Psychology Midterm 1

What is psychology?

Recent definition: **the study of mental processes/events and behaviour**

Meyers: the science of the study of the *mind* (mental processes) and *behaviour*

Original definition: the science of the study of the "mind" (psyche) or "mental processes"

Other definition: Psyche is the reality of the human mind, consciousness, and unconsciousness ("life" soul")

Mental Processes/Events:

- What are "mental processes"?
    - Difficult to define
    - Mental processes cannot be observed
    - They can be inferred
        - Can you observe a memory? No. But you can infer it.

Problems:

- Science is objective.
- In any science, we must:
    - Define our variables
    - Observe our variables
    - Quantify our variables

Behaviour:

- Can be defined, observed, measured

Major Divisions of Psychology:

- Experimental Psychology
    - **Began in mid-to-late 1800s**
        - As a branch of physics

        - Psychophysics (perception)
    - First experimental psychology lab was created by Wilhelm Wundt in Leipzig, Germany
    - "The exact description of consciousness is the sole aim of experimental psychology."
    - Basic principles of experimentation are used to explain psychological phenomena (are you conscious? Partially conscious? Unconscious?)
    - **Structuralism:** Developed by Edward Titchener in the US.
        - Basic structures of the mind (analogous to the basic elements in Chemistry)
            - Colour! Do we see RGB when projector projects white (mixture of RGB)?
        - The participant had to look inward (self-reflect, or "introspect") on the contents of their consciousness.
        - This proved to be very unreliable and highly subjective
    - Debate over whether the mind is physical or non-physical
    - Theory of Evolution
        - Darwin - how we managed to survive. Survival of the fittest.
    - What is the function (purpose) of these various mental processes?
    - **Functionalism** (pragmatism - who cares whether the mind is physical or non-physical, what is the function of these various mental processes?
        - Developed by William James in the US (father of American Psychology)
            - What is the function of our thoughts, consciousness and emotions?
        - James did not carry out experimental research.
        - Developed a number of theories about consciousness, attention, and memory.
            - Passive attention, attention capture. (Drilling the walls...are you conscious of it? Could be critical for survival)
        - Wrote the first textbook on Psychology.
        - Again, the study of functions proved to be highly subjective

- *Clinical* Psychology
    - Counselling – psychotherapy
    - Major roots of clinical psychology and therapy are recent - perhaps in the late 1940s in US.
    - 1st Clinical psychology department in Canada - uOttawa!
    - Now a major field in psychology.
    - Sigmund Freud
        - Considered the founder of psychotherapy
        - A psychoanalyst not psychologist

- Applied Psychology
    - Apply knowledge of basic, fundamental psychology
    - Social, developmental, educational (can a child subconsciously be attentive to the teacher?), industrial psychology (how to maximize profit)

Schools of Psychology

*Experimental, Clinical, and Applied can be subdivided into a number of other branches: "schools".

- Cognitive
    - Initially began in late 19th Century (William James).
    - Study of higher "mental functions" -- memory, attention, decision-making, language.
    - Attempts to infer hypothetical mental states of "information" processing based on current response patterns/performance/ decision time.
        - Example) Lexical Decision Task
            - Subject is presented with a list of words. Some are valid English words. Some are not. The subject is asked to push one button if the word is real and another button if it is not. The delay in pushing the button (reaction time) is measured.
            - Can manipulate reaction time.

- Psychology is the study of *behaviour* and the mind
    - What behaviour did we directly observe: How long it took you to respond.
    - How do we explain the delay in RT to the nonword: Searching all our vocab. Known words take less time to recognize.
    - Can we observe this lexical processing? No. We must *infer* this process.
        - Main criticism of Cognitive.
- Attempts to infer Hypothetical mental states of "information" processing
- An exceedingly elegant means to test various cognitive functions (mental events)
    - But these mental processes must be inferred on the basis of performance (RT and accuracy)
- Fell into disrepute because it was thought to be unscientific (by the behaviourists)
    - Revival in 1950s. Now, a "boom" field.
- Subdivisions
    - Cognitive Psychology (see above)
    - Cognitive Neuroscience: use of biological methods to study cognitive activity
    - Cognitive Modelling:
        - Use computers to mimic cognitive/information processing.
            - How many "decisions" must the computer need to make to arrive at a solution to the problem?

- Biological
    - Biological psychologists attempt to measure actual mental events by monitoring brain activity.
    - They either:

    a) Manipulate psychological state/mental events (attention, memory, decision-making) and observe the effect of this manipulation on brain activity and structure
    b) Manipulate brain (stimulate, lesion, drugs) and determine effect on psychology/mental events.
  - Manipulate psychological state and see effect of this manipulation on brain activity, brain structure.

- Behavioural (Early 1900s)
  - Behavioural psych criticized cognitive as being unsciencey, the only think that can be observed is behaviour!
  - Began in 1920s with J. Watson and his criticism of cognitive psychology and psychoanalysis.
  - B.F. Skinner (1935-1990) laid out much of the tenets of "**behaviourism**"
    - Psychology as an objective science
  - The study of mental events is unscientific. This is because mental events are private. They cannot be defined, observed, or measured.
  - All behaviour can be explained by consequences of behaviour.
    - We learn to repeat behaviour that has been "reinforced" + rewarded
    - We do not repeat behaviour that has not been reinforced.
  - A strict environmental (not inner "mind") explanation of behaviour
  - All behaviour is learned
    - A criminal is a criminal because past criminal-behaviour has been reinforced.
  - No need to postulate about genetic influence
  - No need to infer "inner" mental causes
  - (no need to postulate about hidden, "repressed" motives)
  - No point inferring about different types of memory; consciousness, etc.
  - **Deterministic Theory**: all behaviour is determined by consequential events (reinforcement, punishment)

        - If behaviour is inappropriate, it is because of poor learning (reinforcement was given inappropriately) and... Will have to be re-learned (or "corrected")

- Social Psychology
    - Emphasis on social "behaviour"
    - Study of social environment and its effects
    - Social attitudes; social learning

- Evolutionary/Genetic
    - Social-biology (ethology)
    - Most of human behaviour can be explained through evolutionary/genetic principles
    - Selection of traits that enable survival
    - Reproduction of species (and individual genes)
    - Emphasis on the study of animal behaviour (ethology)
    - Deterministic theory
    - Focus on survival of MY genes
    - E.O. Wilson (1975 to present)
    - Richard Dawkins 91975 to present)

- Psychoanalytical/Psychodynamic
    - S Freud (late 19th, early 20th century)
    - Role of unconscious when determining our behaviour
    - Much of behaviour and "emotions" is repressed (especially sexuality).
    - It is these repressed, unconscious influences that dictate our personality and behaviour.
    - Deterministic -- behaviour is determined by unconscious "drives"
    - Criticized as being unscientific
    - How can we prove that there is an unconscious? If we can't it isn't scientific.

- Phenomenological/Humanistic (Clinical Psychology)
    - **Humanistic theories**: Emphasis on unique human quality of behaviour.
    - Concerned with individual's unique personal experience, their phenomenology
    - Focus on subjective experience
    - Concern with developing theories of inner life rather than explaining behaviour
    - Criticized as being unscientific

- Difference among Psychoanalysis, Psychiatry, Clinical Psychology, Experimental Psychology
    - Psychoanalyst: trained in psychoanalysis
        - Emphasis on Freud and post-Freudian (ex. Jung) theory
        - May or may not be a psychiatrist
    - Psychiatrist: residency in "psychiatry". Must have and MD
        - Psychiatrists employ a medical model (look at symptoms then make diagnosis)
        - Psychiatric disorders are a mental "illness". Treatment methods can include psychotherapy and drug therapy.
    - In Canada, only psychiatrists can prescribe medication.
    - Clinical psychologist: In Canada, must have a research degree (Ph.D)
        - Trained in both research and clinical psychology
        - In some regions in the US, a D.Ps will suffice (not trained in research)
        - Emphasis on "abnormal" behaviour and not necessarily "illness"
        - Emphasis on "change" through counselling/psychotherapy
    - Experimental psychologist: Trained only as a researcher (in one of several different areas). Still PhD
        - Not trained in clinical psychology
        - Legally, cannot provide psychotherapy or counselling

- SUMMARY NOTES
    - In psychology, we manipulate the mind, a mental state
    - According to behaviourists, the study of cognition is unscientific
    - Most clinical psychology and psychotherapy does not follow principles of behaviourism
        - Rejected as unworthy to study

- People
  - Wilhelm Wundt
    - First experimental psychology lab; studied basic and simple concepts of consciousness
  - Edward Titchener
    - Attempted to isolate the basic elements/structures of the mind
  - William James
    - Father of American psychology: wrote about "cognitive" psychology; important contributor to a branch of philosophy called *pragmatism*

Scientific Methods

- Epistemology (Methods of obtaining knowledge)
  - Big Research Issues (According to Myers)
    - Stability vs Change
    - Rationality vs Irrationality
    - Nature vs Nurture
  - Divine (non-physical) insight
    - Gain through communication with a higher, non-physical being
    - Knowledge is presumed to be absolute, thus the truth
    - Must have faith or belief in divine truth
  - Pure logic and thought (Aristotle)
    - If logical enough in our reasoning, we should be able to deduce all knowledge
  - Scientific Manipulation
    - Manipulating a variable; observes effect of the varying; now have knowledge

- Idealism vs Materialism
  - Idealist
    - Ex) Plato
    - Does not believe in the physical reality of our existence
  - Materialist
    - Believes all that exists must exist in physical form
    - Must obey laws of physical universe
    - No faith; does not believe in a higher existence (God); Atheist

- Scientific Process
  1. Observation of universe. What is the problem that needs to be solved?
     i. Variables: What is it that varies? Why?

ii. Men are more physically violent than women. Why?

2. Theory: literature search and a summary/synthesis of what is already known
    i. Opinion or speculation? Must arrive to a conclusion by the end (theory)
    ii. Different theories. Controversy
        - Testosterone is associated with aggression
        - Social Learning/modelling
    iii. Hypothesis: educated prediction
        - Must be testable
    iv. Replication: others must be able to replicate processes
    v. Good theory: one that can potentially be proven wrong
3. Definition of variables of interest. Operational definition.
    i. Before a theory can be tested, we need to define our variables
    ii. Problems defining psychological concepts.
        - Define aggression
4. Measure/ quantification of variables. Quantification = more or less.
5. Design the study. Run the study
6. Analyze the results. Usually (but not always) requires the use of statistics.
7. Interpret the results…is the hypothesis supported? Update theory (is it correct or wrong)

- Measures of Central Tendency
    - There are usually (almost always) individual differences in the dependent measure. Some individuals score high; some score low.
    - Statisticians typically employ 3 different measures of central tendency ("typical" score)
    - Perfectly normal curve (mean, median, and mode are identical)
        - **Mode:** the score that occurs most often
        - **Mean:** the average of all the scores
            - Problem: if measures not normally distributed, might distort it (If values too high or too low)
        - **Median:** the value at which half the individuals score above and half score below
            - Better measure of central tendency

- Types of studies
  1. **Case Studies:**
     a. Study one or more exceptional individuals in detail to obtain data that would be true for all of us
     b. Can suggest hypothesis for further testing
     c. BUT can be misleading: generalization, exceptions to the rules
     d. Can think of a single case that can prove the theory right/wrong
     - **Sampling**
       - Selection of certain individuals who are representative of the population
       - Better to have a small but representative sample than large unrepresentative sample
  2. **True Experiments**
     a. Manipulation of one variable (independent) CAUSES another variable (dependent) to vary in a controlled setting
     b. Cause-and-effect: when the manipulation of the independent variable will cause another variable to change
     c. Independent variable: varies since it is manipulated; statistically significant
     d. Dependent variable: the variable which is measured
     e. When scientists don't know why certain variables vary, it is an error; ignorant – inexplicable variance.
     f. Problems:
        i. Small sample often (can it be generalized to the population as a whole?)
        ii. Power of replication! ☺
     - Experimental Design
       - Researchers employ different designs to test theories; assure the results obtained can be explained by extraneous variables that aren't the focus of the studies.

       I. One design uses control and experimental conditions
          a. Control: a condition provides a baseline to which the experimental condition can be compared (receives no manipulation)
          b. Experimental: manipulation is carried out
          c. Random assignment: participants will be randomly assigned to either the control or experimental conditions.

       II. Pre-post designs:
          a. Since we randomly assigned participants as control or experimental there can be different outcomes

        i. Solution: use the same group of participants in both conditions!
    b. Placebo condition
        i. Ensures that all patients have the same expectations. The patients don't know which treatment is being given, but expect the same (one half of patients given placebo, other half given active ingredient. = Random)
    c. Double Blind Study:
        i. Neither the subject nor the experimenter knows if the patient will be getting the placebo or active ingredient.

3. **Quasi-Experiments**
    a. Often in the humanities and health sciences, not possible to manipulate the independent variable (age, sex, etc)
    b. Compares one group to another (ex. Males vs Females)
        i. Ex) males are smarter at math than woman (no manipulations)
    c. Assumed that the differences found are caused by the independent variable.

4. **Naturalistic Observation**
    a. Not in laboratories; studies carried out in the field or "natural" environments to attempt to overcome the limitation of generalization that is imposed on lab studies
    b. Problems
        i. Hard to implement the control of other variables that might affect results
        ii. Difficult to carry out the experiments in the natural environment; researcher cannot easily know why differences occur.
5. **Survey Studies**
    a. In social sciences/psychology, we often gain knowledge of human beliefs and attitudes by directly asking about them with surveys
    b. Participants are asked report behaviour, attitudes, or beliefs; asked a question with which they can either agree or disagree

c. Can be used in a true experiment
d. Problem:
    i. Hard to determine if the sample is truly representative of the population

6. **Correlational Studies**
    a. A change in one variable is also associated with a change in another
    b. A co-relationship (correlation)
    c. Note: this does not mean that change in one variable CAUSES the other variable to change
        i. Ex) smoking and cancer, testosterone and violence
    d. <u>Correlation</u>
        i. A statistical measure of the extent of a relationship between two variables
        ii. Allows one to predict scores on one variable if the scores on another variable are known
        iii. Correlation varies from -1.0 to +1.0
        iv. If negative => scores on one variable increase, the scores on another decrease
        v. If positive => as one score increases, the other score increases as well
        vi. No correlation = 0.0
        vii. Larger the correlation => stronger the association (ability to predict)

- Ethics of Research:
    - Informed consent
        - Can children volunteer to participate? No. parents have to consent.
    - Subjects are anonymous
    - Results are confidential
    - Risks/Harms must be explained
        - Can we allow children to be very violent in a school setting? Is it ethical? Probably not.

- Animals in Research
    - Morality of animal research
    - Are animals "equal" to humans?
    - Are animals a human "resource"?
    - Acceptable to use animals but there must be some benefit to the world as a whole
    - Overall use of animals should be minimized
    - Pain and distress should be minimized
    - Phylogenetic "scale": Use "lowest" animals. (Ex) rat instead of monkey)
        - Replace vertebrate animals with either lower animals or non-animal alternatives (plants)

- Causality and Logical Positivism
    - Every scientific theory must be potentially falsifiable
    - We cannot prove something does not exist
        - I assume there are no tigers on campus, can't prove there aren't any.
    - We can proves something exists (positivism)
    - Logical Positivism
        - Based on theory, scientists form a hypothesis. (Stress; smoking; cancer)
        - According to many philosophers of science, we assume all theories are false unless proven otherwise
        - Thus we assume the negative
        - The *null* hypothesis.

- The Social Modeling theory:
    - We are reinforced by mimicking our peers (model what we consider to be “popular”)
    - Those who watch more violent mass media will be more aggressive

- The Freudian Catharsis theory:
    - Exposure to experiencing a drive will decrease the "Drive"
    - Hypothesis; if children watch violent mass media, the aggression drive will be released.

- Unexplained Variance/Error
    - Variance within each of the groups; there are individual difference among our subjects (cannot explain)
- Explained Variance/Error
    - If the independent variable causes the dependent variable to change, we will know why

- Statistical Significance
    - Divide explained variances by unexplained variance
    - If ration is large enough, the difference is said to be statistically significant
    - The researcher MUST indicate what is the probability of finding a difference this large by chance alone

- Interpret the findings
    - Null hypothesis: violent video will have no effect on children's aggression. => WRONG
    - Psychoanalytic/Freud hypothesis: violent video will cause a decrease in children's aggression => WRONG
    - Social modeling hypothesis: violent video will cause an increase in children aggression
        - Positive evidence to support this.

- A difference is statistically significant?
    - F = explained variance/unexplained variance
    - Ensure explained variance is large
    - The size of experimental effect
        - Likelihood of finding statistical significance increases according to the size of the experimental effect.
        - Larger differences are more likely to be significant.
        - The likelihood of finding significance decreases when the size of the experimental effect is small.
        - The likelihood of finding significance increases when unexplained (individual) variance is small,
            - Decreases when individual variation (individual differences) is large.

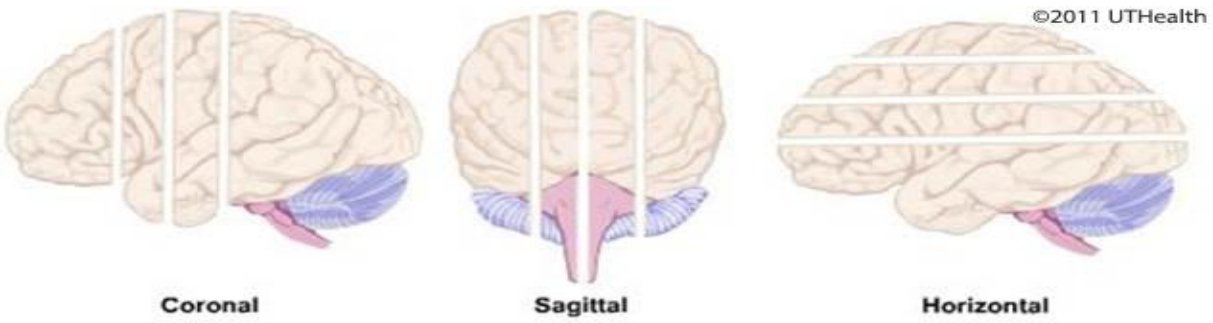
- Ensure unexplained variance is small
- The size of individual differences
- Sample size
  - More confident with results from large samples
  - If very large sample is used, very small differences may be statistically significant

Biology of the Mind

The Brain and Nervous System

- Orientation:
  - Medial-Lateral
  - Ventral-Dorsal
  - Anterior-Posterior
  - Superior-Inferior

- Slices:



- Imaging Techniques:
  - Anatomical techniques:
  - Slicing the human brain
  - Viewing macrostructures with the human eye or microstructures with a microscope
  - Appropriate for Cadavers

- MRI (magnetic resonance imaging)
  - Advantage: provides high resolution images of the human brain
  - Problems:
    - Static. Provides an image of the structures but does not indicate their functions
    - Resolution is limited (cannot see single cells)

        - Very expensive

- Observing the active brain (functional techniques)
    - What areas of the brains are responsible for different animal and human functions?
    - In the clinical setting: Observe functions lost because of brain injury (trauma, stroke, tumours, etc.)
    - Problem: human brain injuries are often widespread and not highly specific
    - In the experimental setting: Lesion a specific part of animal brains to determine its function
    - Stimulate a specific area of the brain to observe the function it controls
    - Optogenetics
    - Problems: in many cases, it is difficult to know just what an animal is experiencing
    - Higher mental states may well differ across species. How applicable are these studies to humans?

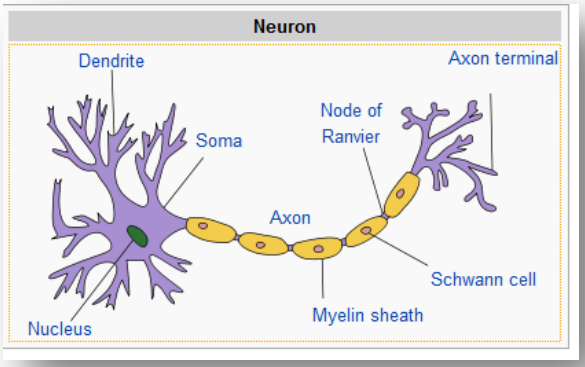
- Human Stimulation Techniques
    - Trans-Magnetic stimulation (TMS)
    - Deep Brain Stimulation (DPS)

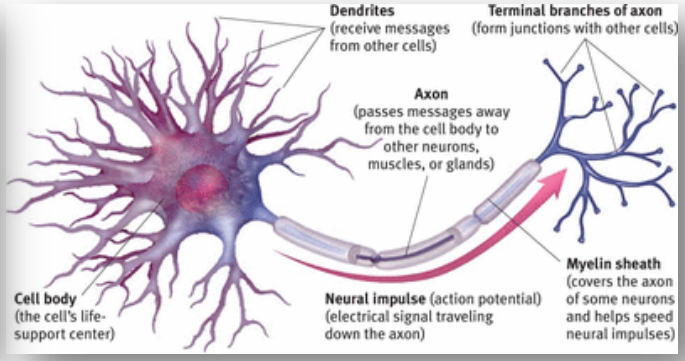
- Human Functional Techniques:
    - PET (Positron emission Tomography)
        - Deoxyglucose (radioactive agent) injected into blood.
        - Indicates which areas are active (and require glucose) for a task to be completed
        - Problems:
            - Invasive. Requires deoxyglucose to be injected into the blood
            - Very slow. Blood circulates slowly. The PET provides an image of all the brain areas that were active within the last 1-2 minutes.
            - The brain makes rapid decisions.
            - Expensive.
    - Functional MRI (fMRI)
        - Uses MRI scan
        - Indicates which areas are active (and require oxygen) for a task to be completed.

        - Problems:
            - Slow. Can be as fast as 200-500 ms to obtain image, but the brain makes decisions much more rapidly than this.
            - Expensive
    - EEG/Evoked Potentials
        - Electrodes attached to scalp
        - Provides an indication of the electrical activity of the brain
        - Evoked Potential
            - When a stimulus is presented, the changes in the electrical activity (the evoked potentials) can be measured.
        - Advantages:
            - Rapid. Processing
            - Inexpensive
        - Disadvantages:
            - Poor spatial resolution
            - Electrical activity from the scalp provides a poor indication

- Studying the developing nervous system

Structure of Neuron





- *DENDRITES*: short branches projecting from cell body. Within the dendrites are embedded highly specialized receptors (see section on terminal endings below)
    - *receive* messages from other neurons

- *CELL BODY (soma):* contains the nucleus of the cell and other basic elements necessary for the survival of the cell.

- *AXON*: a long, slender tube which carries information from the cell body to synaptic terminals. It is analogous to a wire or a cable.
    - The axons of longer neurons are surrounded by a *myelin sheath*. This causes them to appear white. Axons of shorter neurons are not surrounded by a myelin sheath. They thus appear to be grey.
    - The myelin sheath is made up of a lipid (fat) material that may surround long axons. They serve to (1) protect the axon (2) insulate the axon … this thus preventing axonal "cross-talk" (3) speed up transmission
    -
- *TERMINAL ENDING (bouton endings):* As the name indicates, this is the terminal ending of the axon. At this ending, there is a swelling (the "bouton"). This is caused by the storage of neurotransmitter substance here. A physical gap (called the "synaptic gap" or simply the "synapse") separates the terminal ending and the dendrites of the next neuron. When (and if) the neurotransmitters are released, they must travel across this gap. Embedded in the walls of the dendrites of the postsynaptic neuron are highly specialized receptors that can "recognize" the chemical code of the neurotransmitters. The neurotransmitters can then attach themselves (or "bind") to the receptor site. The neurotransmitter may excite or may inhibit the activity of the second neuron (more about this later)

Different Types of Neurons

- *Sensory Neurons*: transmit impulses received by sensory receptors to CNS. These are also called *afferents*.

- *Motor Neurons*: carry outgoing signals from CNS to muscles & glands. These are also called *efferents*.

- *Interneurons*: Sometimes, receive signals from sensory neurons and send impulses to other motor neurons. Much more often, the interneuron is far removed from either sensory or motor neurons. One interneuron communicates with another. This is the route to memory, learning, and complex behaviour.

Neuronal Transmission

Resting Potential

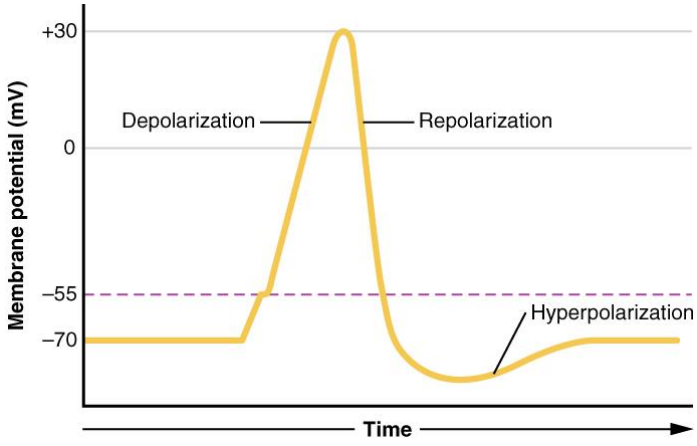
- The neuron, like other cells, carries an electrical charge. Unlike other cells, the charge of the neuron can change.
- This allows one neuron to communicate with another (or perhaps with a muscle).
- An inactive neuron contains an excess of *negatively* charged ions *inside* the cell membrane
- The charge inside the neuron is about -70 milliVolt (mV), but this does vary depending on the species studied (see Figure below on Action Potentials.)
- This charge is called the *resting potential* of the neuron. Thus, the resting potential represents the electrical charge of a neuron when it is inactive. When a cell is charged, it is said to be "polarized".

Excitation of the Neuron (*Depolarization*)

- Outside of the neuron, there is a buildup of positively charged molecules ("ions") ions, largely sodium (Na+) but also potassium (K+). Inside the neuron there is a surplus of both potassium and an excess of negatively charged ions, proteins and importantly chloride (Cl-) charged molecules ("ions").
- This excess negatively charged ions is the cause of the -70 mV charge inside the nerve cell compared to the external cell environment.
- The sodium-chloride balance is critical for the proper functioning of the neuron. Where does the sodium-chloride come from? The salt balance within the body.
- Sodium (and potassium) cannot easily pass through the cell wall (the membrane) of the neuron. Sodium is a relatively large molecule. Moreover, other molecules easily bind to the sodium molecule making it even larger.
- When the dendrite is stimulated by another neuron through the release of an excitatory neurotransmitter (more about this below), or in the lab by electrical stimulation, the cell membrane's "channels" (or "gates") open, allowing *positively* charged ions to flow in (point 1 in the figure above).
- This change in the charge of the neuron (less negativity or more positivity) is called *depolarization.*

Action Potential

- The flow of the positively charged ions into the nerve cell causes the cell's resting electrical potential (or charge) to change. The cell is now less negatively charged (it is now "depolarized"). In the Figure on the right, an electrode stimulates the nerve cell at time 1. Within 1 ms (millisecond), we see the effect. The stimulation causes the cell's electrical potential to change (i.e., to depolarize). The extent of change is dependent on the intensity of stimulation. If it is a small stimulation (low intensity stimulation), the change in the electrical potential of the nerve cell might now be -65 mV (see yellow lines, "failed initiations" in the Figure). If the intensity of the stimulation increases, the electrical potential of the cell may now change to -60 mV (also in yellow).



- Again, the reason the inner cellular environment is now less negatively charged is because of the flow of positively charged ions into the cell.
- When the flow of positively charged ions reaches a certain critical threshold (the "*threshold of excitation"),* the neuron "fires". In the Figure on the right, the "threshold" is about -54 mV. This threshold for firing however varies among different neurons. Once the change in electrical potential reaches the -54 mV threshold (again, the threshold does vary for different neurons), a dramatic change is observed.
- This is called the *action potential.* Now, the channels of the neuron wall open completely and so many positively charged ions rush into the cell (the rising phase of the action potential in the illustration) that the electrical potential initially is at 0 mV (the number of negatively and positively charged ions is the same) but then the neuron becomes "hyperpolarized"). There is now a net positive charge in the nerve cell. The action potential also "propagates" the entire length of the axon. The action potential (the rushing in of the sodium and other positively charged molecules) continues inevitably down the entire length of the axon. Again, this is called *propagation* of the action potential. (point 2 and 3 in Figure on previous page).
- If the level of excitation is not enough (the critical threshold is not reached), the electrical charge of the neuron will return to its resting potential ("failed

initiations" in the Figure) and the charge will not propagate the entire length of the axon.

- The likelihood of reaching the critical threshold is increased by either having a single (or a few) neurons release a great deal of excitatory neurotransmitters (explained later) or perhaps many neurons release only a small quantity of excitatory neurotransmitters but more or less at the same time and the effects of one excitation summates with the others. Thus, the effects of the excitation of several neurons can summate together.
- Once the action potential is initiated, it will travel down the length of the axon. It may then subsequently influence the firing of another neuron.

All-or-None Law

- The action potential will be *propagated* the entire length of the axon or, if the threshold of excitation is not reached, it will not be propagated at all. It is *all-or-none*.
- The amplitude of the action potential is also constant (again, no variation here). In the Figure, the change in the electrical potential in now +40 mV. This amplitude will not vary as the charge moves down the length of the axon. This is inevitable (no variation here). This is also part of the *all-or-none law*. We either get the action potential or we do not. Increasing the intensity of stimulation will not cause the action potential to get larger. Once the action potential is initiated, its amplitude will not become larger, regardless of the intensity of stimulation. Again, the amplitude of the action potentials is all-or-none.
- This has important consequences for coding in the nervous system.
- For example, we cannot code the intensity of the stimulus by the size (or amplitude) of the action potential. Its amplitude cannot vary. If I whisper in your ear and you hear the sound, it is because of action potentials in your auditory neurons. If I now shout, the action potential will be exactly the same amplitude. It will not be larger! However, you can certainly distinguish a whisper from a shout. How? Intensity could be coded by how often the neuron fires or perhaps by how many neurons carry the message.
- The all-or-none law ensures that once the action potential is initiated, it will travel the length of the axon and its amplitude will not vary. There is little room for "freedom" or "flexibility" in the well-protected world of the axon. The response (the action potential) cannot easily be altered (unless there is a fault with the chemical or nutritional balance).
- Once the action potential reaches the end of the axon (at the terminal ending), it will cause a release of neurotransmitters that may travel across the gap (the "synapse") between the pre- and post-synaptic neurons.

- The all-or-none law will NOT apply to synaptic communication. Learning and the formation of new memories will involve changing how the nervous system responds (we'll see this when we study learning and memory). Learning involves flexibility. The nervous system is in one state before learning but in a different state after learning. The changes to the nervous system with the formation of new memories probably take place at the level of the synapse. In very advanced brains (those seen especially in mammals, primates and humans), capable of very elaborate learning, many more synapses will form compared to the more rigid and inflexible nervous systems of phylogenetically "lower" animals. While insects can show very complex behavior, this is largely "hard-wired" and cannot easily be altered. In higher mammals the massive number of synapse come to make exceedingly complex connections and the formation of grey matter.

Propagation of Action Potential

- Action potentials will travel down the length of the axon.
- This involves a slow, tedious process. The cell membrane gates initially open upon excitation, resulting in depolarization.
- This depolarization causes the neighbouring membrane gates to also open, and then this neighbour's gates also open and so forth until the action potential slowly reaches the end of the axon at the terminal ending.
- Long axons are mylineated (they have a myelin sheath).
- The myelin sheath is not continuous. Because the myelin is made of lipid material, the charged molecules cannot penetrate into the axon. At places, the bare axon is exposed. These places are called the nodes (or more correctly, the nodes of Ranvier, named after the French neuroanatomist)
- This allows the action potential to "jump" from node to node.
- Thus, transmission is much faster in mylineated axons. Because long axons tend to be myelinated, while short axons are not, transmission is much more rapid in long axons.

Release of Neurotransmitter

- Under influence of action potential, neurotransmitters are released into the synaptic gap.
- Neurotransmitters may travel across this gap to the post-synaptic neuron.
- Keep in mind that this gap is the "real" extra-cellular (outside the cell) environment outside of the well-protected neuron. Nature protects the neuron with its cell membrane and possible myelin sheath. The neurotransmitters are not nearly as well protected in the external environment at the synaptic gaps.

The neurotransmitters are subject to attack by poisons (toxic agents). They might not be released. They might not reach the post-synaptic site.

- Embedded in the dendrites of the post-synaptic neuron (or perhaps a muscle), specialized receptors can "recognize" the chemical code of the neurotransmitter (similar to a lock and key mechanism).
- The neurotransmitter binds to the post-synaptic receptor. Other chemicals in the synaptic gap cannot bind easily to the post-synaptic receptor site because their chemical code fails to match the "correct" code (but as we shall see later, certain "drugs" may have a chemical code that is quite similar to that of the neurotransmitter and thus these drugs may well bind with the receptor site). It is at the receptor site that the neurotransmitter has an effect on the post-synaptic neuron. It may have an excitatory or an inhibitory effect (see next section).
- The neurotransmitter will have a long-term effect (for example, cause continual depolarization) unless its actions are terminated. Enzymes break down the neurotransmitter so that its effect is not continuous. The molecule is "broken apart". Often the more basic elements of the neurotransmitter are then recycled back into the pre-synaptic neuron to be used again. This is the reuptake process step 3 in the figure.
- Each and every one of these steps can be altered. "Drugs" that are similar in chemical structure to a true neurotransmitter may also bind with the receptor site. They may block the site. When the true neurotransmitter arrives, it will find the receptor site already occupied. As an example, a neurotransmitter called acetylcholine (ACh) causes muscles to contract. A drug (or perhaps a toxic agent) may have a chemical structure similar to ACh and binds with the receptor site on the muscles. Thus, even though the neurotransmitter has been released and should cause muscles to contract, they will not because the receptor site is already occupied by a drug. Your lungs contract because of muscles. This drug will thus prevent the animal from inspiring (breathing in) and it will die a very painful death. This is how the nerve gases of World War I (and more recently in Iraq and Syria) operate. Drugs can also mimic the effect of a neurotransmitter. They may also occupy the receptor site but in this case, they act as a false neurotransmitter. Thus certain drugs may cause you to hyperventilate (you breathe too rapidly). The reuptake process may be ineffective. Perhaps the enzymes are in short supply. Perhaps drugs "attack" the enzymes. Thus, the effect of the neurotransmitter will be prolonged. It will remain at the receptor site for a very long period of time. And, the reuptake mechanism will be delayed. This will leave a short-supply of neurotransmitters in the pre-synaptic site.
- The cozy protected environment of the axon is thus not the rule at the synapse. While transmission in the axon was highly inflexible, obeying an all-or-none

law, this is not the case at the level of the synapse. If we wish to design a nervous system in which flexibility of behaviour (altering past behaviour), learning, memory and complexity are desired, the synapse is the place to do it. It should come as no surprise that in evolution, complex behaviour comes about as a result of expansion of the grey matter, where tiny, unmyelinated interneurons are tightly packed, forming billions and trillions of synapses, and permitting exceedingly elaborate inter-neuronal communication. Unfortunately, these exceedingly elaborate interactions are also exceedingly difficult to understand. The end result is that we, in fact, poorly understand the functioning of the higher centres (the grey matter of the cortex) of the brain, even in very simple animals (those that are not well-cortically endowed). This should however be good news for students… lots of research still to be done and new discoveries to be made.

Actions of Neurotransmitters

- Recall the all-or-none law of the action potential. No flexibility here. This is not the case with the neurotransmitters.
- Neurotransmitters are either excitatory or inhibitory. Thus, it is possible either to increase or to decrease the likelihood that a post-synaptic neuron will fire (i.e., an action potential will be initiated).
- An *excitatory* neurotransmitter will increase the likelihood that the post-synaptic cell will fire. An excitatory neurotransmitter *depolarizes* the neuron. The resting potential becomes less negatively charged than normal.
- An *inhibitory* neurotransmitter will decrease the likelihood that the post-synaptic cell will fire. An inhibitory neurotransmitter hyperpolarizes the neuron. The resting potential becomes more negatively charged than normal. Perhaps rather than having a resting potential at -70 mV, it is now -94 mV. Thus, in order to now reach the threshold of firing for the action potential, the level of excitation must be much higher than usual.
- Why is it necessary to have both excitatory and inhibitory neurotransmitters? Imagine trying to walk. Certain muscles in your leg must be excited (an excited muscle contracts). Others, however, must not contract. If all muscles were contracted, you could not walk (incidentally, this lack of motor "coordination" is often a problem in various muscle dystrophies and in Parkinson's-like diseases). Another example, this time from cognitive psychology and the study of consciousness: Your sensory receptors are constantly bombarded with incoming stimuli. You are however only conscious of a very, very small number of these sensory inputs. Your brain cannot possibly process all this input because of its limited capacity (even though you have a massive amount of grey matter). Only the most relevant of sensory input should reach the very

busy cortex and you might become conscious of this. The vast majority of sensory input is irrelevant, thus processing of what in the end is irrelevant, needs to be inhibited and you will never be conscious that this input had actually stimulated the receptor. Another example: A good deal of the frontal regions of your brain is involved with the inhibition of inappropriate action. This is the essence of the saying: reason over passion… activate the frontal lobe (the centre for reason and logic) but inhibit the drives and passions of the limbic system (the centre for emotions).

Drug Interaction

As already mentioned, drugs can wreak havoc on the effect of neurotransmitters. Keep in mind that neurotransmitters may have either excitatory or inhibitory effects. Again, let us use the example of selective attention and consciousness. To become conscious of relevant stimulus input, processing of that which is irrelevant must be inhibited (or "ignored"). Assume that a drug blocks the inhibitory effects of a neurotransmitter involved in this attentional mechanism. The end result would be that the individual would be overwhelmed with stimulus input not knowing what is relevant and irrelevant.

There are at least 6 ways that this is possible (again, please note the very large flexibility in synaptic transmission):

- Block release of neurotransmitter
- Block storage of neurotransmitter in pre-synaptic neuron
- Cause release of excessive amount of neurotransmitter
- Stimulate or block receptor on post-synaptic membrane
- May attack enzymes that break down neurotransmitter
- Block reuptake of neurotransmitter

Neurotransmitters

Adding to the complexity and flexibility of synaptic transmission is the fact that there are many different types of neurotransmitters having different chemical structures. Several neurotransmitters have now been identified (although we will mercifully only mention a few) and it is thought that considerably more remain to be discovered (any budding biochemists?) All neurotransmitter molecules need to be synthesized from simpler elements, typically extracted from the circulating

blood. We shall return to the neurotransmitters when we discuss how psychoactive drugs can alter the "mind". Here is a short list of known neurotransmitters:

Acetylcholine (ACh)

- ACh is generally excitatory on membranes of skeletal-muscle fibers. It causes muscles to contract.
- Muscle paralysis can be caused by, for example:
    - Botulin (or more properly, botulinum toxin). Botulin blocks ACh release. Pure botulin is amongst the most toxic and lethal substances known 100-200 ng (billionths of a gram) can kill a human adult weighing 100 kg. Botox, an extremely low dosage of botulin, causes muscle paralysis preventing "wrinkling" of the skin.
    - Nerve gas may block receptor site, or interfere with reuptake. Many insecticides also work in this manner.
- Muscle convulsions can be caused by venom in many animals
    - Example: Black widow spider venom (stimulates release of ACh)
- In CNS, role in memory –
    - ACh is depleted in Alzheimer's disease.

Norepinephrine (NE) in the U.S., but *Noradrenaline (NA)* in many other countries

- Synthesized from epinephrine (or adrenaline), a hormone released by the adrenal gland (and the entire world calls it the adrenal gland).
- Important role in alertness and mood.
- Cocaine and amphetamines prolong action of NE -- stimulant effects.
- Lithium -- speeds up breakdown of NE -- depressed mood.

Gamma-Aminobutyric Acid (GABA)

- Major *inhibitory* neurotransmitter of the brain.
- Sedative, sleep and anti-anxiety medications.
    - Benzodiazepines (For example, valium acts by stimulating GABA receptors)

Dopamine (DA)

- Predominantly inhibitory.

- Implicated in movement in the periphery. In the brain, attention, decision-making and learning. Might be involved in ADHD.
- Insufficient quantity of DA: Parkinson's disease leading to tremors & paralysis
- Too much DA: psychosis.
- A side effect of Parkinson's treatment is psychotic symptoms.

Serotonin (5-HT)

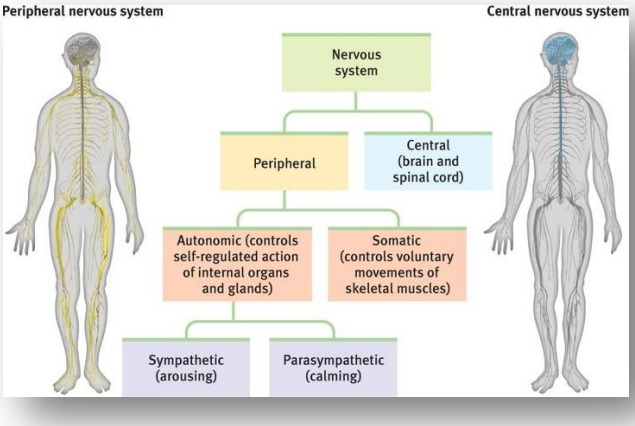
- plays a role in sleep (dreaming?), perhaps control of eating, mood, and pain regulation.
- Drugs that mimic 5-HT may result in bizarre hallucinations. Psychedelic drugs such as LSD, and mescaline have a chemical structure that is remarkably similar to 5-HT. They may thus block the receptor site.
- Certain drugs cause an over-release of 5HT (example MDMA – "Ecstasy"… increase energy. It may cause 5-HT to be completed depleted resulting in withdrawal-like symptoms).

Endorphins

- So-called "natural opiates" of the brain
- Chemical structure similar to opiates (heroin, morphine)
- Inhibit sensation of pain. This explains how pain can be reduced through "natural" means.
- Increase mood and pleasure

Divisions of the Nervous System

1. Peripheral nervous system
    1. Autonomic
        1. Sympathetic
        2. Parasympathetic
    2. Somatic
2. Central nervous system:
    1. The spinal cord
    2. The brain



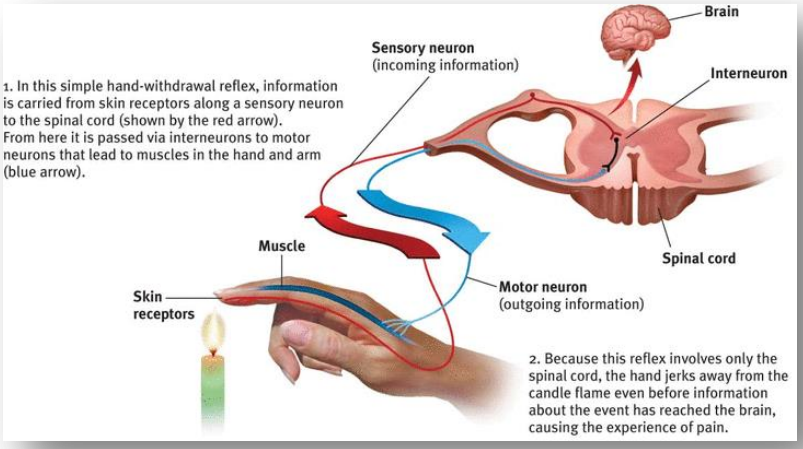
<u>The Peripheral Nervous System</u>

1. Sensory receptors -- in the body and also, specialized receptors in the head
2. Sensory and motor "nerves" -- in the body (soma) and in the head (specialized "senses")
3. Sensory nerves -- *afferent* information from the sensory receptors to the C.N.S.
4. Motor nerves -- *efferent* information from the C.N.S. to the muscles; motor action. Control of “autonomic” or smooth muscles. Control of skeletal (peripheral, surface) muscles. Division is thus known as the autonomic and somatic nervous system. We cannot (easily) control the autonomic nervous (note, it is not called the “automatic” nervous system). It operates essentially independent of our “volition”. By contrast, we do have voluntary control of the somatic nervous system.
5. Autonomic Nervous System: Sympathetic (provides energy and arousal in times of emergency) & Parasympathetic (calming; returns system to normal functioning) branches. For more detail, see section on “Autonomic Nervous System later in these notes.

The Spinal Cord

1. Central grey region: Central region (looks like an “H”) takes on a greyish colour because of densely-packed neurons in this region are not surrounded by a myelin sheath. The neurons are very short. There is very elaborate inter-neuronal communication. Inter-neuronal communication permits flexibility in behaviour. It is this complexity of inter-neuronal communication that will lead in evolution to complex behaviour such as learning, memory and so forth.
2. White surround region: Surrounding the central grey region is the white "surround". This consists of ascending "sensory" pathways that ascend from the spinal cord to the brain and the descending "motor" pathways that descend from the brain to the spinal cord. These ascending sensory pathways are located in the dorsal region of the spinal cord. The descending motor pathways are located in the ventral portion of the spinal cord. The sensory and motor pathways can be very long, up to 5 metres in animals such as the giraffe and whale. Because of their length, the pathways need a means to communicate rapidly. The addition of the myelin sheath to the axons permits very rapid neuronal transmission. Since myelin is lipid (i.e. , fat) material, it takes on a white colour. Thus, the long ascending and descending pathways appear white to the eye.

3. Flexibility of behaviour is also called “plasticity” (it can be moulded). It is also called soft-wiring.
4. The opposite of flexibility is the hard-wiring. Many connections in the nervous system are “wired” genetically. This forms the basis of a reflex (inevitable sensory input-motor output that cannot be altered through learning).
5. Monosynaptic reflex. Sensory input -> motor output (see image below of withdrawal reflex)



6. Polysynaptic reflex

Divisions of the Brain

1. Hindbrain -- medulla, pons
2. Midbrain. Collectively, the medulla, pons and midbrain form what is called the *brainstem*.
3. Forebrain -- diencephalon; cerebrum

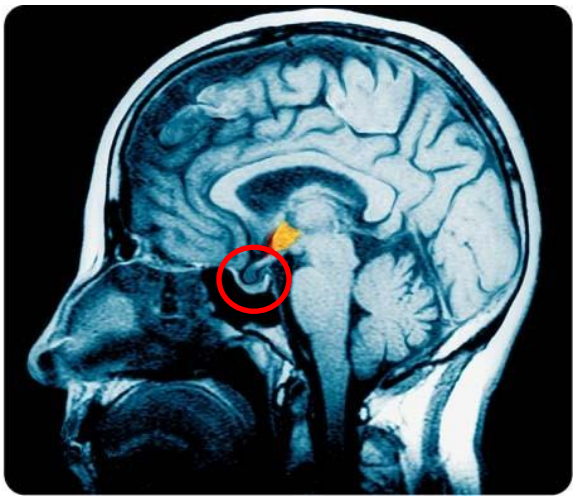
The Brainstem

1. Medulla, pons, midbrain
2. Specialized senses of the head (vision, hearing, taste, smell)
3. Head "muscles" -- eye, ear movement, facial muscles, tongue, lips, etc.
4. Life "support" systems -- temperature; heart, respiration
5. Sleep-wake cycle
6. Reticular activating system (central red area in image). Looks like a spider's web or net (rete in Latin means net). Stimulate any part of the reticular formation and eventually all parts will be stimulated. This does not allow for specific communication. But it is a good means of assuring a generalized reaction. This system allows for general arousal of the brain.
7. Cerebellum. Properly speaking not part of the brainstem but it is connected to it via the pons, the "bridge" over the brainstem that will also provide connections to the motor cortex of the cerebrum. Inter-neuronal communication within the cerebellum is enormously complex. We do know that a good deal of our motor "skills" must be learned. The formation of these motor memories, motor programmes and circuits are stored in the cerebellum. But, we are typically not conscious of the motor programmes. Thus, if I were to ask you how to ride a bicycle, you would have a very difficult time demonstrating to me how to ride the bicycle (because you are not conscious of the various steps in the motor programme). You could nevertheless demonstrate to me how to ride the bicycle. The motor programme must thus be stored. This is also a very important example of

soft-wiring and plasticity. The circuits for the specific motor skill were not established at birth (i.e., established genetically). Rather the circuit is established though "experience" and learning after considerable practice. By contrast, most of the connections in the brainstem are hard-wired and are established through genetics, not through learning and experience.

The Diencephalon

1. Thalamus – Located immediately superior to the brainstem (see image above and MRI image immediately to the right) and inferior to the massive cortices. This is the first place where all sensory systems merge. The thalamus can thus act as a type of receptionist, filtering through which sensory afferents are relevant (and in which case, the message will be relayed to the very busy cortex) and those that are not (in which case, further processing will be inhibited). Functions include integration of incoming sensory information, attention, and consciousness.

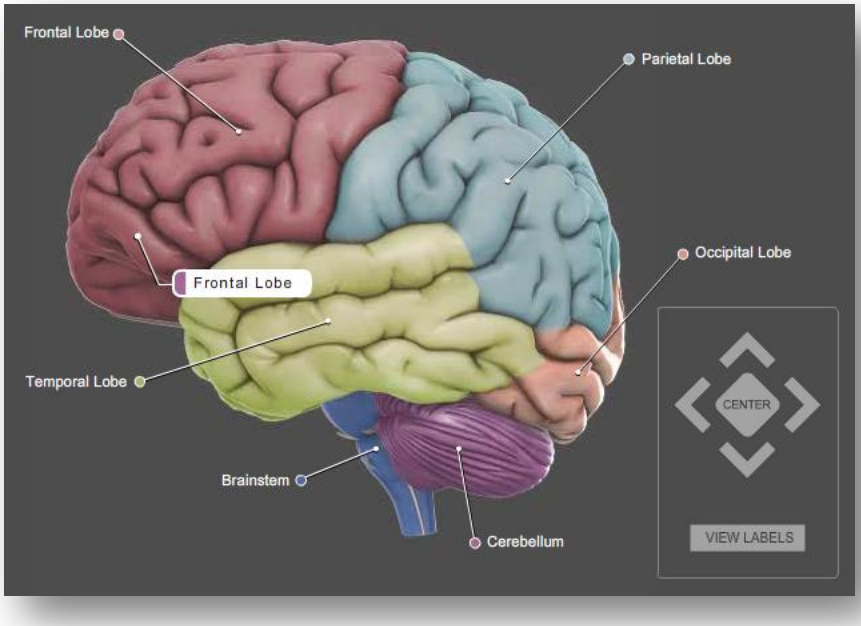


2. Hypothalamus – Located inferior to the thalamus at the base of the brain. The MRI sagittal scan on the right shows the brainstem and posterior to it, the cerebellum and superior to the brainstem is the thalamus. The hypothalamus is inferior to the thalamus (shown in orange). The hypothalamus has many subdivisions each of which controls the basic needs and drives of the organism: eating, drinking, mating, temperature regulation. The hypothalamus monitors the blood that is circulating at the base of the brain. As an example, if there is not enough glucose, a signal goes out and we feel "hungry". If blood pressure is low, we feel "thirsty". The hypothalamus forms part of the autonomic nervous system. The Autonomic Nervous System operates autonomically and is generally not under the control of the cortex. Indeed, it appears to operate independently of our conscious awareness. The hypothalamus is connected at its base to the pituitary gland and ultimately controls it.
3. Pituitary gland – Located at the base of the brain, inferior to the hypothalamus (circled in red in the MRI scan). The pituitary gland, properly speaking is not part of the brain at all. It is the "master" gland of another

system of communication, the endocrine system. The endocrine glands release hormones that circulate in the blood. This is believed to be an older system of communication in the body. The neuronal means of communication is very rapid and can be very specific (it is possible to lift only the left index finger) or can be quite general (generalized sleep, wakefulness). Hormonal communication by contrast is very slow (because hormones circulate in the blood), long-lasting, and generalized. As a result, hormones produce a generalized "drive" that appears to haunt and invade consciousness. The hypothalamus closely monitors the endocrine levels that are circulating in the blood. It can then command the pituitary to increase or decrease the output of hormones in other glands. Ultimately, however, the pituitary is under the control of the brain and more specifically, under the control of the hypothalamus. Thus, it is the hypothalamus that controls the endocrine system.

The Neocortex

1. Sulci and gyri
2. Architecture (6-layered)
3. Central white (more or less) and grey surround
4. Complex interconnections
5. Sub-divided into the frontal, parietal, temporal, occipital lobes
6. Longitudinal fissure separates the left and right hemispheres
7. Central fissure separates the frontal and parietal lobes
8. Lateral fissure separates the frontal/parietal lobes from the temporal lobe.
9. Corpus callosum. A thick band of white matter that connects the left and

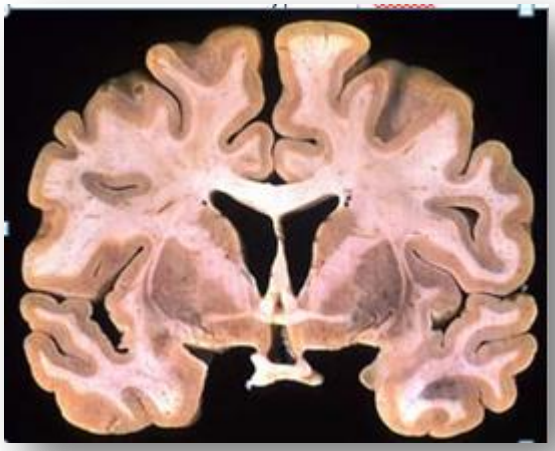


right hemispheres so that one knows what the other is doing.

Architecture of the Cortex

- Neocortex: 6 layered grey matter. In evolution, as the behavioural complexity of the animal increases, the amount of grey cortical matter must also increase. Behavioural complexity-flexibility (learning, memory) requires the complex interaction that is only possible with massive interneuronal communication. The formation of new memories requires a physical change in the structure of the brain! New synapses must develop, or at the very least, the nature of existing synapses must alter. Note the significance of this statement. It implies that a good deal of the neocortex is not genetically determined. The connections that are made in the cortex are largely not genetically laid out. However, other researchers would say that this statement is too strong. They would claim that while some of the neocortex is not genetically laid out, most of it is. Some (if not large) portions of the neocortex develop with learning (i.e., "experience" with the environment).

Image courtesy of www.g2conline.org. This site will allow you to rotate and label the various structures to obtain a 3D view of the brain.



- The image on the right is a coronal slice showing the left and right hemispheres. The dark areas are grey matter and the light areas, white matter. The neocortex consists of sulci (the various crevices) and six layers of grey matter (the gyri). The left and right hemispheres are connected by a thick layer of white matter, the corpus callosum.

Sensory/Motor/Association Cortices

1. There are 3 major types of cortices within the brain: the sensory, the motor and the association.

2. The *sensory* cortex receives input about sensory information via relays from the thalamus (although there are direct inputs from the olfactory system that bypass the thalamus).
3. The *motor* cortex in turn sends motor output into the peripheral via the efferent projection system.
4. The *association* cortex has no direct contact with the outside world. The association cortex has very elaborate inter-neuronal communication. One neuron communicates with perhaps several other neurons. It is the association cortex that permits the complex behaviour, learning and memory that is associated with "intelligent" species. It is the association cortex that allows for considerable behavioural flexibility.

Sensory Cortex

1. Visual (almost 50% of the occipital lobe)
2. Auditory (the gyrus of Heschl, embedded in the superior part of the temporal lobe))
3. Somatosensory (post-central gyrus - immediately posterior to the central fissure; thus in the parietal lobe.). Touch, temperature

Motor Cortex

1. motor (pre-central gyrus – immediately anterior to the central fissure. Thus in the frontal lobe)
2. Cerebellum (read Myers for details)

Speech Areas

1. Motor (communicate) aspects: Broca's area in the inferior region of the frontal lobe
2. Sensory (receptive) aspects: Wernicke's area at the junction of the parietal and temporal lobes.
3. Hemispheric differences. In 95-99% of right-handed individuals, the "dominant" (dominant means the centre for speech) hemisphere is the left hemisphere. In left-handers, it is not quite this simple. For about 50%, the left hemisphere is still dominant but for perhaps as many as 40%, the right is dominant. For some left-handers (from 10-25%), both hemispheres are dominant. Assuming that the left hemisphere is dominant, damage to Broca's area in the left hemisphere will result in an inability to speak. Damage to the Wernicke's area in the left hemisphere will result in an inability to understand speech. But there are also important language roles in the right

hemisphere. Damage to Broca's area in the right hemisphere will result in monotone speech. Speech lacks "tonality". Damage to Wernicke's area in the right hemisphere will result in an inability to understand the emotional aspects of speech.

Association Cortex

1. Includes very large areas of the frontal lobe, parietal lobe, temporal lobe and portions of the occipital lobe
2. Association areas have no direct contact with the outside world. They are neither sensory nor motor cortices. They receive information only after considerable processing by the sensory (or motor) cortices.
3. Their architecture consists of small interneurons with very elaborate and complex interconnections. Their function is exceedingly complex.
4. The size of the association cortices massively expands with evolution. A monkey thus has much more of its cortex devoted to association functions than a horse. A human has much more association cortex than a monkey. One should not be terribly impressed by the size of the human brain. Whales and elephants also have large brains. A good deal of the elephant’s brain is, however, devoted to motor activity (there is a good deal of muscle to control). Sharks, who are considered to be simple animals, actually have a fairly large brain, at least with respect to fish. However, most of this is devoted to sensory (smell) and motor functions (the exquisitely fine and rapid motion associated with swimming).

Frontal Lobe

1. Motor functions.
    1. Primary motor cortex in the pre-central gyrus
    2. Broca's area (inferior frontal lobe) and speech
2. Psychological function - highly complex "higher mental" functions. Selective attention, concentration; "will"; initiative (initiator of appropriate action); social norms; insight, logic, feedback (ability to learn from error); consciousness (awareness of the external world/ awareness of one's own thoughts and actions); self-consciousness (awareness that I am aware that I am aware); personality. The essence of human existence is probably a result of the development of the frontal lobe.

Temporal Lobe

1. Primary auditory cortex in the superior portion of the temporal lobe (Gyrus of Heschl)
2. Wernicke's area (receptive speech)
3. Short-term memory systems -- hippocampus; amygdala (?) .
4. The hippocampus (in green in image on right) is located in the infer-medial portion of the temporal lobe and then loops (like a ram's horns) toward the hypothalamus. The next image shows a view from a superior location. The hippocampus (in green) is located in an inferior location in the temporal lobe and then loops upward and toward the middle (medial) portion of the diencephalon. The *hippocampus* appears to be specialized for the storage of short-term memories. If the information is relevant enough, the hippocampus can allow for the transfer of short-term memories into permanent memory. If the hippocampi (the hippocampus is embedded in both the left and right hemispheres) is severed, the patient we will not be able to learn anything new. This is because the patient will be unable to transfer information from the short-term to permanent, long-term memory. (Images courtesy of genes to cognition online (www.g2conline.org)
5. Amygdala & limbic system (see later section for details)

Parietal Lobe

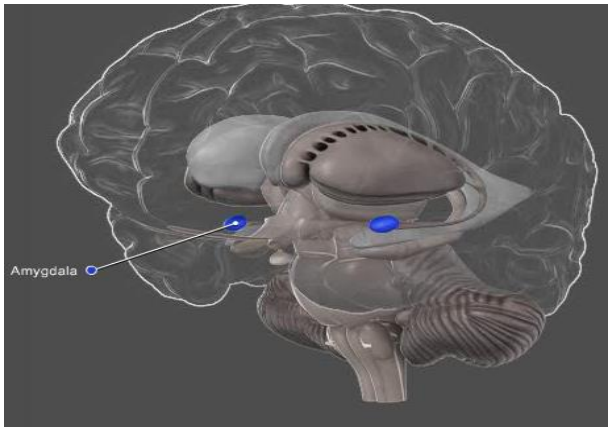
1. *Permanent memory* (or "long-term" memory) systems
2. *Switching of attention*. While the frontal lobe appears to be specialized for the focussing or "maintenance" of attention (this is called "vigilance" or "concentration"), when something novel occurs, we need to switch attention. This is a role of the parietal lobes.
3. *Hemi-neglect*. Patients who have damage to the right parietal lobe fail to attend to information arising on their left side. They thus "neglect" half of their universe. This tendency to neglect the left side occurs only when there is also information on the right side. Thus, if there is information on the left side and none on the other, the right parietal lobe patient will detect it. Thus, there is nothing wrong with the sensory systems. The patient can hear, see or feel information on the left side of their bodies. But if there is information on both the left and the right side, the patient will not see (or hear or feel) the information on the left. They thus attend to the information on the right side (that therefore is transmitted to the left hemisphere) and neglect information on the left side. This can lead to very bizarre behaviour. Patients may only dress half of their bodies and be completely unaware of it. They may claim

that there is nothing at all wrong with them and can thus be very difficult to treat. If you are on the patient's left side and speak to them, she/he will hear you (since there are no sounds entering the right ear) but not see you (since they will also be seeing objects in the room on the right side). Patients may thus complain that they are hearing voices. At times, these patients are misdiagnosed as being "psychotic".

Hemisphere Differences

See Myers for additional detail on this subject.

1. Dominant (Left) Hemisphere (for most right-handers and some left-handers). Functions include - language, mathematical operations (?), logic (?). But as the "?" indicates, classifying functions as belonging to the left or right hemisphere is overly simplistic.
2. Nondominant Hemisphere: spatial construction/block design; face recognition; tonality/emotional expression; perhaps music
3. Corpus Callosum. This is the major commissure of the brain. A commissure connects the left hemisphere to the right and the right to the left allowing the left hemisphere to communicate to the right and vice versa.
   See Myers for a discussion of what will happen if the corpus callosum is severed.



Limbic System

Again, see Myers for additional detail.

1. The anatomy of the limbic system is quite complex. The word "limbic" means circle or loop. The loop within the brain includes: the cingulate cortex- hippocampus/amygdala-hypothalamus circuit. In the image, the amygdala (involved in emotions such as defensive and offensive aggression) is displayed in blue. The amygdala is located immediately anterior and somewhat superior to the hippocampus (in grey).
2. The limbic system plays an intimate role in the maintenance and expression of emotions. The role of the limbic system has been summarized as

consisting of the 4 F's: feeding, fighting, fleeing, undertaking mating behaviour

Autonomic Nervous System

1. The autonomic nervous system appears to function "autonomously" from the cortex. The cortex may not be aware ("conscious") of what the autonomic nervous system is doing. The cortex may have only limited control or no control at all over the autonomic nervous system.
2. Controlled by the hypothalamus. It (the autonomic nervous system) consists of two branches, the sympathetic and parasympathetic.
3. *Sympathetic* branch - Increase energy available to the body. When under stress the sympathetic branch provides energy - increases the heartbeat, respiration, dilate skeletal muscles; constrict arteries of skin (so that places that need the energy and nutrients carried by the blood - such as the brain - can get them); inhibit digestive system
4. *Parasympathetic* branch conserve energy -- slow heartbeat, etc.