BNS Midterm #1

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Lecture→ Intro, Anatomy, Research Methods, Evolution.

CHAPTER ONE- Biopsychology

Biopsychology

- Neuroscience: the scientific study of the nervous system
  - Neurons: cells that receive and transmit electrochemical signals
    - Brain has 100 billion neurons and trillions of connections
    - brain is a plastic (changeable)→ grows and changes in response to genes and experiences
- Biopsychology →the study of the biology of behaviour.
  - Developed into a discipline in the 20th century (still young)
  - *'The Organization of Behvaiour'* by D.O Hebb played major role:
    - developed the first comprehensive theory of how complex psychological phenomena, might be produced by brain activity.
  - Evolutionary perspective: thinking of the environmental pressures that likely led to evolution of our brains & behaviour.

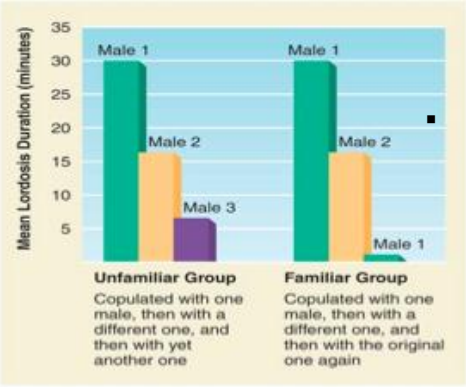
Biopsychology & other disciplines

- D.O.Hebb→ organization & behaviour
  - First comprehensive theory of how complex (perception, emotion, memories) might be produced by brain activity
- Biopsychology→ integrates knowledge from other neuroscience disciplines & applies it to the study of behaviour.
  - Neuroanatomy→ study of the structure of the nervous system.
  - Neurochemistry→ study of the chemical bases of neural activity.
  - Neuroendocrinology→ study of interactions between the nervous & endocrine systems.
  - Neuropathology→ study of nervous system disorders.
  - Neuropharmacology→ study of the effects of drugs on neural activity.
  - Neurophysiology→ study of the functions/activities of the nervous system.

Type of research

- Human & nonhuman Subjects:
  - Human brains:
    - follow instructions, report experiences, cheaper

        - more ethical restraints
        - brains differ from nonhumans in terms of overall size and the extent of their cortical development (more quantitative)
    - Non-human brians:
        - Simpler brains & behaviour
            - (likely to reveal fundamental brain-behaviour interactions)
        - Comparitive approach→ understand biological phenomena by comparing them different species .
        - Less ethical restrictions
        - More expensive, require the highest standards of care
- Experiments & non-Experiments
    - Experiments:
        - Between-subjects design:
            - →different group tested under different condition .
        - Within-subjects design:
            - →test the same group of subjects under different conditions.
        - Morgans Canon:
            - →when there are several possible interpretations for a behavioural observation, the rule is to give precedence to the simplest one.



        - Ex. Coolidge effect: a copulating male who becomes incapable of continuing to copulate with one sex partner can often recommence copulating with a new sex partner (studied hamsters)
            - Altered experiment to get rid of confound variable of male tiredness.
            - Measured lordosis (arched back, tail up posture of rodents)
            - →Females copulated more with unfamiliar hamsters.
    - Nonexperimental studies:
        - Quasiexperimental Studies:
            - →studies of groups of subjects who have been exposed to the conditions of interest in the real world.
                - Confound variable cannot be controlled
                - Ex. no random assignment to treatment
        - Case studies:
            - →extensive studies on a single subject

- lack generalizability

- Pure & applied research:
    - Pure Research→ motivated primarily by the curiosity of the researcher
        - More vulnerable to vagaries of politic regulation, many don't understand the drive for research without practical benefit.
    - Applied Research→ intended to bring a direct benefit to mankind

<u>6 Divisions of Biopsychology</u>

- 1) Physiological psychology→ studies the neural mechanism of behaviour through the direct manipulation of the brain in controlled experiments
    - surgical/electrical brain manipulation
    - lab animals
    - pure research → to contribute to theories of neural behaviour control.
- 2) Psychopharmacology→ focuses on the manipulation of neural activity and behaviour with drugs
    - drug manipulation
    - mostly animals
    - basic & applied research
- 3) Neuropsychology→ the study of the psychological effects of brain damage in human patients.
    - Effects of brain damage
    - most applied.
    - Case studies & quasiexperimental
    - Focus is on the cerebral cortex (outer layer of the hemispheres.)
- 4) Psychophysiology→ studies the relation between physiological activity and psychological processes in human subjects
    - humans, typically non-invasive
    - focuses on attention, emotion, information processing
    - looks at activity in the autonomic nervous system (ANS)
        - →regulates the bodies inner envronment.
            - ex. EEG, heart reate, BP
- 5) Cognitive neuroscience→ studies the neural bases of cognition (thought, memory, attention).
    - Newest division
    - focus is on humans, must be non-invasive
    - ex.fMRI, PET

- 6) comparative psychology & ethology→ deal with the biology of behaviour rather than neural mechanisms. Compare the behaviour of different species to understand evolution, genetics and adaptiveness.
    - *Evolutionary psychology*→ subfield that focuses on understanding behaviour from evolutionary origins
    - *Behaviour genetics*→ the study og genetic influences on behaviour.
    - *Ethological research*→ the study of the animal behaviour in its natural environment, not in the lab

Converging Operations

- Converging operations→ combining different approaches to focus on a single problem. strengths of one approach compensate for weaknesses of the others.
    - ex neuropsychology & physiological psychology can be combined to study the psychological effects of damage to the cerebral cortex.
        - Neuropsychological:
            - strength→ deals with human patients
            - weakness→ its focus on humans precludes experiments.
        - physiological psychology:
            - strength→ can use experimental method & neuroscientific technology to do research on animals.
            - weakness→ there may be deficits between the research of animals and that of humans.
- Korsakoffs syndrome: severe memory loss, while otherwise quite capable. (Jimmie G).
    - Common in alcoholics, associated with thiamine (vitamin B) difficiency.
    - Proved the inadvisability of basing causal conclusions on case studies.
        - Not caused by alcoholism, but directly correlated.
- → it is rarely sufficient to consider the results of only one study/experiment type.
    - MULTIDISCIPLINARY approach is best!

Scientific Inference

- Scientific Inference→ the empirical method used to study the unobservable.
    - Biopsychologists use to characterize, through empirical methods, the unobservable processes by which the nervous system controls behavior.

Critical thinking & Biopsychological Claims

- Critical thinking→ process of spotting the weaknesses of existing ideas and the evidence on which they are based
- Validtity:
    - Published in a reputable scientific journal?
    - Peer-reviewed?
- Ex. Jose & the Bull
    - Implanted an electrode in a bulls brain, controlled by a hand-held stimulator which sent an electric current into the caudate nucleus, and stoped the bull from charging. Claimed that the caudate was a taming-center, and stimulating this area eliminated aggression. But there could have been many other explanation, the pathway stimulated was actually controlling movement
    - Morgans Canon→when there are several possible interpretations for an observation, the rule is to give precedence to the simplest one.
- Ex. Becky, Moniz & prefrontal lobotomy
    - Observed changes in behaviour between a chimpanzees who normally was easily upset, and its behaviour after damage to its prefrontal lobe. Performed a prefrontal lobotomy with successful results, rapid increase in psychosurgeries. Surgeries were based on an observation form a single case on monkeys, wasn't properly understood before conducted. Also, the consequences on the surgery weren't carefully evaluated.
    - Psychosurgery→
        - brain surgery performed to treat psychological problems .
    - Prefrontal lobotomy→
        - Severing the connections between the prefrontal lobes and the rest of the brain as a treatment for mental illness.
            - Prefrontal lobes→ large left & right areas in the frontal brain
            - Leucotome→ surgical device used for lobotomies
        - Became clear that they had little therapeutic benefits and many side effects. Still continue to be performed in some countries.
    - Transorbital lobotomy→
        - inserting an ice-pick like device under the eyelid, driving it through the eye socket with a few taps, and pushing it into the frontal lobes, where it is waved back and forth to sever the connections
            - Frequently performed in the surgeons office.

CHAPTER TWO- Evolution

- Zeitgeist: general intellectual climate of our culture which ingrains in our minds.

The biology of behaviour: dichotomies to interactions

- Physiological or psychological:
  - Cartesian dualism: the human mind and brain are separate entities
    - A category of human activity that somehow transcends the brain.
  - PROBLEMS:
    - Assumption that some functioning is so complex it could not be a product of the physical brain.
      - Ex. "the man who fell out of bed"
      - Asomoatognosia→ deficiency in the awareness of parts of one's own body, usually from right parietal lobe damage.
      - →all human experience, even very complex ones, can be produced by manipulation of the brain.
    - Some nonhuman species (primates) have abilities that were assumed to once be purely psychological/human.
      - Ex. self-awareness of chimps
      - →Even non humans (no mind) are capable of psychological complexity (self awareness)
- Nature or nurture (learned/inherited)
  - Ethology: The study of animal behaviour in the wild
  - Instinctive behaviours: Behaviours that occur in all like species
    - Emphasized the role of nature, not just nurture.
  - Progression of debate:
    - 1st) factors other than genetics/learning proved to influence behaviour (broadened concept of nurture- included experience.)
    - 2nd) behvaiour is result of nature & nurture combined.
  - PROBLEMS:
    - How-much-is-genetic-how-much-is-from-experience:
      - Assumes they combine in additive fashion- not interaction.
- Model of the biology of behaviour:
  - →all behaviour is the product of interaction of 3 factors:
    - 1) genetics (product of evolution)
    - 2) experience
    - 3) perception of current situation

Human evolution

- Darwin:
  - Evolve→ undergo gradual orderly change
  - 3 kinds of evidence:
    - 1) evolution of fossil records through progressively more recent geographical layers.
    - 2) Striking structural similarities between living species (evolving from common ancestors).
    - 3) The major changes brought about in plants and animals through of selective breeding.
  - Natural selection→ heritable traits associated with high rates of survival and reproduction are the most likely ones to be passed on.
    - Fitness→ the ability of an organism to survive and contribute its genes to the next generation.
  - scientific theory→ an explanation that provides the best current account of some phenomenon based on the available evidence
- Evolution & behaviour
  - Social dominance:
    - males of many species establish a stable *hierarchy of social dominance* through combative encounters with other males.
      - Physical damage, threatening until one backs down.
      - Hostilities then diminishes in lower levels
    - some species dominant males copulate more, more effective in passing on their characteristics to future generations
    - some species dominant females are more likely to produce more, and have more healthy offspring.
  - Courtship display:
    - Male approaches female, signals interest (olfactory, visual, auditory, or tactual), may elicit a signal from female, may elicit another response from male, leads to copulation.
    - Promotes evolution of new species
      - reproductive barrier stops breeding between a subpopulation and rest of the species. Subpopulation evolves independently until cross-fertilization is impossible.

        - Behavioural barrier→ different courtship displays between *conspecifics* (members of same species)
- Course of human evolution:
    - Hierarchy:
        - Kingdom-phylum-class-order-family-genus-species
        - Animal-Chordate-Mammal-Primate-Hominid-Homo-Sapiens
    - Vertebrates: (425 million years ago)
        - Multicellular water-dwelling organisms turned into > chordates
        - Chordates→ animals with dorsal nerve cords (large nerves, running along the center of the back)
            - evolved to have spinal bones to protect nerves> vertebrate
        - vertebrate→ first ones were bony fish, now cinlcudes fish, amphibians, reptiles, birds & mammals.
            - Important fossil discoveries show the transition.
    - Amphibians: (400 million years ago)
        - Bony fish ventured to land for short periods, advantages caused natural selection to transform fins & gills to legs & lungs
    - Reptiles: (300 million years ago)
        - First vertebrate to lay shell-covered eggs & have dry scales.
            - Can live far from water
    - Mammals: (180 million years ago)
        - Were fed through mammary glands
        - Nurtured in mothers until mature enough to be born.
        - 20 different types: we are primates
            - chimpanzees are closest relative
    - humankind:
        - *hominin* family→ *homo* genus→ *sapiens* species
        - little evidence of the transition:
            - population of 3 ft tall homosapiens on an indonesian island 13,000 years ago.
            - Fossil of 3-yr old Australopithecus girl found in Ethiopia
                - (other genus of hominin family)
                - believed to have evolved 2 million years ago in Africa from line of apes. Though to have existed for 5 million years before extinction.
                    - Approx 4 ft tall, small brains, upright

        - Early homosapiens:
            - Larger brain cavity than prior, but smaller than present day.
            - Coexisted with Australopithecus
        - 200,000 years ago→ modern humans
        - 50,000 years ago→ migrated out of africa
- thinking about human evolution
    - Misunderstood points about evolution
        - Evolution does not proceed in a single line
        - Humans have little reason to claim supremacy. We are the last surviving species of a family that has existed for only a blip of evolutionary time
        - Evolution does not always proceed slowly and gradually
        - Few products of evolution have survived today
        - It does not progress to perfection
        - Not all existing behaviours or structures are adaptive
            - Spandrels→ incidental non-adaptive evolutionary byproducts (Ex. Belly button)
        - Not all existing adaptive characteristics evolved to perform their current function
            - Exaptations→ Evolved to perform one function and were later co-opted to perform another (Ex. Bird wings that were first evolved for the purpose of walking)
        - Similarities among species do not necessarily mean that the species have common origins
            - Homologous→ similar structures as result of same origin.
            - Analogous→ similar structures which don't have same origin
            - Convergent Evolution→ the evolution in analogous species to the same environmental demands
- evolution of the human brain:
    - although healthy adult human brains vary greatly in size-between about 1000-2000 g. there is no clear relationship between overall human brain size and intelligence.
        - More reasonable: compare different brain regions.
            - *Brain stem*: regulates reflex activities that are critical for survival (heart rate, respiration)
            - *Cerebrum*: involved in complex adaptive processes

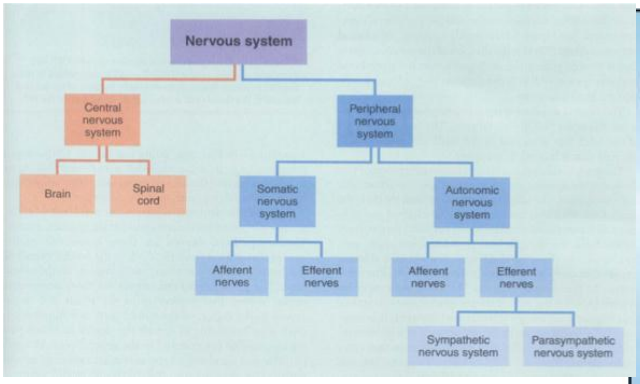
- (learning, perception, & motivation)

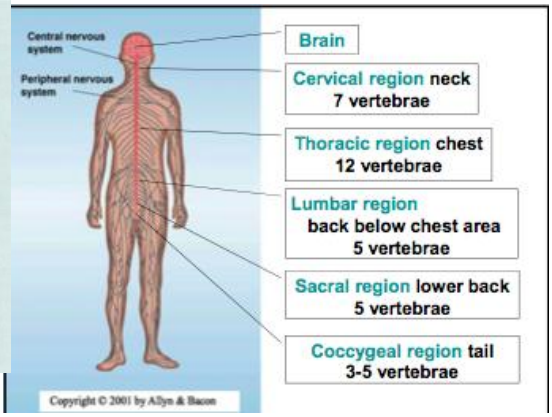
- Evolution of brain:
  - Has increased in size
    - Most increase in cerebrum
  - increased the number of convolutions (folds on cerebral surface)
    - increased volume of the cerebral cortex
- Similarities:
  - Neural structures of one species is usually found in similar species

- understanding mate bonding:
  - Polygyny→ one male forms mating bonds with more than one female
    - Most common
    - Because females make more contribution too their young.
      - Causes females to produce few offspring and males many.
  - Polyangry→ one female forms mating bonds with more than one male
    - Not in mammals
    - Occurs when males contribute more to reproduction (sea horse)
  - Monogamy→ a mate-bonding pattern in which enduring bonds are formed between one male and one female
    - 4% of mammals
    - more help raising children > increase likelihood of passing genes.
    - Humans are not necessarily monogamous in comparison to other species.
- Current aspects of mate selection:
  - Men prefer youth and attractiveness
  - Women value power and earning capacity
  - Physical attractiveness best predicts which women will bond with men of high occupational status
  - Mate strategy of women is increasing their physical attractiveness, in men it is displaying their power and resources
  - Men are more likely than women to commit adultery

CHAPTER THREE- Anatomy of the Nervous System

Layout of the Nervous System



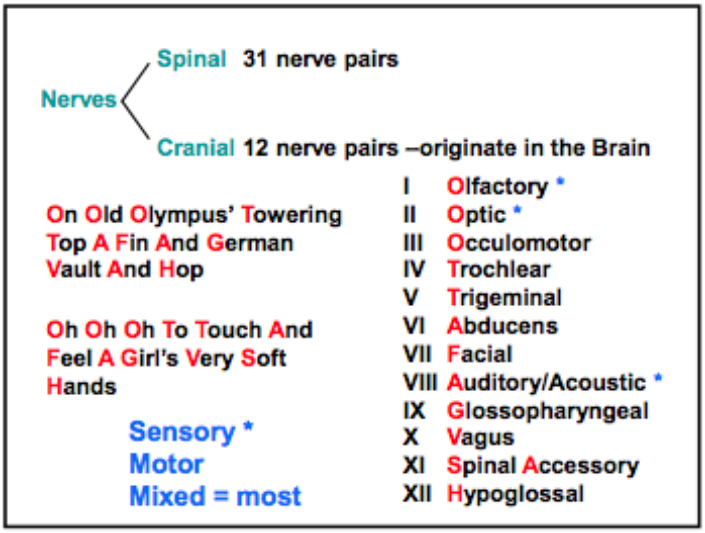


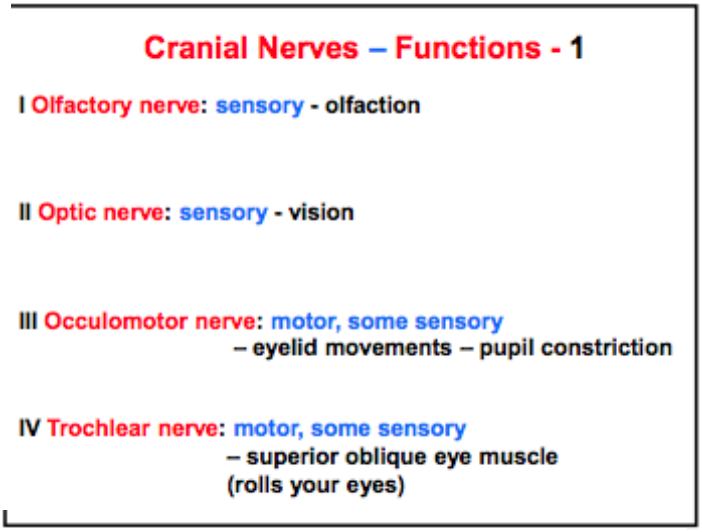
Divisions:

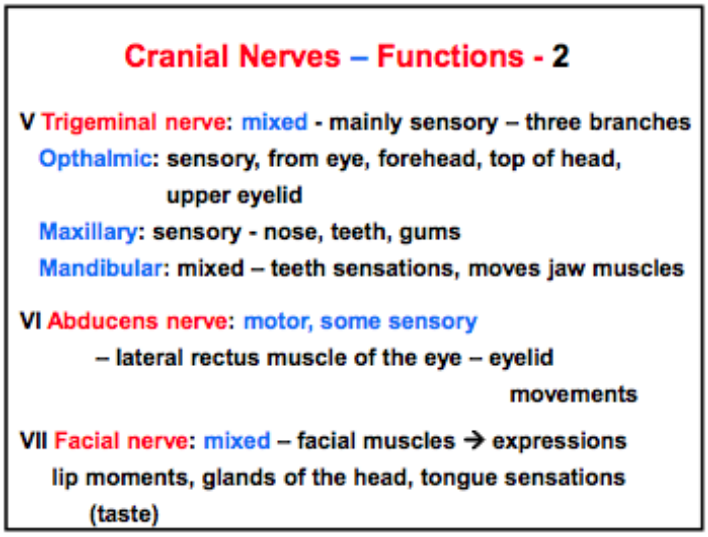
- CNS→ located within the skull and spine (brain & spinal cord)
    - some Neurons in the CNS contain their cell body within the spinal cord area, and their axons project outward and are part of the PNS.
- PNS→ located outside the skull and spine
    - 1) Somatic (SNS): part that interacts with the external environment
        - afferent nerves → *sensory* info from skin/joints/eyes/ears etc, *toward* the CNS
        - efferent nerves → *motor* signals *away* from CNS to skeletal muscles.
    - 2) Autonomic (ANS): part that regulates internal environment
        - I) Afferent → carry signals from internal organs *toward* CNS
        - II) efferent → carry signals *away* from CNS to internal organs
            - →2-stage neural paths: project from CNS & go part way to target organ, then *synapse on* 2nd stage neurons that carry the signals the rest of the way.
            - → the activity of each autonomic target organ is controlled by levels of sympathetic and parasympathetic input.
            - a) Sympathetic→ autonomic motor nerves that go from CNS to lumbar and thoracic regions of the spine.
                - → stimulate/organize/mobilize energy resources in threatening situations
                - → charges show psychological *arousal*
                - →2nd stage neurons carry signals long distances
            - b) Parasympathetic→ autonomic motor nerves that go from brain and sacral region of the spine
                - → act to conserve energy
                - → charges show psychological *relaxation*

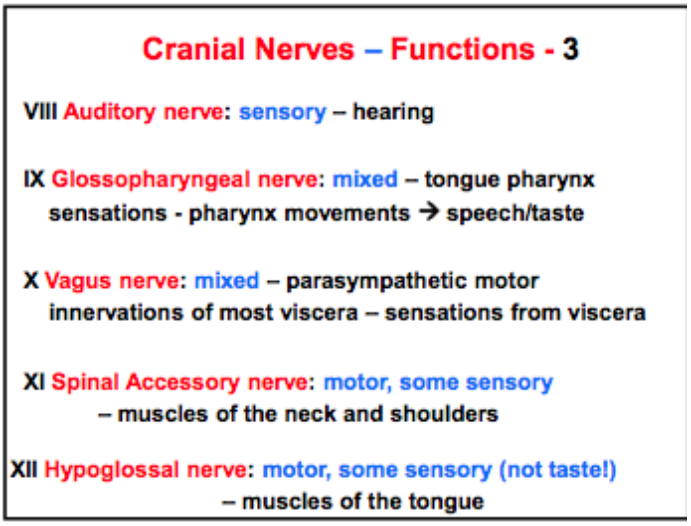
- →2nd stage neurons carry signals short distances

- 12 Cranial Nerves:
  - →only peripheral nerves that doesn't project from the spinal cord EXCEPT (project from brain instead). Include purely sensory nerves, most contain sensory & motor fibers
    - The longest cranial nerve → vagus (X) nerves (motor & sensory fibers to and from the gut)
    - Cranial nerves are parasympathetic



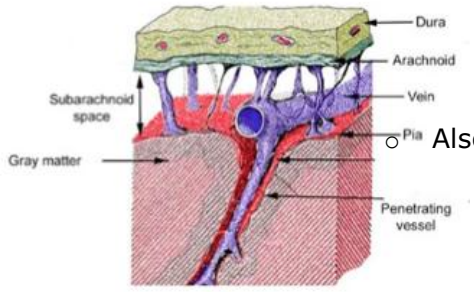






Meninges, ventricles & Cerebrospinal Fluid:

- Brain and spinal cord: most protected organ
  - Covered by 3 meninges
    - 1) *dura mater* (Outer meninx)→ tough membrane



- 2) *arachnoid* layer (Middle menix)→ fine spider-like membrane
  - *sub-arachnoid space* (contains large blood vessels & CSF)
  - 3) *Pia mater* (Inner)→ delicate, adheres to surface of CNS

○ Also protected by Cerebrospinal fluid (CSF):

- → supports and cushions the brain.
- Fills the subarachnoid space & other various cavities
- produced by the *choroid plexus:*
  - →network of capillaries that protrude into ventricles from the pia mater.
- Excess CSF is absorbed by the subarachnoid space in *dural sinuses*
  - →large blood filled spaces running thru dura matter into jugular veins of the neck.
  - Flow is occasionally blocked by a tumour in a narrow channel that links the ventricles
    - Ex. cerebral aqueduct (3rd & 4th ventricl)
    - Hydrocephalus→ brain expands from build up of CSF

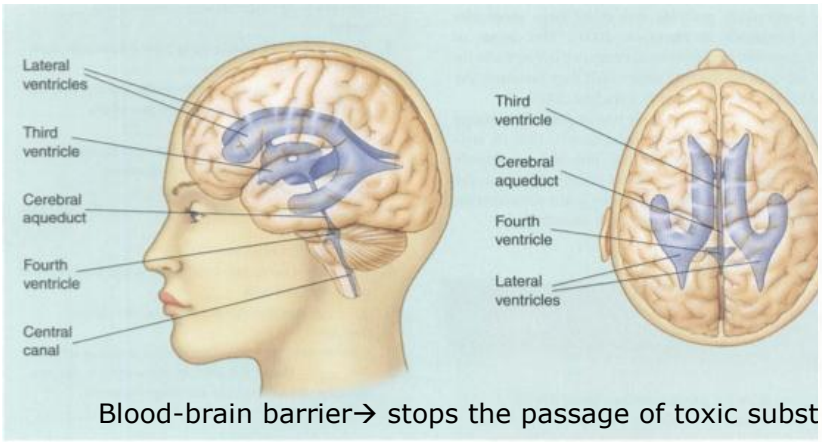
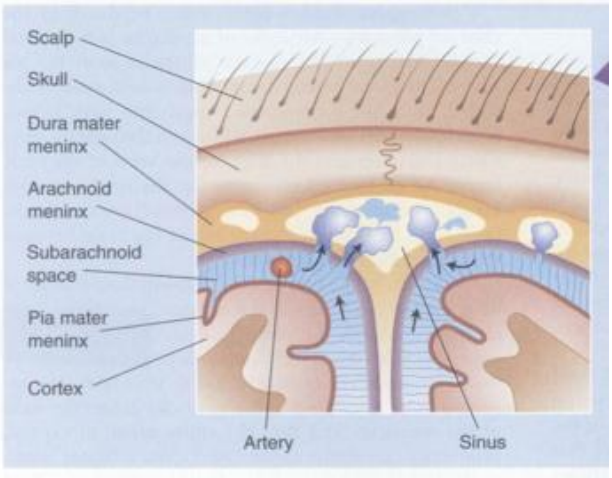


FIGURE 3.3 The cerebral ventricles.



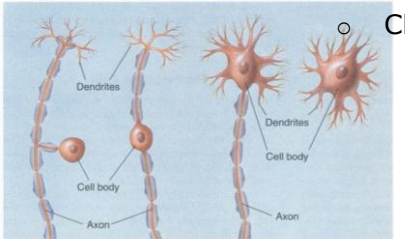
Blood-brain barrier→ stops the passage of toxic subst

- Special tightly-packed structure of cerebral
- Some large molecules can pass through walls.

<u>Cells of the nervous system:</u>

Neurons:

- Neurons→ cells that are specialized for the reception, conduction and transmission of EC signals
  - Membrane:
    - Lipid bilayer, with numerous embedded proteins (channel or signal)
  - Classes: (based on # of projections from their cell body)



        - Multipolar neuron→ (most common) more than one process
        - Unipolar neuron→ only one process
        - Bipolar neuron→ two processes
        - Interneurons→ short/no axon. integrates the neural activity within a single brain structure, not from structure to structure.
    - Structures
        - CNS→ clusters of cell bodies are nuclei (nucleus)
            - Bundles of axons are called tracts
        - PNS→clusters of cell bodies are called ganglia (ganglion)
            - Bundles of axons are called nerves

- External features:

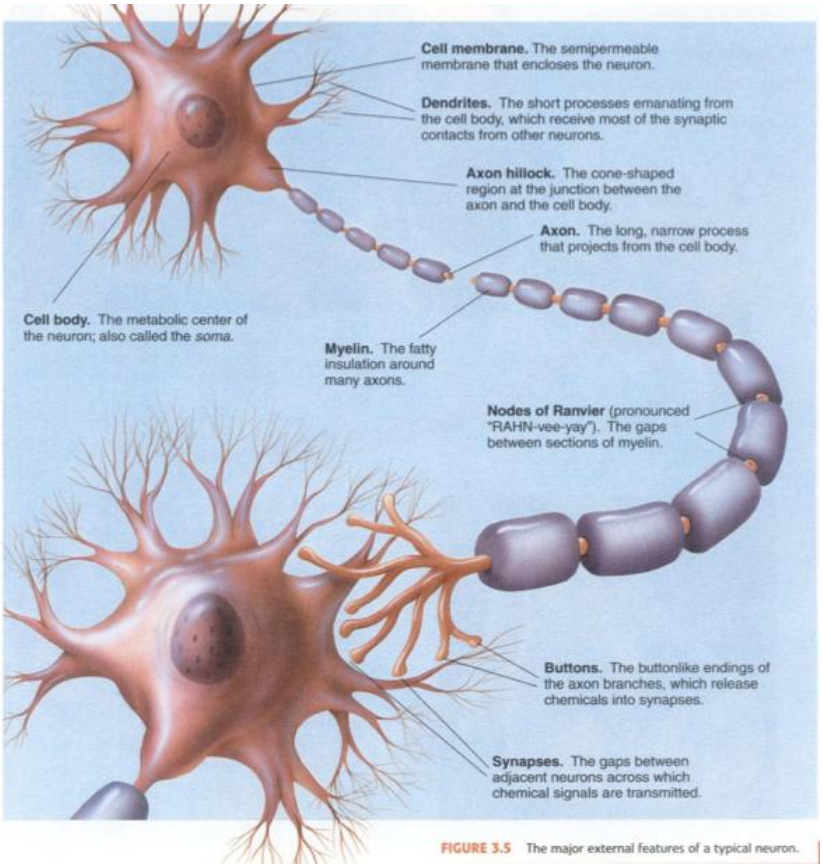


FIGURE 3.5 The major external features of a typical neuron.

- Internal Features:
    - Endoplasmic reticulum:rough portions (synthesis of proteins); smooth portions (synthesis of fats).
    - Ribosomes: proteins are synthesized (in the ER)
    - Golgi complex: packages molecules in vesicles
    - Mitochondria: sites of aerobic energy release
    - Microtubules: responsible for the rapid transport of material

- Synaptic vesicles: store neurotransmitter molecules
- Neurotransmitters: released and influence the activity of other cells .

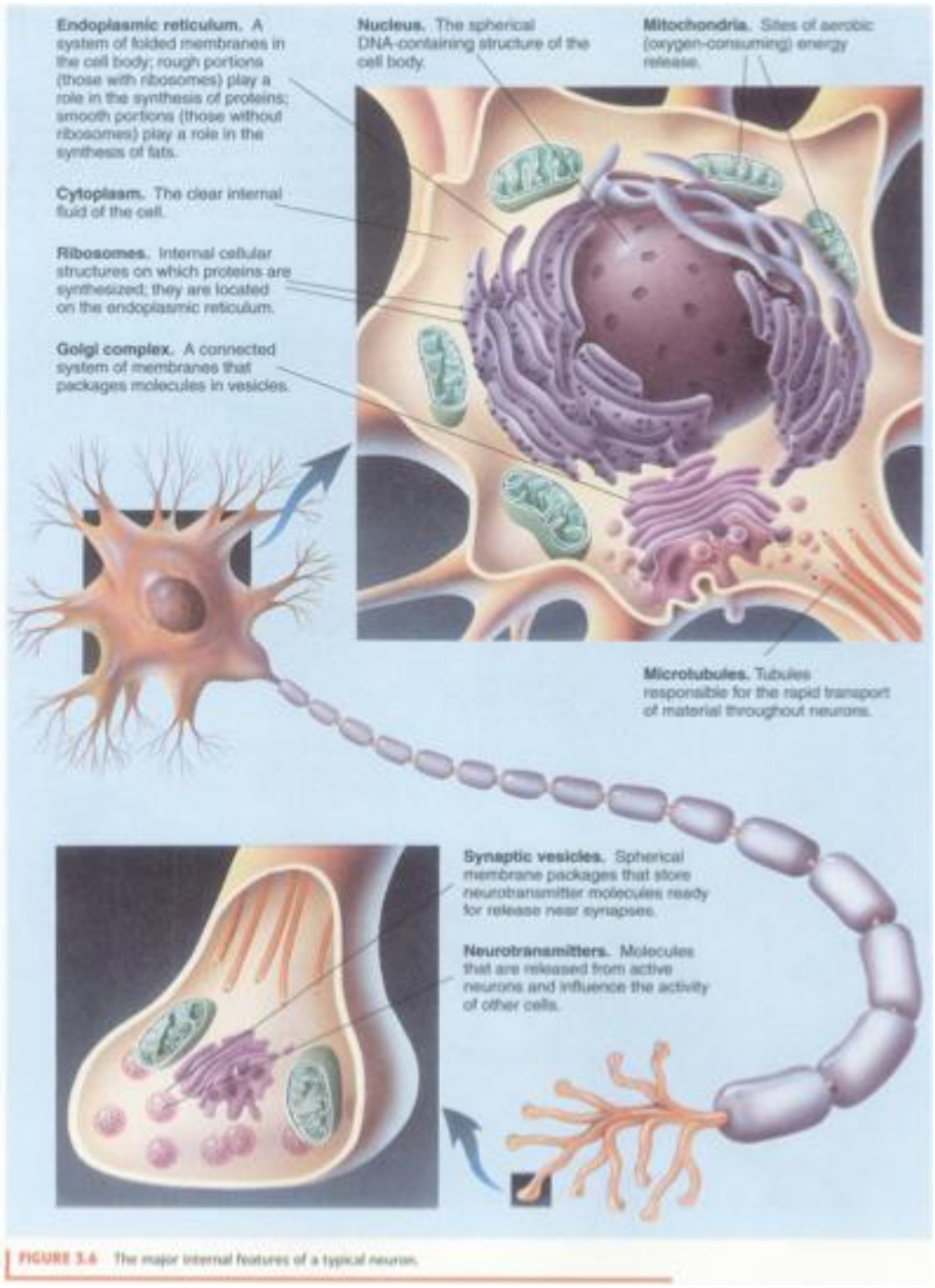
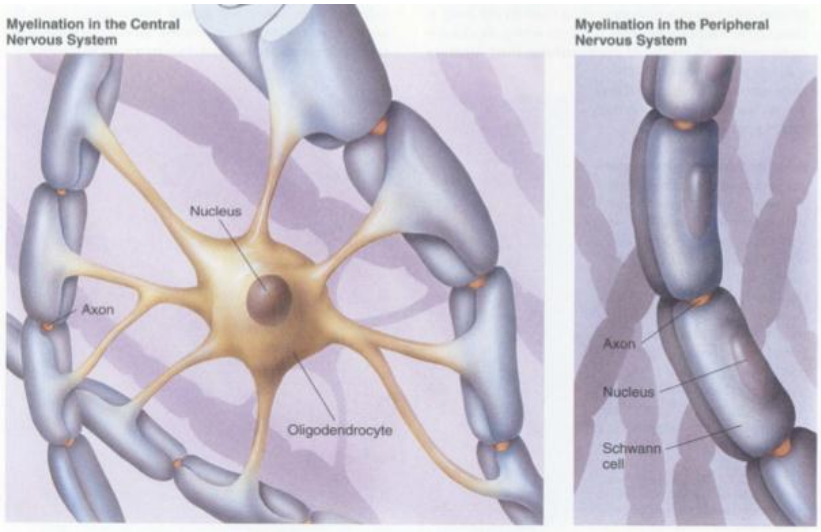


FIGURE 3.6 The major internal features of a typical neuron.

Glial cells

- → more abundant than neurons in some brain areas, but overall #s are equal.
- Types:
  - Oligodendrocytes→ extensions that wrap around axons CNS neurons.

        - Rich in several myelin segments & form myelin sheaths
    - Schwann cells→ glial cells that compose myelin sheath of PNS.
        - promote axonal regeneration after damage
    - Microglia→ smallest, respond to injury or disease by multiplying, engulfing cell debris, and triggering inflammatory responses
    - Astrocytes→ largest, star shape. Extensions cover surfaces of blood vessels, contact neural cell bodies.
        - role in allowing/blocking passage of some chemicals into CNS
        - Send & receive signals, maintain synapses, control neural activity, maintain axon function, and participate in glial circuits



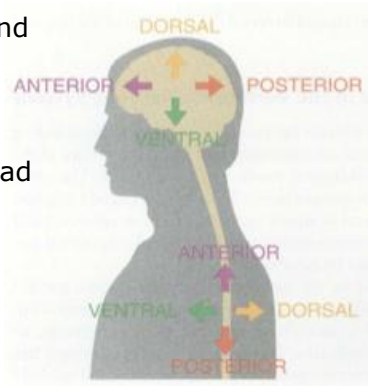
<u>Neuroanatomical techniques</u>

- Golgi stain→ stains neurons black (used when shape of the neurons is of interest)
    - Accidental discovery, shows silhouettes of a few neurons in a space.
- Nissl stain→ penentrate all cells, but bind only to structures in neuron cell bodies
    - Commonly used: cresyl violet dye.
    - Used to estimate the number of cell bodies in an area
- Electron microscopy→ captures neuronal structure in exquisite detail
    - Coating thin layers of tissue with electron absorbing substance which is taken up by neurons. Pass a beam of light through the tissue onto a film.
    - Scanning electron microscope→ provides spectacular electron micrographs in 3D, but not as much magnification as regular electron microscope
- Neuroanatomical tracing techniques:
    - Anterograde tracing→ (forward) trace the path of axons projecting away from cell bodies in a particular area

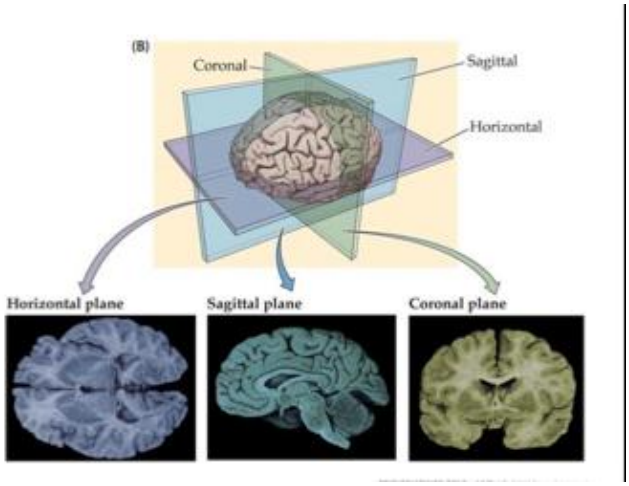
- Retrograde tracing→ (backward) trace the paths of axons projecting into a particular area

Neuroanatomical directions

- Anterior→ (rostral) towards the nose end
- Posterior→ (caudal) towards tail end
- Dorsal→ towards back or top of head
- Ventral→ toward chest or bottom of head
- Medial→ towards midline of the body
- Lateral→ towards body's surface



- Planes:



Spinal Cord

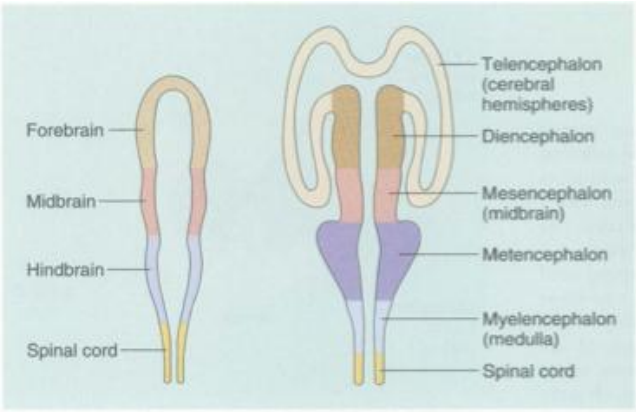
- 2 areas:
  - 1) Gray matter→ composed of cell bodies and unmyelinated interneurons
    - Dorsal horns: 2 dorsal arms of spinal matter
    - Ventral horns: 2 ventral arms of spinal matter
  - 2)White matter→ composed largely of myelinated axons
- spinal nerves:
  - 31 pairs (62 nerves) attached to left & right sides of the spine
    - 31 different levels
    - each of 62 nerves divides as it reaches the cord
      - Dorsal root:
        - Neurons are sensory (afferent)
        - Unipolar, cell bodies grouped together just outside the cord to form the dorsal root ganglia.

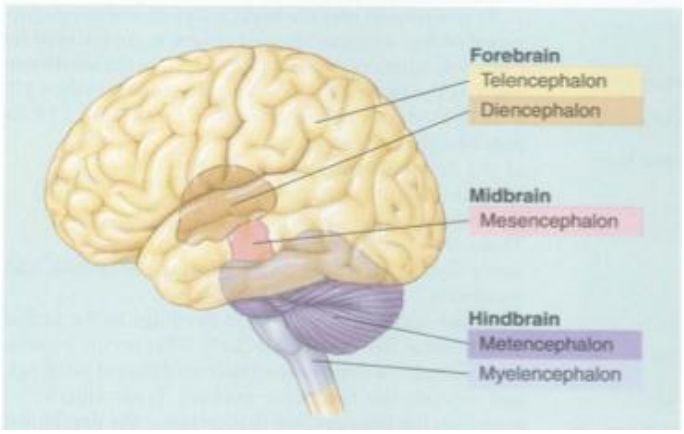
- Many synaptic terminals are in the dorsal horns of the gray matter .

- Ventral root:
  - Neurons are motor (efferent)
  - Multipolar, cell bodies in the ventral horns.
  - part of the SNA→ project to skeletal muscles
  - ANS→ project to ganglia, where they synapse on neurons that in turn project to internal organs.

<u>5 Divisions of the Brain</u>

- The first indications of a developing brain are 3 swellings at the anterior end
  - Forebrain, midbrain, hindbrain
- Before birth, 3 swellings become 5 (forebrain & hindbrain divide)
  - 1) telencephalon
    - undergoes the greatest growth in humans
  - brain stem: *"t* is on *top*, rest are *alphabetical"*
    - 2) diencephalon
    - 3) mesencephalon
    - 4) metencephalon
    - 5) myelencephalon (medulla)





<u>5 major structures of the brain:</u>

- → same for the brain stem & spinal cord, but are rotated by 90° for the forebrain.

1) Myelencephalon (medulla): most posterior division

- Tracts carrying signals between the rest of the brain and the body
- Reticular formation: (activating system)
  - →complex network of tiny nuclei, net-like structure

- →Plays a role in arousal, sleep, attention, movement, muscle tone maintenance, and various cardiac, circulatory and respiratory reflexes.

2) Metencephalon: houses many tracts & part of the reticular formation (activating system)

- 2 main structures:
  - 1) pons→ bulge on the brain stem's ventral surface.
  - 2) cerebellum (little brain) → large structure on brain stems dorsal surface.
    - Cerebellar damage eliminates the ability to control movements and to adapt them to changing conditions. (use of language)

3) Mesencephalon: 2 divisions;

- 1) Tectum (roof): dorsal surface of the midbrain.
  - Mammals:
    - Inferior colliculi→ auditory
    - Superior colliculi→ visual
  - Vertebrates:
    - Entirely visual.
- 2) Tegmentum: ventral to the tectum
  - 3 structures:
    - 1) Periaqueductal gray
      - → gray matter around cerebral aqueduct
    - 2) Substantia nigra (black substance)
      - → involved in sensorimotor system
    - 3) Red nucleus
      - → involved in sensorimotor system

4) Diencephalon: 2 structures:

- 1) Thalamus: large, 2-lobed structure, top of the brain stem
  - 1 lobe sits on each side of the 3rd ventricle, joined by massa intermedia
  - White *lamina* (layers) composed of myelinated axons
  - Sensory relay nuclei→ nuclei that receives signals from sensory receptors, process them and then transmit to/from areas of the sensory cortex.
    - Ex. areas→ lateral geniculate nucleus, medial geniculate nucleas, ventral posterior nuclei.
- 2) Hypothalamus: located below the anterior thalamus (hypo=bellow)
  - role in the regulation of motivated behaviours (sleep, eat, sex)
  - *pituitary gland* (dangles from brain) → uses to regulate hormone release
  - *optic chiasm*→ point where optic nerves come together

- *Mammillary bodies*→ pair of spherical nuclei located on inferior surface

5) Telencephalon: largest division, mediates most functions

- Initiates voluntary movement, interprets sensory input, and mediates complex cognitive processes such as learning, speaking and problem solving

cerebral cortex → layer of tissue covering the hemispheres

- Contains small unmyelinated neurons (gray matter)
  - Beneath the cortex is large myelinated axons (white matter)
- Fissures→ Large furrows/convultions
  - Sulci→ small ones.
  - Longitudinal fissure→ seperates the 2 hemispheres
  - Cerebral commisures→ tracts connecting the hemispheres
    - Corpus callosum→ largest cerebral commisure.
  - Central fissure & lateral fissures→ divide hemispheres into 4 lobes
    - 1) Occipital lobe→ visual input
    - 2) Parietal lobe:
      - postcentral gyrus→ analyzes sensation
      - other areas→ perceiving the location of objects & our body and in directing our attention
    - 3) Temporal lobe:
      - superior→ language and hearing
      - Inferior→ complex visual patterns
      - Medial→ not visible and important in memory
    - 4) Frontal lobe:
      - precentral gyrus & adjacent frontal cortex→ motor function,
      - frontal cortex anterior→ complex cognitive functions
        - (response sequence, evaluating outcomes of patterns of behaviour, etc.)

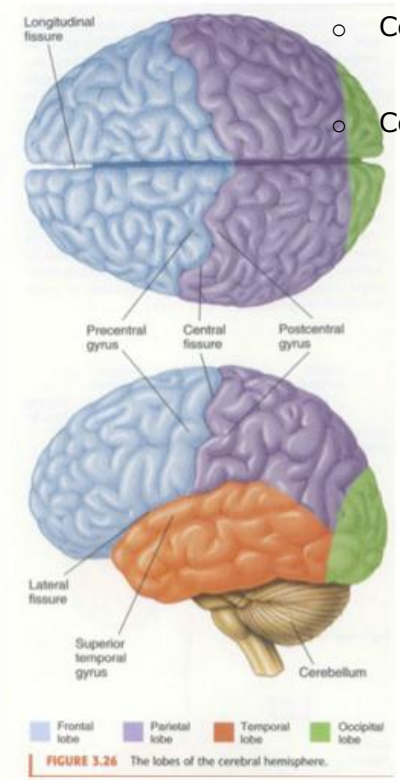


FIGURE 3.26 The lobes of the cerebral hemisphere.

- neocortex→ 90% of cerbreal cortex:
  - 2 categories of neurons:
    - pyramidal cells→ large, multipolar, pyramid shape body, long axon
    - stellate cells→ small, interneurons, star shaped.
  - 6 layers differ from one another in terms of size/density
  - Many long axons and dendrites course ventrically through the neocortex
    - Columnar organization→ neurons in vertical columns often perform a single function
  - Variations in the thickness of the layers from area to area

- Hippocampus→ resembles a sea horse. Role in memory and spatial location
    - 3 layers
    - involved in memory, particularly of spatial location.

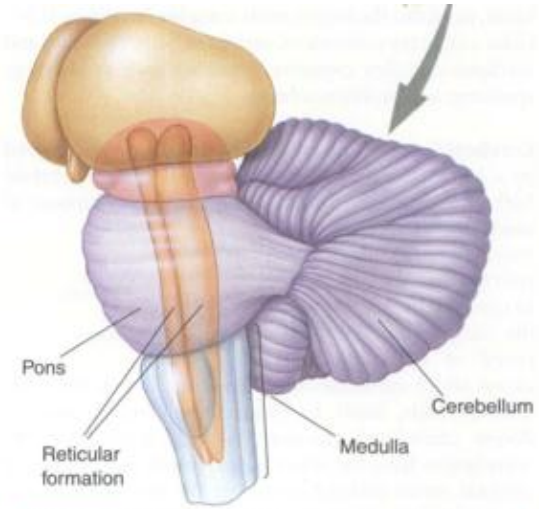


FIGURE 3.21 Structures of the human myelencephalon (medulla) and metencephalon.

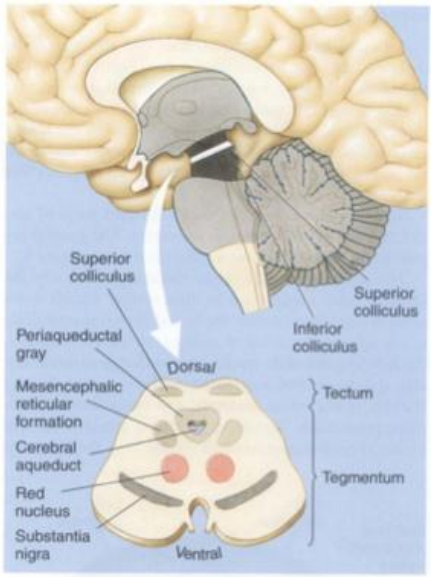


FIGURE 3.22 The human mesencephalon (midbrain).

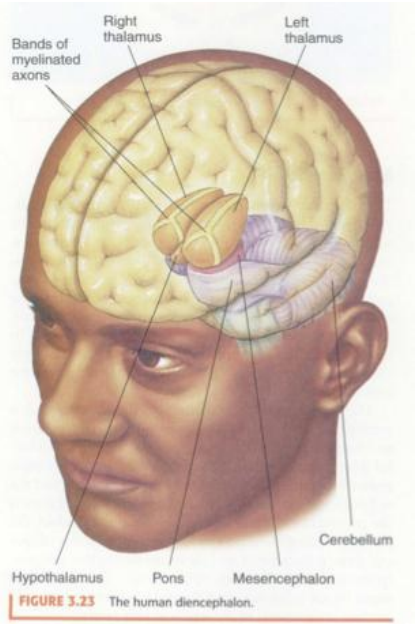


FIGURE 3.23 The human diencephalon.

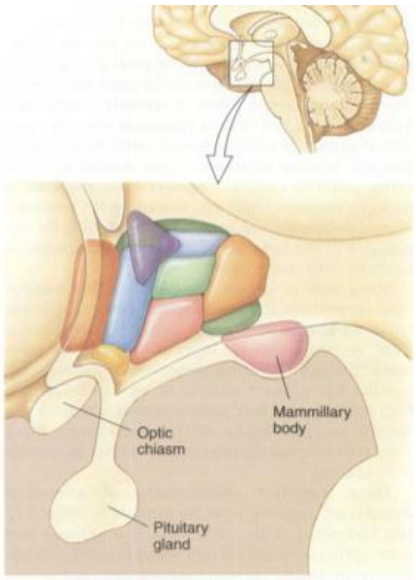


FIGURE 3.24 The human hypothalamus (in color) in relation to the optic chiasm and the pituitary gland.

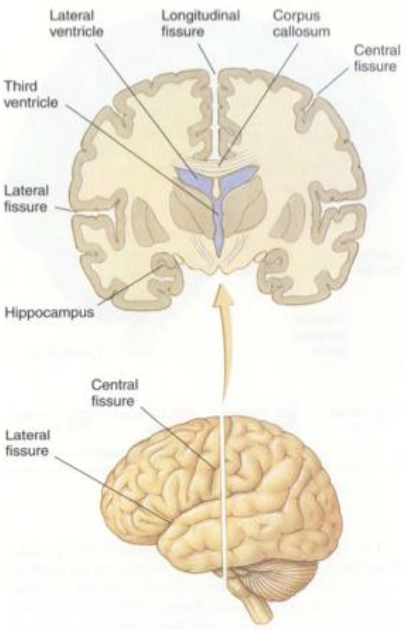


FIGURE 3.25 The major fissures of the human cerebral cortex.

Limbic system: a circuit of midline structures that circle the thalamus

- regulation of motivated behaviours (fleeing, feeding, fighting, fucking)
- Major structures
    - Amydala→ almond-shaped nucleus

        - Emotion→ fear
    - Hippocampus→ uns beneat thalamus in medial temporal lobe
    - Cingulated cortex→ large strip of cortex in the cingulated gyrus
        - Encircles the dorsal thalamus
    - Fornix→ major tract of the limbic system
        - Encircles the dorsal thalamus
    - Septum→ midline nucleus located at the anterior tip of the cingulated cortex
    - Mammilary bodies

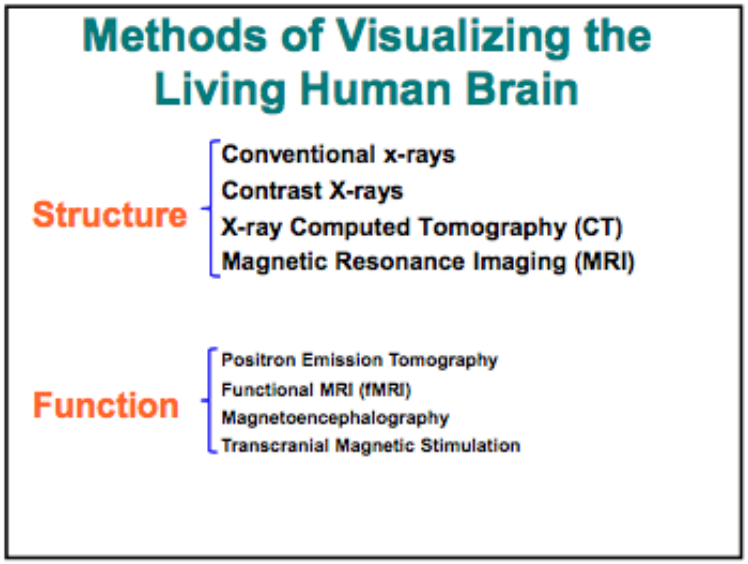
Basal Ganglia:

- →voluntary motor responses
    - parkinson's disease: deteriation of pathway from striatum to the midbrain
    - nucleus accumbens: medial portion of ventral stratum
        - role in rewarding effects of drugs & reinforcers.
- Major structures:
    - Amygdal
    - Striatum:
        - caudate (tail-like)→ forms almost complete circle
        - putamen→ center of the caudate, connected by fiber bridges.
    - globus pallidus→ circular structure

Telencephalon	Cerebral cortex	Neocortex Hippocampus
	Major fissures	Central fissure Lateral fissure Longitudinal fissure
	Major gyri	Precentral gyrus Postcentral gyrus Superior temporal gyrus Cingulate gyrus
	Four lobes	Frontal lobe Temporal lobe Parietal lobe Occipital lobe
	Limbic system	Amygdala Hippocampus Fornix Cingulate cortex Septum Mammillary bodies
	Basal ganglia	Amygdala Caudate | Striatum Putamen | Striatum Globus pallidus
	Cerebral commissures	Corpus callosum
Diencephalon	Thalamus	Massa intermedia Lateral geniculate nuclei Medial geniculate nuclei Ventral posterior nuclei
	Hypothalamus	Mammillary bodies
	Optic chiasm	
	Pituitary gland	
Mesencephalon	Tectum	Superior colliculi Inferior colliculi
	Tegmentum	Reticular formation Cerebral aqueduct Periaqueductal gray Substantia nigra Red nucleus
Metencephalon	Reticular formation Pons Cerebellum	
Myelencephalon or Medulla	Reticular formation	

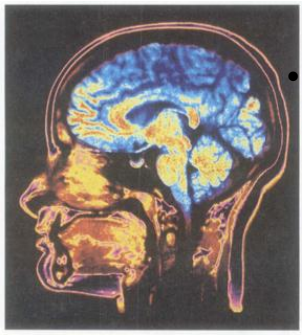
CHAPTER FIVE: PART 1: Research Methods

- Professor P→ tumour on his right auditory-vestibular cranial nerve (CNVIII)
    - Had it cut out, was left with the inability to talk, eat or breath.

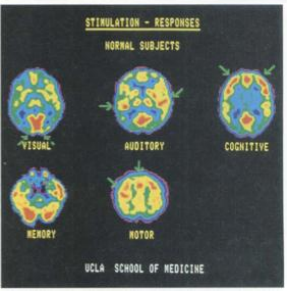


Methods of Stimulating the Brain

- 1) X-rays→ beam is passed through an object and then onto a photographic plate
  - characterizes internal structures that differ from surroundings
- 2) Contrast x-ray technique→ injecting a substance that absorbs x-rays into part of the body either less than or more than surrounding tissue.
  - Cerebral angiography→ uses the infusion of radio-opaque dye into a cerebral artery to see the cerebral circulatory system. finds vascular damage and tumors through displaced blood vessels.
- 3) X-Ray Computed tomography (CT)→ projects an x-ray beam through the head to an x-ray detector on the other side, then rotate to take multiple pictures

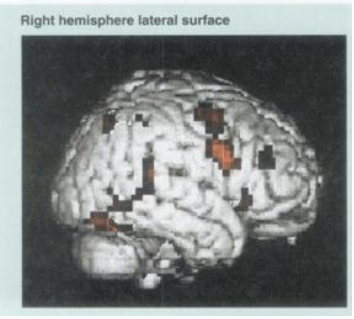


- 4) Magnetic Resonance Imaging (MRI)→ high-resolution images are constructed from the measurement of waves that hydrogen atoms emit when they are activated by radio-frequency waves in a magnetic field
  - High spatial resolution: the ability to detect & represent differences in spatial location
  - can produce 3D images.



- 5) Positron emission tomography (PET)→ first brain imaging to provide brain activity
  - Looks at function not structure.
  - Radioactive 2-deoxyglucose (2-DG) is injected into carotid artery, where it is rapidly taken up by avtive cells/neurons until it is broken down.
  - Not really images, rather a coloured map of the radioactivity

- 6) Functional MRI (fMRI) → produces images representing the increase in oxygen flow in the blood to active areas of the brain



  - The signal recorded by fMRI is the BOLD signal (blood-oxygen-level-dependant signal)
  - Advantages:
    - no injections
    - functional and structural functions
    - better spatial resolution
    - can produce 3D images
  - disadvantages:
    - too slow to capture many neural responses (takes 2-3 seconds)
- 7) Magnetoencephalography (MEG)→ measures changes in magnetic fields on the scalp surface, produced by changes in underlying patterns of neural activity.
  - Advantage:
    - temporal resolution→ can record fast changes in neural activity
- 8) Transcranial magnetic stimulation (TMS): to see the activity in an area of the cortex by creating a magnetic field under a coil positioned next to the skull
  - *proves causation of brain activity on cognitive activity (unlike others)
  - magnetic stimulation temporarily turns off part of the brain while the disruption of cognition is recorded.

<u>Recording Human Psychophysiologicla Activity</u>

Psychophysiological recording methods→ records physiological activity from surface of body.

- 5 types:
  - Scalp EEH→ measures brain activity
  - Muscle tension→ measures somatic NS activity
  - Eye movement→ measures somatic NS activity
  - skin conductance→ measure ANS activity
  - cardiovascular→ measure ANS activity
- 1) scalp electroencephalography: measures electrical activity in the brain.
  - Electroencephalography→ uses EEG machine (large electrodes on scalp)
    - Sum of electrical events in head (action potential, postsynaptic potentials, electrical signals from skin/muscles/blood/eyes.)
    - EEG Waves:

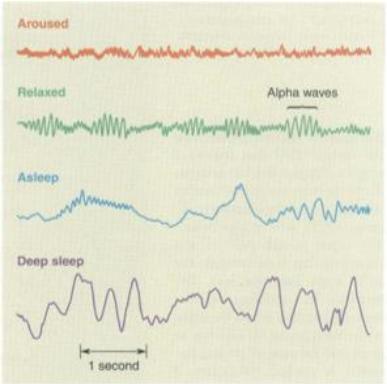


FIGURE 5.8 Some typical electroencephalograms and their psychological correlates.

        - Associated with levels of consciousness (Ex. Alpha waves→ regular, 8-12 per/sec, high amplitude, associated with 'wakefulness')
        - *Event-related potentials*→Accompany certain events
            - Sensory evoked potential: change in EEG signal as a result of momentary presentation of a stimulus.
        - *Signal averaging*→ method to reduce the 'noise' of an EEG

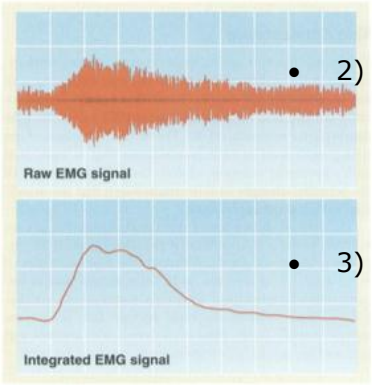


FIGURE 5.12 The relation between a raw EMG signal and its integrated version. The subject tensed the muscle beneath the electrodes and then gradually relaxed it.

- 2) muscle tension:
    - electromyography→ procedure for measuring muscle tension (EMG)
        - recorded between 2 electrodes tapes to skin surface over muscle.
        - Amplitude of EMG→ number of muscle fibers contracting at once.
- 3) eye movement:
    - Electrooculography→ records eye movement using potentials
        - There is a steady potential difference between the front & back of the eyeball. Electrodes placed around the eye can measure the change in potential as the eye moves.
- 4) Skin Conductance:
    - Skin conductance level (SCL)→ measures background levels of skin conductance associated with particular situations.
    - skin conductance response (SCR)→ measure transient changes in skin associated with discrete experiences.
    - →sweat glands tend to become active in emotional situations, with certain areas extremely sensitive (hand, armpits etc)
- 5) Cardiovascular activity: heart & blood vessels distribute O2 & nutrients to tissues of the body, remove metabolic waste & transmit chemical messages.
    - Heart rate→ (EKG) Each heart beat can be recorded
        - avg resting adult→ 70 beats/min
    - Blood pressure→
        - systole= contraction
        - diastole= relaxation (Avg. 130/70 mmHg)
        - normal resting adult → 130/70 mmHg
        - Hypertension→ 140/90 mmHg
    - Blood volume→Changes in the volume of blood in part of the body
        - Plethysmography→ various techniques for measuring changes in the volume of blood in a particular part of the body

        - Ex. String around tissue to measure enlargment, or shinnign light through tissue to measure colour change.

Invasive Phsyiological Methods:

- Stereotaxic surgery→ devices are precisely positioned in the depths of the brain
    - Stereotaxic atlas→ locates brain structures similar to a geographical map
        - Brain has 3 dimensions, distance is in millimetres,
        - Bregma: reference point on top of the skull where 2 of the major sutures (seams of the skull) intersect.
    - Stereotaxic instrument→
        - head holder: firmly holds the brain in the right position
        - electrode holder: holds the device inserted
            - Can move anterior-posterior, dorsal-ventral, lateral-medial

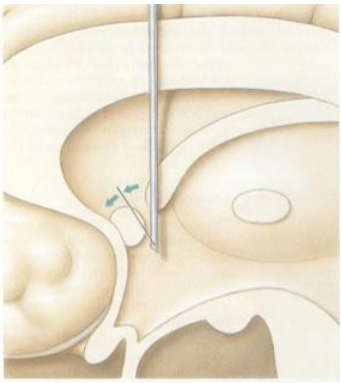


FIGURE 5.15 A device for performing subcortical knife cuts. The device is stereotaxically positioned in the brain; then, the blade swings out to make the cut. Here, the anterior commissure is being sectioned.

What Stereotaxic Surgery can be used for

- Implant electrodes for:
  - Lesions
  - Recording
  - Stimulation
- Inject chemicals for
  - Lesions
  - Pharmacological effects
  - Tracing
- Implant cannulae for later:
  - Treatment delivery
  - Sample collection
- Implant capsules/minipumps for continuous treatment delivery
- Implant optic fibers for light stimulation ("optogenetics")

- Lesion method→ part of brain is removed & destroyed, effects are measured
    - Aspiration lesions→ tissue is drawn off by suction through the fine tip of a glass pipette
    - Radio-frequency lesions→ pass RF current through the tissue from the tip of an electrode
        - The heat destroys the tissue
        - Size and shape are determined by duration and intensity
    - Knife cuts→ used to eliminate conduction in a nerve or tract
        - Blade can be hidden, then swings out to cut once in proper area.
    - Cryogenic blockage→ neurons are cooled until they stop firing (cyroprobe)
        - Temperature is maintained above freezing so there is no structural damage, and can return to normal after warmed up. (reversible)
    - Unilateral lesions→ lesions restricted to half the brain (milder)
    - Bilateral lesions→ lesions involving both sides of the brain (more severe)

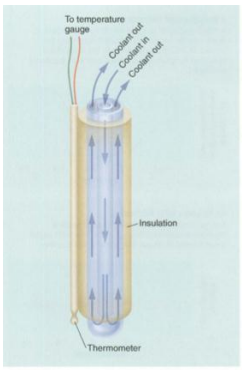


FIGURE 5.16 A cryoprobe. The cryoprobe is implanted in the brain; then the brain area at the uninsulated tip of the cryoprobe is cooled while the effects on behavior are assessed. Cryoprobes are slender so that they can be implanted in the brain without causing substantial damage; they are typically constructed of hypodermic tubing of two gauges.

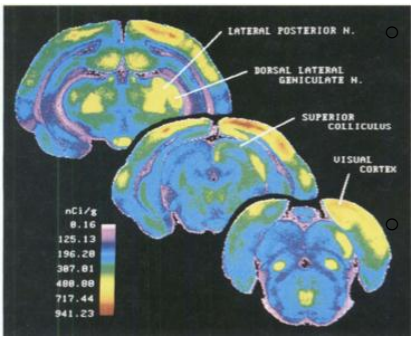
        - Studies of lesion effects are usually bilateral, rather than unilateral (pg 113)
- Electrical stimulation→ delivered across the two tips of a bipolar electrode
    - *two* insulated wires wound tightly together & cut at the end.
        - Weak pulses→immediate increase in neurons firing near electrode
    - Often has behavioural effects opposite of lesions, can elicit many behaviour sequences. (eating, drinking, attacking etc)
    - Behaviour depends on:
        - location of electrode
        - parameters of the current
        - test environment of stimulation
- 4 invasive electrophysiological recording methods:
    - 1) Intracellular unit recording→ a moment-by-moment record of the graded fluctuations in MP (membrane potential)
        - Typically performed in chemically immobilized animals (must carefully place microelectrode tip inside neuron)
    - 2) Extracellular unit recording→ provide a record of neural firing (AP) but no information about membrane potential. (MP)
        - Can record up to 100 neurons simultaneously
        - Special flexible microelectrodes that can shift slightly with the brain
    - 3) Multiple-unit recording→ large electrode tip that can pick up many neuron signals (slight shifts in movement have little effect)
        - → a graph of the total number of AP per unit of time (0.1 seconds)
    - 4) Invasive EEG recording: EEG signals are recorded through large *implanted* electrodes
        - Cortical EEG signals→ use stainless steel skull screws
        - Subcortical EEG signals → use stereotaxically implanted wire electrodes

<u>Pharmacological research Methods:</u>

- Routes of administration:
    - Orally→ fed
    - Intragastrically→ injected through tube into the stomach
    - Intraperitoneally (IP)→ injected hypodermically into cavity in abdomen
    - intramuscularly (IM)→ into large muscle
    - subcutaneously (SC)→ into fatty tissue beneath skin

- intravenously (IV)→ into large surface vein
- PROBLEM→ many drugs cannot pass through the BBB, so they are inserted into a *cannula* (fine hollow tube) that is implanted in brain.

- Selective chemical lesions:
  - Neurotoxins: are injected, have an affinity for certain components of the NS and are used for more selective lesions.
    - Ex. *6-hydroxy- dopamine (6-0HDA)*→ taken up only by neurons that release the neurotransmitter *norepinephrine* or *dopamine,* and it leaves other neurons at the injection site undamaged.
- Measuring Chemical Activity of the Brain:



  - 2-Deoxyglucose technique: measure chemical activity
    - Animal is injected and placed in a test situation. It is killed, brain is removed and sliced. Areas of the brain that absorbed 2-DG appear as black spots on the slides
  - Cerebral dialysis: measures extracellular concentration of neurochemicals
    - Involve implantation of a semi permeable tube into the brain
    - Positioned so EC chemicals will diffuse in the tube
    - It is then removed and analyzed
- Locating neurotransmitters & receptors in brain:
  - Immunocytochemistry→ when a foreign protein (antigen) is injected, antibodies attack it
    - A procedure for locating particular neuroproteins in the brain by labelling their antibodies with a dye then exposing brain tissue to the labelled antibodies. Dyed areas show location of neuroproteins.
  - In Situ Hybridization→ hybrid RNA that are complimentary to the desired mRNA are obtained. Locates peptides & proteins.
    - Hybrid RNA stranda are dyed, and brain slices are exposed to hybrid RNA. They bind to complimentary mRNA, marking location of neurons that release the target neuroprotein

<u>Genetic engineering:</u>

- Gene knockout technique→ creating organisms that lack a particular gene under investigation.
  - 'knockout mice' often conducted to clarify neural mechanisms of behaviour
    - ex. malenopsin mice→ study the role of melanopsin in regulating the light-dark cycles that control circadian rhythms.

        - Knocking out melanopsin, reduced the responses of the clock mechanism to light changes, and it impaired the ability of mice to adjust their circadian rhythms.
        - →melansopsin appears to contribute to the control of circadian rhythms by light, but it is not the only factor.
- Gene replacement technique→ replacement of one gene with another.
    - Transgenic mice: mice that contain genetic makeup of another species
        - add defective gene→gene found in schizophrenia family
        - replace with identical gene which can be turned on/off with chemicals.
- Green fluorescent protein (GFP)→ a protein that exhibits bright green fluorescence when exposed to blue light.

CHAPTER 5: PART 2: Behavioural Research Methods

- Behavioural paradigm→ a single set of procedures developed for the investigation of a particular behavioural phenomenon

Neuropsychological testing

- Neuropsychological testing can help brain-damaged patients in 3 important ways:
    - 1) Assisting in the diagnosis
    - 2) Serving as a basis for counseling and caring for the patients
    - 3) Providing a basis for objectively evaluating the effectiveness of the treatment and the seriousness of its side effects
- Modern approach:
    - Single-test approach:
        - → (1950s) goal was to determine if the patient with psychological problems suffered from structural or functional brain damage. Unsuccessful
    - Standarized-test-battery approach:
        - →(1960s) objective was the same as single-test but it involved multiple tests that were scored and added up to give an overall number. That was then used for a diagnosis. Somewhat successful.
            - Effective between *neurological patients and healthy patients*
    - Customized-test-battery approach:
        - → objective was to characterize the nature of the psychological deficits of each brain-damaged patient

        - Begins with custom tests, then custom tests to go more detailed based on first test symptoms.
        - Newer tests are designed to measure aspects of psychological function that have been spotlighted by modern theories and data
        - Interpretation does not rest on how well the patient does (ex. The strategy used)
        - Requires more skill and knowledge on neuropsychologist to select the right test
        - Highly successful
- Tests of the common neuropsychological test battery
    - Intelligence→ poor measure of brain damage
        - Wechsler Adult Intelligence Scale (WAIS)
            - Test of *general knowledge*
            - Knowing IQ helps interpret the following tests
        - Cqn sometimes draw conclusions from pattern of deficits
            - Left hemisphere damage= low scores on verbal tests
            - Right hemisphere damage= low scores on performance
    - Memory→ hard to miss, usually reported by family or patient
        - digit span: longest sequence of random digits that can be repeated
            - tests short-term memory
            - most people have digit span of 7
        - general knowledge & short-term are least effected by damage.
    - Language→
        - WAIS→ low verbal score
        - token test→ 20 tokens, different shapes, sizes, and colours. Patients is asked to touch "red square". Progressively gets more difficult, eventually they must read the instructions themselves & follow them.
    - Language lateralization→ knowing which hemisphere is dominant in language helps (most people are left dominant for language)
        - Used prior to surgery: to plan surgery & avoid language areas
        - Sodium amytal test→ injects sodium amytal into either carotid artery. This anaesthetizes the ipsilateral (same) side while leaving the contralateral (opposite) hemisphere unaffected
            - Test while anaesthetized & tests afterwards to compare

        - When dominant side is tested, patient is mute for 2 mins.
    - Dichotic listening test→ sequences of spoken digits are presented to subjects through headphones. 3 in one ear, 3 in the other.
        - Subjects correctly report more digits heard by the ear contralateral (opposite) to their dominant hemisphere
- Tests of specific neuropsychological function
    - Memory→
        - 4 questions must be answered
            - impairment involve short-term/long-term/both?
            - long-term memory deficits: anterograde/retrograde/both?
            - Long-term deficits: semenatic (knowledge of the world), or episodic (personal experiences)?
            - Long-term deficits: explicit (patient aware) or implicit memory (patient unaware)?
        - Repetition priming tests:
        - → patients are shown a list of words and asked to study them. Then must complete fragmented words (pu_p__) emnesic patients can comlete the words normally, but have no memory of the initial list. (display implicit memories without explicit memory)
    - Language→
        - Phonology: rules governing the sounds of the language
        - Syntax: the grammar of the language
        - Semantics: meaning of the language
    - Frontal-lobe function:
        - Wisconsin Card sorting test
            - →cards of shapes, colours, numbers.
            - Asked to correctly sort deck into piles under stimulus card. 1st sort by colour, after many correct answers, changes to different sorting.
            - *Preservation*→ Patients with damage to frontal lobes often continue to sort for 100 trials after it has become incorrect

<u>Behvaioural methods of Cognitive neuroscience:</u>

- Cognitive neuroscience:
    - Goal→ identify parts of the brain that mediate certain cognitive processes.
    - 2 assumptions:

        - 1) Constituent cognitive processes→ each complex cognitive process results from the combined activity of simple cognitive processes
        - 2) each constituent cognitive process is mediated by neural activity in a particular area of the brain.
- Paired-imaging subtraction technique→ involves obtaining PET or fMRI images during several different cognitive tasks.
    - Then brain activity associated with that process can be established by comparing with other tests.
    - Ex. subjects spent a minute reading aloud printed nouns as they appeared on a screen. Other group observed the same nouns on the screen but responded to each of them by saying aloud an associated verb (e.g., *truck- drive).* They then subtracted the activity in the images that they recorded during the two tasks to obtain a *difference image,* which showed the areas of the brain that were involved in word association.
- Default mode→ brain activity when human subjects sit & let their mind wander.
    - Default mode network: brain structures active in the default mode
        - Medial & lateral parietal cortex
        - medial frontal cortex
        - lateral temporal cortex

<u>Biopsychological Paradigms of animal behaviour</u>

- Behavioural paradigm→ used to study the biopsychology of laboratory species

1) Paradigms for the assessment of species-common behaviours:

- Species-common behaviours→ displayed by all members of a species
    - within the same age & gender
    - Examples: grooming, swimming, eating, drinking, copulating
- I) Open-field test→ subject is placed in a large, barren chamber & record activity
    - drawing grid & count line crossings or # of boluses (droppings)
        - fearful rats→ Thigmotaxi (rarely venture from the walls)
- II) Aggressive/Defensive Behaviour tests:
    - Colony-intruder behaviour→ behaviour during combative encounters between male rat of established colony and small male intruder.
        - Aggression: piloerection, lateral approach, flank/back biting
        - Defensive: freezing, boxing (rearing & pushing), rolling over.

    - Elevated plus maze→ the time a rat spends in the closed end vs open end of maze
        - 4 armed maze that is elevated, 2 arms have sides, 2 don't.
        - give drugs and measure the anxiety by proportion of time spent in enclosed/open ledges.
- III) tests of sexual behavioru:
    - Lordosis quotient→ the proportion of male mounts that elicit lordosis
        - intromission: inserting of the penis
        - 10 cycles of mounting, intromitting, dismounting→ ejaculation.

2) Traditional conditioning paradigm (learning)

- Pavlovian conditioning paradigm:
    - UCS (meat) causes *UCR* (salivation).
    - pairs CS (tone) with UCS (meat)
    - CS (tone) eventually causes CR (salivation).
- Operant conditioning paradigm:
    - rate of voluntary response (such as a lever press) is increased by *reinforcement* or decreased by *punishment.*
    - self-stimulation paradigm (Most widely used)
        - → animal presses a lever to deliver electrical stimulation to particular sites in their own brain (pleasure centers)

3) Seminatural animal learning paradigm:

- Conditioned taste aversion:
    - →the avoidance response that develops to tastes of food whose consumption has been followed by illness
        - Challenged view that animal conditioning is a step-by-step process
        - showed that temporal contiguity is not essential for conditioning
        - Challenged view that conditioning proceeds in basically the same manner regardless of the stimuli and response
- Radial arm maze:
    - → array of arms (8+) radiating from a central starting area. At the end of each arm is a food cup, which may or may not be baited.
        - Placed in maze each day with same arms baited, able to remember. Can be disrupted by rotating the maze.
- Morris water maze:
    - →placed in pool of water, must swim to find escape platform which is under surface (cant see it)

    - Useful for assessing navigational skills of brain-lesioned/drugged animals
- Conditioned defensive burying:
    - → rats bury test objects that give an aversive stimulus (shock, odor, air blast)
        - antianxiety drugs reduce the amount of defensive barrying.

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