Brain & Behaviour

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Determinants of Behaviour

• Biological Determinants
  ➢ Genetic Influences
  ➢ Growth and developmental Influences
  ➢ Biochemical Influences
  ➢ Psychophysiologica1 parameters

• Learning
• Psychosocial factors
• Sociocultural factors
Biological Determinants of Behaviour

• The complexity of the behavior of any individual is related to the complexity of its nervous system.

• Generally, individuals with complex nervous systems have a greater capacity to learn new responses and thus adjust their behavior.
Scientific understanding of human behaviour and experience in health and disease requires knowledge about:

- Functional Anatomy of the Neuron
- Functional Organization of the Brain
- Neurotransmitters
- Receptors
- Molecular Neurobiology
- Molecular Psychopharmacology
Advances in the understanding of the structure, organization, and function of the brain offer powerful new methods for:

- evaluating behaviour
- diagnosing mental disorders
- understanding pathophysiology of Mental Disorders
- developing specific and effective therapies for Mental Disorders
Human Brain, *Some Facts*

• The brain is one of the largest and most complex organs in the body.

• It is the upper most part of the nervous system.

• The brain monitors and regulates the body's actions and reactions.

• It continuously receives sensory information, and rapidly analyzes the information and then responds.
Human Brain, Some Facts

- The brain is surrounded by 3 layers of tissue called the “meninges”.
- The brain suspended in a fluid called “cerebrospinal fluid (C.S.F)”
- The CSF is isolated from the blood stream by the “blood-brain barrier”.
- The skull (cranium) helps protect the brain from injury.
Human Brain, Some Facts

• The adult human brain weighs on average about (1.5 kg)
• Men's brains are on average 100g heavier than a woman’s
• The size of the brain is around 1130 (cm³) in women and 1260 cm³ in men
• The brain is made up of over 100 billion nerve Cells (Neurons) that communicate in trillions of connections called “synapses”.
• At the age of 20, a man has around 176,000 km and a woman about 149,000 km of myelinated axons in their brains.
The Brain, anatomical parts

The brain is made up of many specialized areas that work together:

• **The Cerebrum (cerebral hemispheres).**

• **The Brain Stem**, between the spinal cord and the rest of the brain.

• **The Cerebellum**, is at the base and the back of the brain.
Functional Anatomy of the Neuron

The “Neuron”

• Is a cell type that is highly specialized, both anatomically and biochemically, to carry out the functions of information signaling and processing.

• Hundreds of specialized types of neurons, each type subserving specialized functions.

• Neurons do not divide once they are mature
The Neuron

Step 2. In the cytoplasm, the strands of mRNA bind to ribosomes.
Functional Anatomy of the Neuron

- Neurons are composed of 4 components:
  - Cell body (perikaryon)
  - Dendrites
  - Axon
  - Presynaptic terminal
1. **Cell body (Perikaryon):**

   Consists of:

   - *The nucleus* contains a nucleolus (plus a Barr body in females)
   - *The cytoplasm* contains inclusions:
     - Nissl substance (involved in protein synthesis)
     - Mitochondria (involved in energy productions)
     - Microtubules (involved in transport of substances)
     - Lisosomes (bodies containing powerful enzymes)
     - Golgi apparatus (involved in synthetic activities?)
     - Microfilaments (unknown function)
     - Melanin pigment (found in substantia nigra and locus coeruleus)
The nucleus

- Controls reactions in the cytoplasm by controlling the formation of proteins and enzymes.
- Stores information needed for when the cell divides.
- Is the place where the transcription of genes and mRNA splicing occur.
- The nucleus is surrounded by a double membrane, the inner and outer membrane fuse at regular spaces, forming nuclear pores.
- The outer membrane has ribosomes.
- Ribosomes are involved in protein biosynthesis, the process of translating RNA into protein.
Cell Nucleus

- The nucleus contains the **chromosomes** and a **nucleolus**.

- **Chromosomes** are thread like strand of **DNA** and associated proteins that carry the genes in a linear order and function in the transmission of hereditary information.

- **Nucleolus** is a small rounded granular body composed of protein and ribonucleic (RNA) and involved in **ribosomal RNA synthesis** and the formation of **ribosomes**.
2. **The Axon**

- Usually single
- The proximal portion is called the “Axon Hillock”
- Branches distally - each branch forms an outpouch at its end called the “Button”
- Myelinated and unmyelinated
- Conducts impulses away from the perikaryon
3. **Dendrites**

- Usually more than one per neuron
- Contain Nissl substance
- Branched are studded with dendritic spines (sites for synaptic contact)
- Conduct information to the perikaryon
The Synapse

- Is a specialized structure involved in the transmission of information from one neuron to another

- The “Synapse consists of:
  - **Button**: outpouch of the terminal portion of the axon of the **Presynaptic neuron**
  - Dendritic membrane of the adjacent **postsynaptic neuron** (dendritic spine)

- Neurotransmission is accomplished by:
  - **Chemical Transmission** by messengers called “**Neurotransmitters (NTs)**”
  - **Electrical Transmission** by nerve impulses and action potentials
The Synapse

Source: Reproduced from Pinel, 1990, with permission from the publishers.
Synaptic Connections
Receptors

• The *dendritic membrane* at the synapse is markedly enriched with "**Receptors**" that respond to the neurotransmitter released by the terminal button of the *Presynaptic neuron*.

• **Neuro receptors** are proteins that span the neuronal membrane.

• Receptors have:
  - *ligand binding regions* that are accessible to extracellular messengers
  - *ligand-gated channels* consist of channel pores
### Developmental Brain Organization

**Brain structures as derivatives of the neural tube**

<table>
<thead>
<tr>
<th>Primary vesicles</th>
<th>secondary vesicles</th>
<th>Brain components</th>
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<tbody>
<tr>
<td>Prosencephalon (forebrain)</td>
<td>Telencephalon</td>
<td>Cerebral Cortex</td>
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<td></td>
<td>Hippocampus</td>
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<td>Amygdala</td>
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<td>Striatum</td>
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<td>Mesencephalon (midbrain)</td>
<td>Diencephalon</td>
<td>Thalamus &amp; subthalamus</td>
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<td>Hypothalamus, Epithalamus</td>
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<td>Rhombencephalon (hindbrain)</td>
<td>Mesencephalon</td>
<td>Midbrain</td>
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<td>Metencephalon</td>
<td>Pons</td>
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<td>Myelencephalon</td>
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<td>Medulla</td>
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Three functional brain systems illustrate the relation between the organizational principles and the structural components of the human brain:

I. Thalamocortical system

II. Basal ganglia system

III. Limbic System
1. Thalamocortical system

- The connection between the thalamus, the cortex, and certain related structures

- Comprises 3 thalamocortical systems (each with different pattern of functional circuity):
  - Sensory System,
  - Motor System,
  - Association System
2. Basal Ganglia System

- A collection of nuclei grouped together on the basis of their interconnections

- **Play an important role in:**
  - regulating movement
  - cognitive functions
Basal Ganglia System

• Major components:

1. Caudate

2. Lentiform nucleus = putamen + Globus pallidus (pallidum or paleo striatum)

3. Subthalamic nucleus

4. Substantia nigra

[Striatum = all the above nuclei]
Basal Ganglia

- Right globus pallidus
- Two lobes of thalamus
- Left globus pallidus
- Head of caudate
- Left putamen
- Tail of caudate
- Left amygdala
Thank You
Psychophysiological Determinants of Behaviour

- The Limbic System
- Reticular activating System (ARAS)
- Cortical Sites (Cerebral Cortex)
The Limbic System

• The **limbic system** is a set of brain structures that forms the inner border of the cerebral cortex.

• The structures include the **hippocampus** and **amygdala** that support a variety of functions including **emotion**, **behavior** and **long term memory**.

• The word “**Limbic**” = Latin word “**Limbus**” (border) applied by “**Pierre Broca**” (French physician, surgeon, anatomist and anthropologist) more than 100 years ago.
Limbic System

• The term Limbic system applied by “Paul MacLean, 1952” to describe the circuitry that relates certain telencephalic (Forebrain) structures and their connections with the hypothalamus and its output pathway that control autonomic, somatic, and endocrine functions.
The **limbic lobe** is named by Broca in 1878.

- He identified it with the [Cingulate](#) and [Parahippocampal gyri](#), and associated it with the **sense of smell**.

- The **limbic lobe** is an arc-shaped region of [cortex](#) on the [medial](#) surface of each [cerebral hemisphere](#), consisting of parts of the [frontal](#), [parietal](#) and [temporal](#) lobes.

- A direct connection between emotion and the **limbic lobe** has been identified.
Limbic Structures

**Amygdala:**

- A Latin word means 'almond', 'tonsil'.
- Are almond-shaped groups of nuclei located deep within the medial temporal lobes of the brain.
- Has a primary role in the processing of memory and emotional reactions.
- Involved in signaling the cortex of motivationally significant stimuli such as those related to reward and fear in addition to social functions such as mating.
The brain as viewed from the underside and front. The thalamus and Corpus Striatum (Putamen, caudate and amygdala) have been splayed out to show detail.

**Corpus Striatum**

- Caudate nucleus
- Lenticular nucleus (globus pallidus and putamen)
- Amygdala
Hippocampus

• Is a **Latin** word meaning “seahorse” or "sea monster”
• **Aranzi** (1587) likened it to a **seahorse**, or alternatively to a **silkworm**.
• It is the ridge running along the floor of the **temporal horn of the lateral ventricle** in the medial temporal lobe underneath the cortical surface.
• Plays important roles in the consolidation of information from **short-term memory** to **long-term memory**.
• It contains two main interlocking parts: **Ammon's horn** and the **dentate gyrus**.
Hippocampus

• The hippocampus is one of the first regions of the brain to suffer damage in Alzheimer's disease.

• Extensive, bilateral hippocampal damage may cause anterograde amnesia.

• Many reports have found reductions in the size of the hippocampus in schizophrenic subjects.
Parahippocampal gyrus

- **Parahippocampal gyrus**: surrounds the hippocampus.

- It plays an important role in memory encoding and retrieval.

- Plays a role in the formation of spatial memory.

- Parahippocampal Asymmetry has been observed in schizophrenia.
Cingulate gyrus

- The Cingulate gyrus is situated in the medial aspect of the cerebral hemisphere, lies immediately above the corpus callosum.

- It is involved with emotion, learning, memory, executive function and respiratory control

- The Cingulate cortex is highly important in disorders such as depression and schizophrenia.

- Anterior cingulate gyrus was found to be smaller in schizophrenic patients.
The Limbic System

- Right cingulate gyrus
- Longitudinal fissure
- Left fornix
- Septum
- Olfactory bulb
- Hypothalamus
- Mammillary body
- Left amygdala
- Left thalamus
- Left hippocampus
- Medulla
Hypothalamus

• The hypothalamus (from Greek under and room, chamber).

• Contains a number of small nuclei with a variety of functions.

• Located below the thalamus, just above the brain stem.

• It is roughly the size of an almond.

• One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland (hypophysis).
Hypothalamus

• The hypothalamus is responsible for certain metabolic processes and other activities of the autonomic nervous system.

• It synthesizes certain neurohormones, often called hypothalamic-releasing hormones, and these in turn stimulate or inhibit the secretion of pituitary hormones.

• The hypothalamus controls body temperature, hunger, thirst, fatigue, sleep, and circadian cycles.
Limbic Structures

**Fornix**: carries signals from hippocampus to the mammillary bodies and septal nuclei.

**Mammillary bodies**: Important for the formation of memory.

**Septal nuclei**: Located anterior to the interventricular septum, they provide critical interconnections

**Parahippocampal gyrus**: Plays a role in the formation of spatial memory

**Dentate gyrus**: contributes to new memories
Thalamus

• The thalamus (from Greek θάλαμος, "inner chamber")

• It is a midline symmetrical structure within the brain, situated between the cerebral cortex and midbrain and surrounds the 3rd ventricle.

• Its function includes:

  ➢ relaying sensory and motor signals to the cerebral cortex,

  ➢ regulation of consciousness, sleep, and alertness.
Functions of the Limbic System

- The limbic system operates by influencing the **endocrine system** and the **autonomic nervous system**.
- The limbic system is highly interconnected with the **nucleus accumbens**, which is considered the brain's **pleasure center**, plays a role in **sexual arousal** and the "high" derived from certain **recreational drugs**.
- The limbic system tightly connected to the **prefrontal cortex**. This connection is related to the **pleasure obtained from solving problems**.
- The limbic structures are closely associated with the **olfactory structures**. This association is important for mating and reproduction.
Psychophysiological Determinants of Behaviour

• The Limbic System

• Reticular activating System (ARAS)

• Cortical Sites (Cerebral Cortex)
The Reticular Formation (RF)

- The RF consists of more than 100 small neural networks between the spinal cord and the thalamus “reticular formation proper”

- Reticular formation nuclei that modulate activity of the cerebral cortex are called the reticular activating system:
  - Ascending Reticular Activating System (ARAS)
  - Descending Reticular Activating System (DRAS)

- The RF is involved in actions such as awakening/sleeping, and filtering incoming stimuli
Ascending Reticular Activating System (ARAS)

- Formed of fibers in the brain stem, which receive **collaterals** from sensory fibers projecting to **thalamus**

- Fibers relay this information to the **thalamic nuclei**, and project this information to the **cortex** in a diffuse manner

- Reticular formation responds to stimuli from all sensory systems
Descending Reticular Activating Systems

• Receives input from sensory collaterals, cerebellum and vestibular system and cortex

• Influences the motor system by sending information to the motor neuron pool via the reticulospinal tract

• Offer tonic influence on motor neurons Gamma Efferent (tone)
Functions of the Reticular Formation

1. **Somatic motor control** in maintaining tone, balance, and posture.

2. **Cardiovascular control** - The reticular formation includes the cardiac and vasomotor centers of the medulla oblongata.

3. **Pain modulation** - The nerve fibers in these pathways act in the spinal cord to block the transmission of some pain signals to the brain.
Functions of the Reticular Formation

4. **Sleep and consciousness** - The reticular formation plays a central role in states of consciousness like alertness and sleep. Injury to the reticular formation can result in irreversible coma.

5. **Filtration of stimuli** - This is a process in which the brain learns to ignore repetitive, meaningless stimuli while remaining sensitive to others.
Thank You
Psychophysiological Determinants of Behaviour

- The Limbic System
- Reticular activating System (ARAS)
- Cortical Sites (Cerebral Cortex)
Frontal Lobe Functions

- Voluntary movement and Skilled movements
- Language production (L)
- Body language
- Judgment and Inhibition
- Executive functions
- Problem solving
- Abstract thought processes and Creative thought
- Initiative taking
- Attention
- Motivation
- Sense of smell Libido (sexual urges)

*Decreased activation is reported in schizophrenia*
Frontal Lobe Injury

• Injury to the Frontal lobe (FL) impairs the executive functions:
  - Actions and sequencing of actions
  - Motivation
  - Attention

• Bilateral lesions in the FL cause changes in personality and Frontal Lobe syndrome:
  (slow thinking; poor judgment; decreased curiosity, social withdrawal; irritability; apathy)

• The FL is a major therapeutic site for the antipsychotic medication
Parietal Lobe Functions

- Tactile sensation: Sense of touch
- Stereognosis: Appreciation of form through touch
- Proprioception: Response to internal stimuli
- Sensory comprehension
- Some language and reading functions, and Calculation (L)
- Visuospatial function
Temporal Lobe Functions

• Some hearing and auditory memories
• Some vision pathways and Visual memories
• Other memory
• Music
• Some language, and Some speech and Language comprehension (L)
• Sensory prosody
• Some behavior and emotions and Fear
Occipital Lobe Functions

• Processing visual information

• Visual perception

• Reading
Cerebral Hemispheres

**Right Hemisphere**
- Controls the left side of the body
- Temporal and spatial relationships
- Analyzing nonverbal information
- Communicating emotion

**Left Hemisphere**
- Controls the right side of the body
- Produce and understand language

**Corpus Callosum**
- Communication between the left and right side of the brain
Posterior Fossa Structures

THE CEREBELLUM
• Balance
• Posture

THE BRAIN STEM
• Motor and sensory pathway to body and face
• Vital centers: cardiac, respiratory, vasomotor
Other Brain Structures

**Hypothalamus**
- Mood and motivation
- Sexual maturation
- Autonomic function
- Temperature regulation
- Hormonal body processes

**Pituitary Gland**
- Hormonal body processes
- Physical maturation
- Growth (height and form)
- Sexual maturation and functioning
Other CNS Structures

Pineal Body
• Circadian rhythm,
• Melatonin secretion during sleep at night for regeneration of cerebral neurons

Ventricles and Cerebral Aqueduct
• Contains the cerebrospinal fluid that bathes the brain and spinal cord

Spinal Cord
• Conduct and source of sensation and movement
Specific Brain Functions

Arousal

- Arousal is physiological and psychological state of being awake or reactive to stimuli.

- Arousal involves the activation of the reticular activating system, the autonomic nervous system and the endocrine system.

- Arousal leads to increased heart rate and blood pressure, sensory alertness, mobility and readiness to respond.

- The Arousal system involves four major neural systems originating in the brainstem, with connections extending throughout the cortex, based on the brain neurotransmitters: acetylcholine, nor-adrenaline, dopamine and serotonin.
Specific Brain Functions

Arousal

• 3 brain regions involved in the establishment and maintenance of an awake state:
  - Ascending Reticular activating system that sets the level of consciousness
  - Thalamus that projects to the cortex
  - Cerebral cortex

• Absence of arousal produces stupor and coma

• Bilateral cortical dysfunction results into a vegetative state

• Maintenance of attention requires an intact frontal lobe

• Brain's neurotransmitters involved in Arousal include: acetylcholine, norepinephrine, dopamine, and serotonin
Specific Brain Functions

Emotions

• The word *emotion* refers to a subjective, conscious experience characterized by psycho-physiological expressions, biological reactions and mental states.

• Emotion *is often the driving force behind motivation, positive or negative.*

• Human emotions are largely learned and include: affection, pride, guilt, pity, envy, and resentment.

• The amygdala organizes behavioral, autonomic, and hormonal responses to a variety of situations, including those that produce fear, anger, or disgust, sexual and maternal behavior.
Specific Brain Functions

Emotions

- The amygdala receives inputs from the olfactory system, temporal lobe, frontal cortex, and the limbic system.
- The amygdala outputs go to the frontal cortex, hypothalamus, hippocampal formation, and brain stem nuclei that control autonomic functions and some behaviors.
- Stimulation of the amygdala leads to emotional responses, and its destruction disrupts them.
- Receptors in the amygdala are responsible for the anxiolytic effects of benzodiazepine drugs and opiates.
Specific Brain Functions

Emotions

- The orbitofrontal cortex plays an important role in emotional reactions.
- The orbitofrontal cortex, receives information from the frontal lobes, temporal pole, and the amygdala and limbic system via the thalamus.
- It produces emotional reactions through its connections with the amygdala and the cingulate gyrus.
- Lesion of left prefrontal area produces depression.
- Lesion of right prefrontal area produces laughter and euphoria.
Specific Brain Functions
Memory

Three periods of memory:
• Immediate – functions over a period of seconds
• Recent – (short term or working memory) functions over a period of minutes to days
• Remote – functions over a period of months to years

3 brain structures are critical to the formation of memories
(Medial Temporal Lobe; Diencephalon; Basal Forebrain)

Alzheimer and Pick disease are examples of memory disorders
Specific Brain Functions

Language

- **Language** is the human capacity for acquiring and using complex systems of communication.

- **Language primarily** is the mental faculty that allows humans to undertake linguistic behaviour: to learn languages and to produce and understand utterances.

- The scientific study of language is called **linguistics**.

- **Speech** is the vocalized form of human communication.

- **Speech involves production, comprehension**
Specific Brain Functions

Language

- 90% of people are Right handed, 99% of them have left hemisphere dominance for language

- Left handed (10%) 7% have left hemispheric dominance and 3% either mixed or right hemispheric dominance.

- Right hemisphere dysfunction causes Developmental Dyslexia: Inability to learn in the context of adequate intelligence, motivation and education in children.

- Music is represented in the right hemisphere.
Specific Brain Functions
Language

• Aphasias are language disorders (inability to understand or produce language in the presence of normal articulation)

  ➢ **Broca’s aphasia** (non-fluent aphasia): Inability to form speech due to a lesion of left inferior frontal lobe (Broca’s area)

  ➢ **Wernicke’s aphasia** (fluent aphasia): Inability to comprehend speech due to a lesion of the left superior temporal lobe (Wernicke’s area)
Thank You