.) Sinauer Assoc.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## Internet links

- http://serendip.brynmawr.edu/- Articles and links on the brain and behaviour.
- http://www.neuroguide.com/ - Links to journals, images, and resources.
- http://anatomy.umas.edu/HTMLpages/anatomyhtml/neuro_atlas.html – Complete pictorial atlas of the brain.
- http://www.cc.emory.edu/ANATOMY/AnatomyManual/nervous_system.html – Illustrated tutorial of the nervous system.

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## Review Questions

- Why is it important for psychologists to have an understanding of biology?
- In what ways do emotions and stress illustrate the interactions between the nervous, endocrine, and immune system?
- In what way might the issues of causation, genetics and evolution be relevant to understanding depression?
- In terms of drug-taking, how would you distinguish between craving and pleasure? Why might the distinction prove important?
- Why is it misleading to attempt to divide behaviour into such distinct classes as ‘genetically determined’ and ‘environmentally determined’?
- In what sense is the expression ‘selfish gene’ a simplification?

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## Further background reading

- Methods of studying the brain :
  - Animal Studies
  - Physical interventions
  - Chemical Techniques
  - Electrical studies of the brain
  - Brain Scans (CAT, MRI, PET)

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