Biological Determinants of Behaviour (Brain & Behaviour)

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Determinants of Behavior

- **Biological Determinants**
  - Genetic Influences
  - Growth and developmental Influences
  - Biochemical Influences
  - Psychophysiological parameters

- **Learning**
- **Sociocultural factors**
- **Psychosocial factors**

Biological Determinants of Behavior

- The complexity of the behavior of an organism is related to the complexity of its nervous system.

- Generally, organisms with complex nervous systems have a greater capacity to learn new responses and thus adjust their behavior.

Brain & 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**

Brain & Behaviour

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**

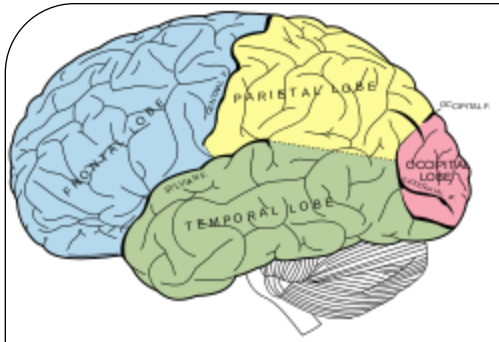
The Brain, *Some Facts*

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

- **It is the upper most part of the nervous system.**

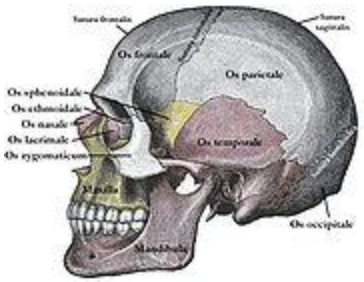
- **The brain monitors and regulates the body's actions and reactions.**

- **It receives sensory information, and rapidly analyzes the information and then responds.**



The Brain, *Some Facts*

- The brain is surrounded by 3 layers of tissue called the "meninges".
- The brain suspended in a fluid called "cerebrospinal fluid"
- It is isolated from the blood stream by the "blood-brain barrier".
- The skull (cranium) helps protect the brain from injury.



The 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 (cm^3) in women and 1260 cm^3 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.**

The Brain, anatomical parts

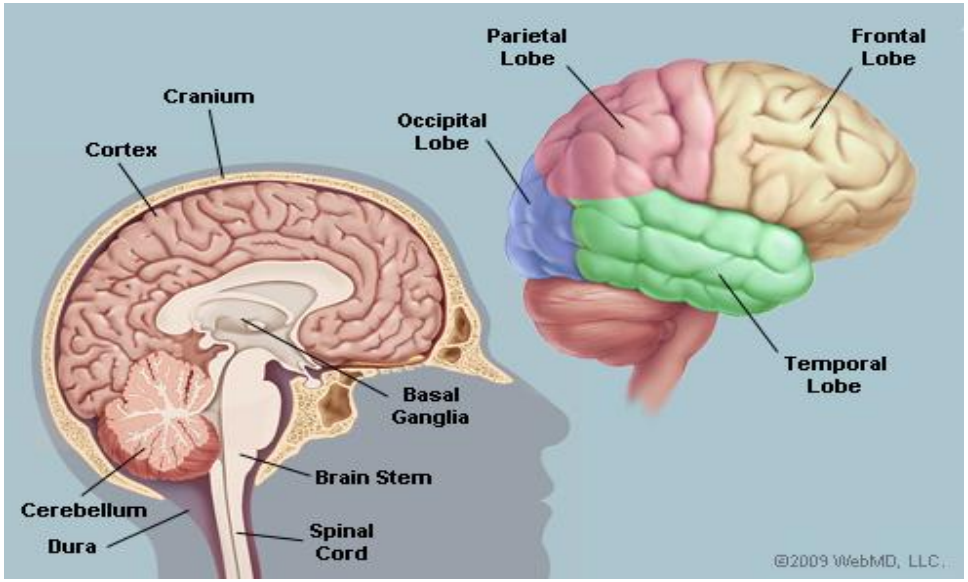
The brain is made up of many specialized areas that work togethe

- **The Cerebrum (cerebral hemisphe**
- **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.**

Cerebrum (Cerebral Hemispheres)

- The two cerebral hemispheres form the largest part of the human brain .
- They are connected by a very large nerve bundle called the “corpus callousum”.
- The cerebral hemispheres are formed of :
  - Cortex “cerebral cortex”, is the outer layer formed of gyri and sulci. Responsible for initiation of thinking and voluntary movements
  - Sub cortical structures (Thalamus, Hypothalamus, Epithalamus, Subthalamus, and Basal Ganglia)

Cerebrum (Cerebral Hemispheres)



- Each cerebral hemisphere interacts primarily with the opposite one half of the body.
- In most people, the left hemisphere is "dominant" for language.

Sub-cortical Structures

- **The Thalamus**
  - **Is a collection of nuclei with diverse functions.**
  - **It is a major relay station between the senses and the cortex.**
- **The Hypothalamus**
  - **Is composed of numerous small nuclei at the base of the forebrain.**
  - **It is the central control station for sleep/wake cycles, eating and drinking, hormone release, and y other critical biological functions.**
- **The Subthalamic area**
  - **Contains action-generating systems for several types of "consummatory" behaviors, eating, drinking, defecation, and copulation**
- **Epithalamus:**
  - **Its function is the connection between the limbic system to other parts of the brain.**

Brain Composition

- **The brain is composed of two classes of cells "Neurons and "Glia".**

- **The "glial cells" outnumber neurons roughly 4 to 1.**
- **"Axons" transmit signals to other neurons by means of specialized junctions called "Synapses".**
- **A single axon may make several thousand synaptic connections.**

Functional Anatomy of the Neuron

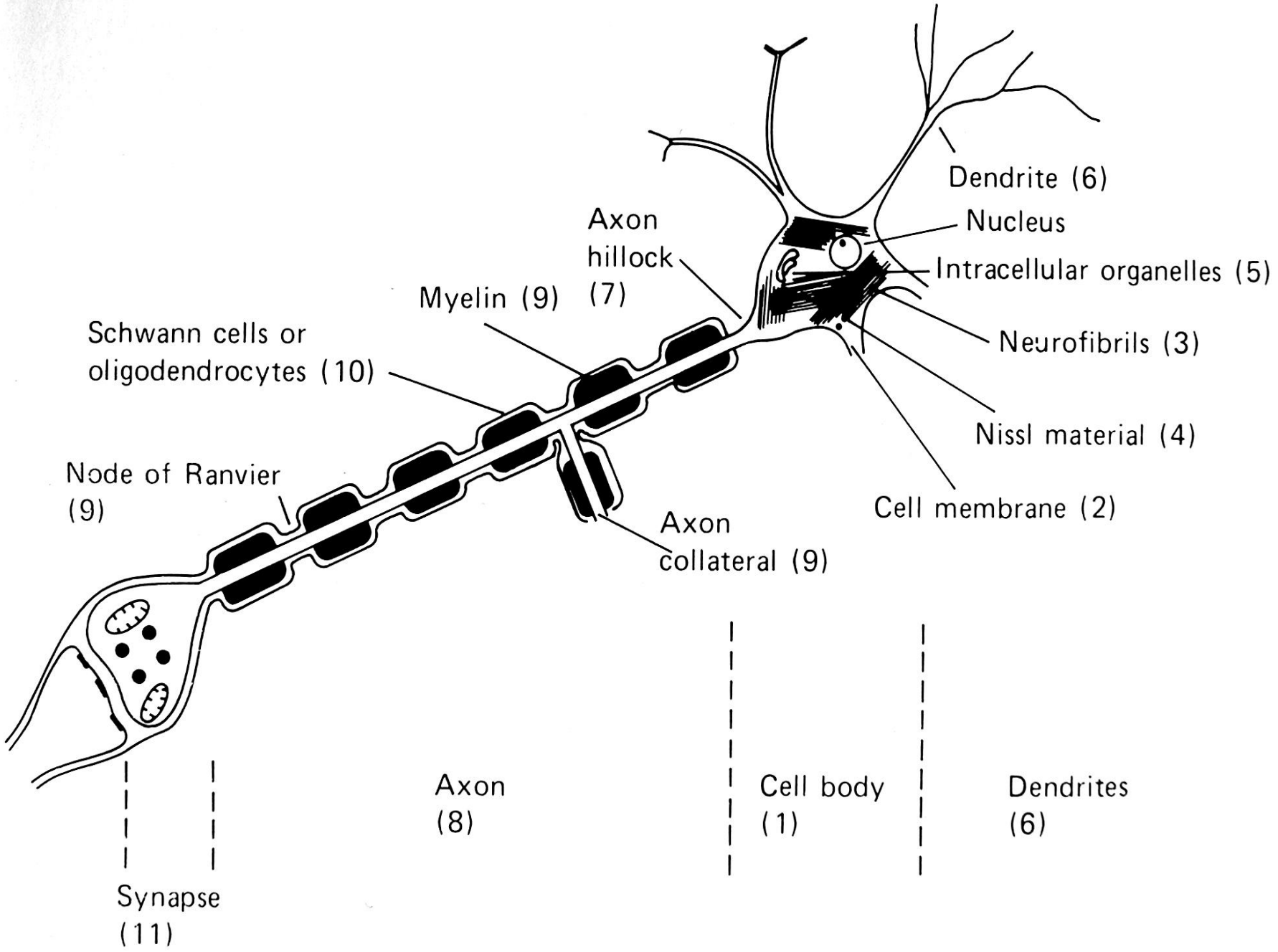
The *"Neuron"*

- 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

Functional Anatomy of the Neuron

- **Neurons are composed of 4 components:**

- **Cell body (perikaryon)**
- **Dendrites**
- **Axon**
- **Presynaptic terminal**


Dendrite (6)
Nucleus
Intracellular organelles (5)
Neurofibrils (3)
Nissl material (4)
Cell membrane (2)
Axon hillock (7)
Myelin (9)
Schwann cells or oligodendrocytes (10)
Node of Ranvier (9)
Axon collateral (9)
Synapse (11)
Axon (8)
Cell body (1)
Dendrites (6)

Structure of the Neuron

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)**
  - **Golgi apparatus (involved in synthetic activities?)**
  - **Mitochondria (involved in energy productions)**
  - **Microfilaments (unknown function)**
  - **Microtubules (involved in transport of substances)**
  - **Lisosomes (bodies containing powerful enzymes)**
  - **Melanin pigment (found in neurons of the substantia nigra and locus coeruleus)**

Cell Nucleus

- *The nucleus has two main functions :*

➢ **Controls chemical reactions in the cell Cytoplasm** *by controlling the formation of proteins and enzymes*

➢ **Stores information needed when the cell division and** *transcription of genes and mRNA splicing occurs*

- *The nucleus is surrounded by a double membrane:*

- *The outer membrane has ribosomes*
- *Ribosomes are involved in protein biosynthesis, the process of translating RNA into protein.*
- *The inner and outer membrane fuse at regular spaces, forming nuclear pores*

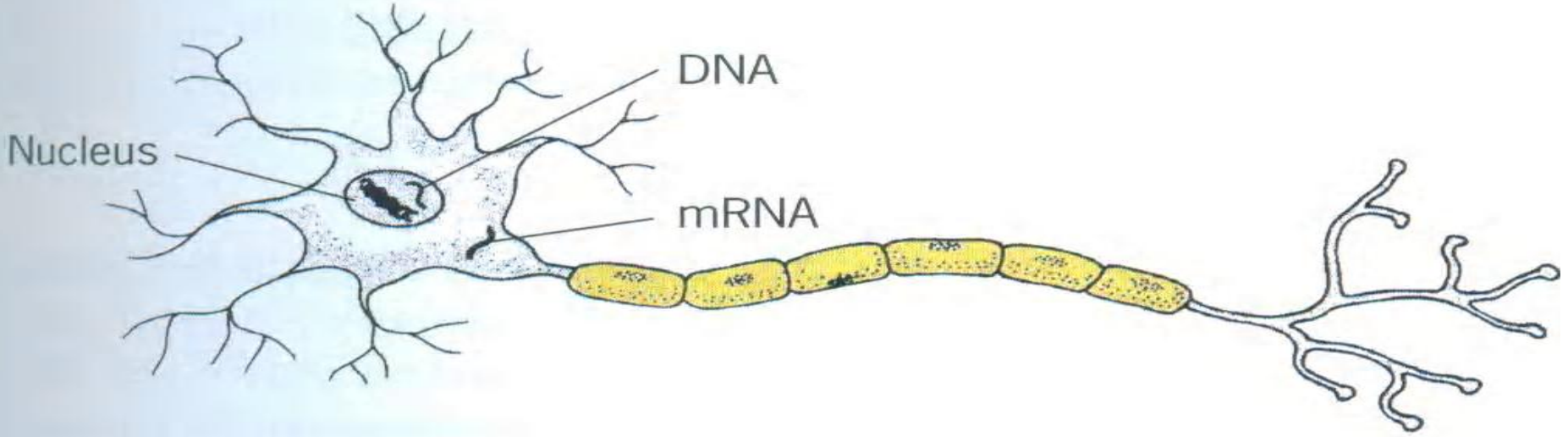
Cell Nucleus

- *The nucleus contains the chromosomes and nucleoli.*

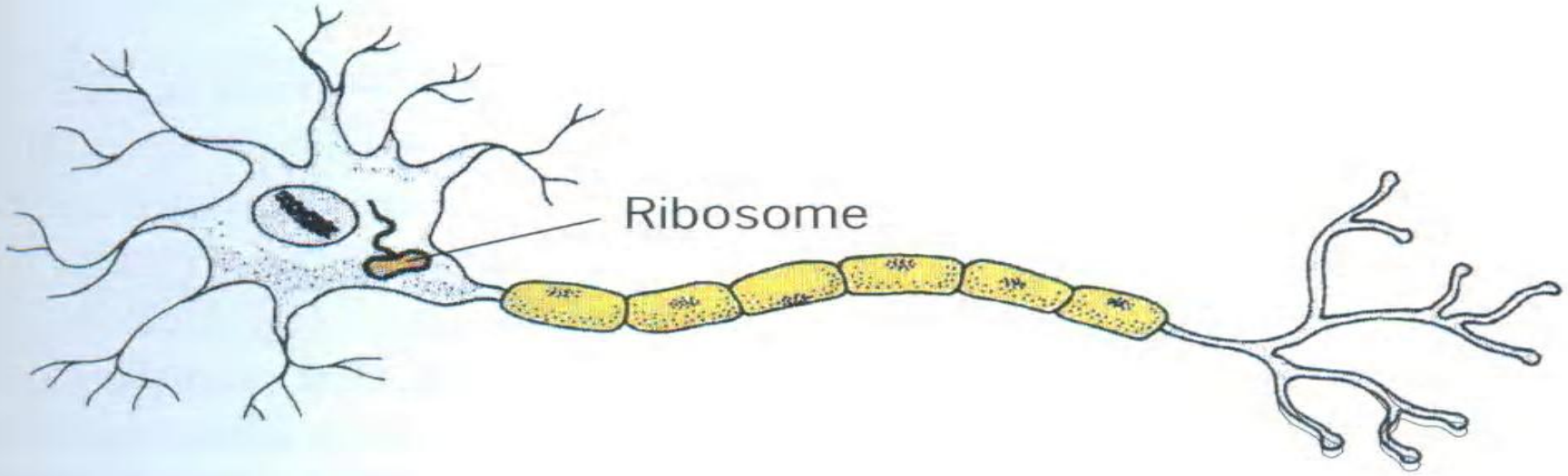
- *Chromosomes contain information encoded in (DNA) attached to proteins called histones and are usually arranged in to a dense network called Chromatin.*

- *Nucleoli are granular structures which make ribonucleic DNA (rDNA) and assemble it with proteins.*

The Neuron



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



Structure of the Neuron

2. The Axon

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

Structure of the Neuron

3. Dendrites

- Usually more than one per neuron
- Contain Nissl substance
- Branched and 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 a branch of the axon of the Presynaptic neuron

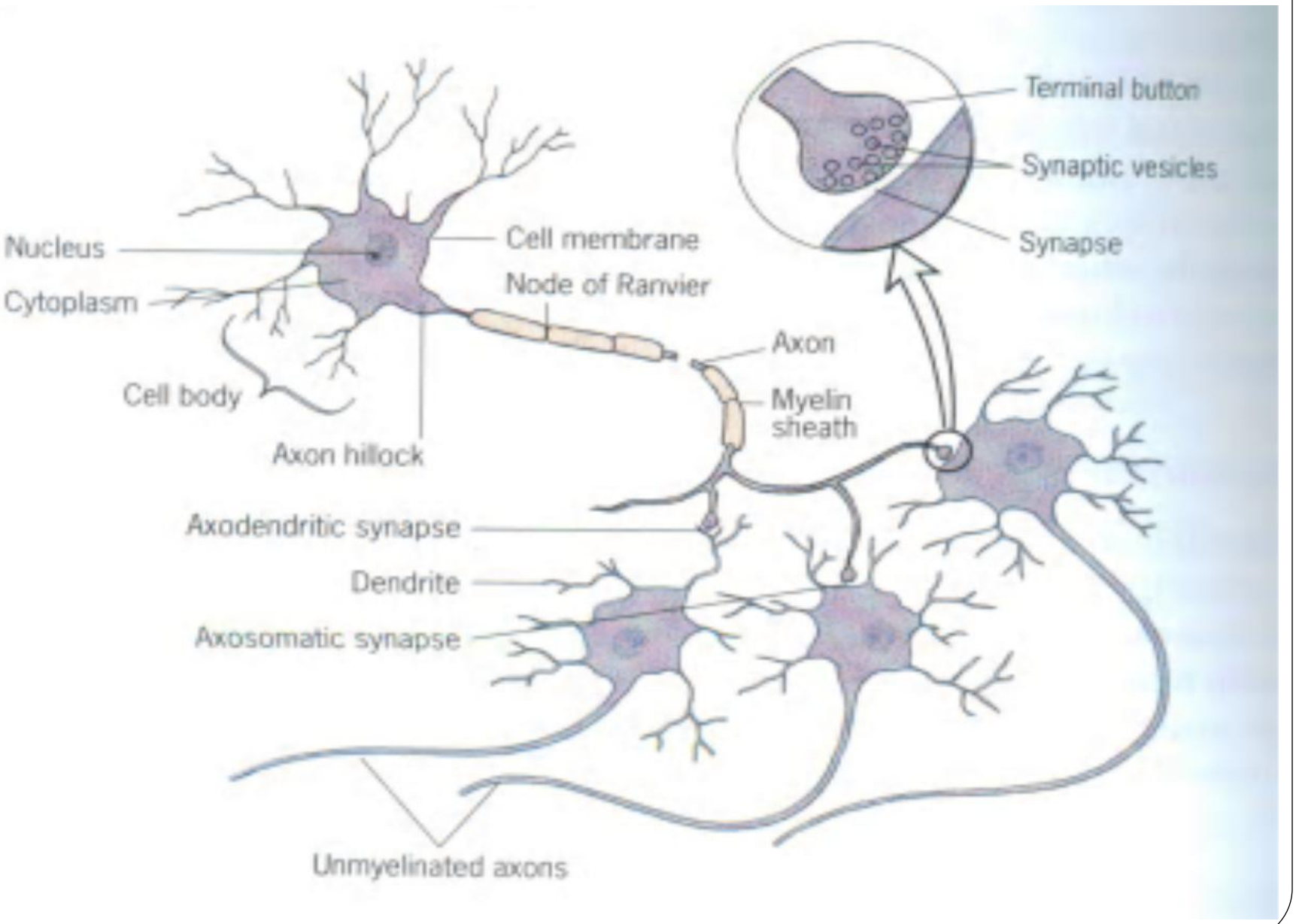
*Dendritic membrane of the adjacent Postsynaptic neuron (specialized contacts)

- Transmission is accomplished by:

➢ Chemical Transmission
by messengers called "*Neurotransmitters (NTs)*"

➢ Electrical Transmission
by ion exchange

Structure of the Neuron



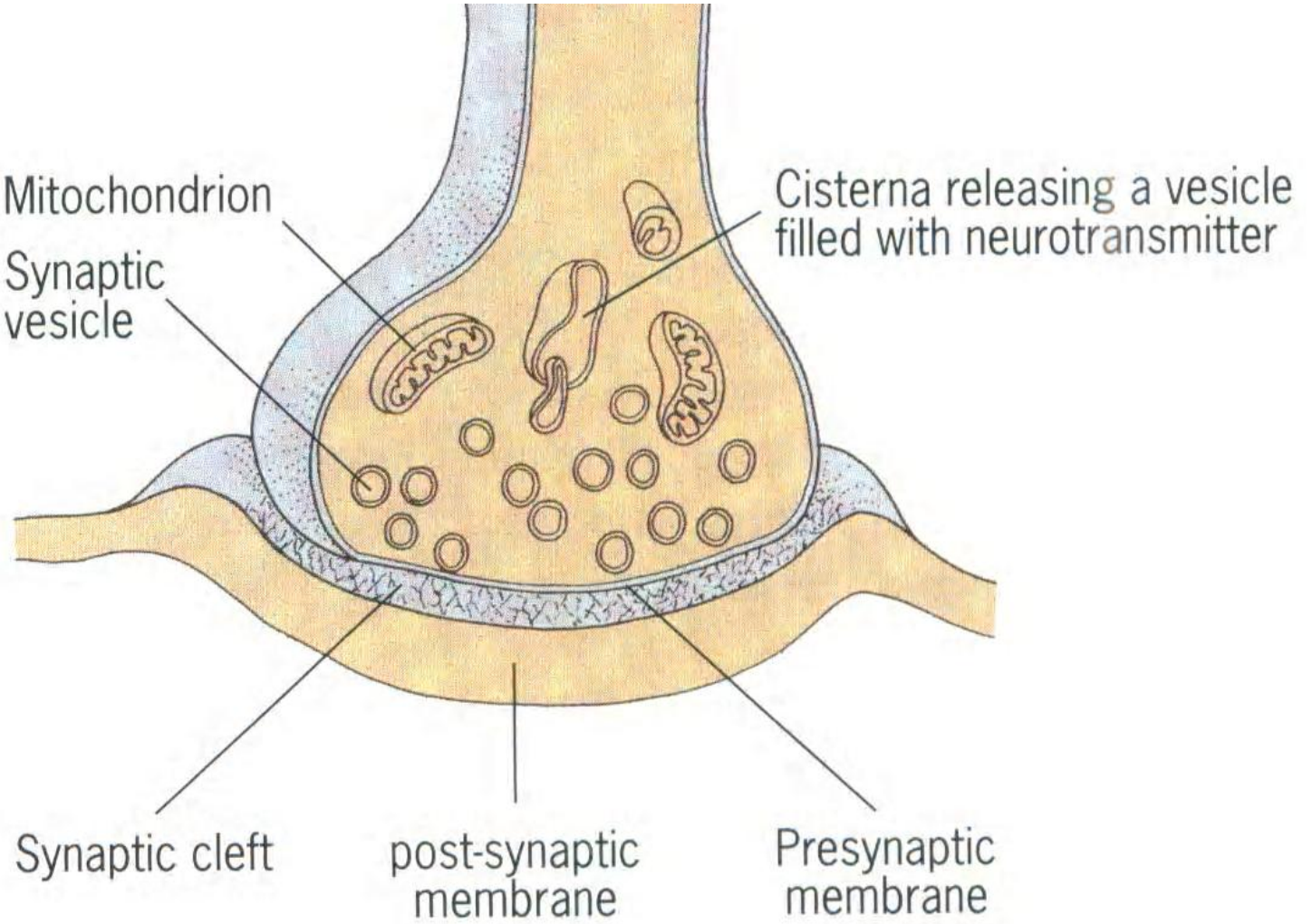
Receptors

- **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*.**
- **Neurotransmitter receptors are proteins that span the neuronal membrane.**
- **Receptors have:**

  - *ligand- inding regions* that are accessible to extracellular messengers

  - *ligand-gated channels* consist of channel pores that allow passage of ions

The Synapse



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Brain Organization

Brain structures as derivatives of the neural tube:

Primary vesicles	Secondary vesicles	Brain components
- Prosencephalon (forebrain)	Telencephalon	Cerebral Cortex Hippocampus Amygdala Striatum
	Diencephalon	Thalamus & subthalamus Hypothalamus Epithalamus
- Mesencephalon (midbrain)	Mesencephalon	Midbrain
- Rhombencephalon (hindbrain)	Metencephalon	Pons Cerebellum
	Myelencephalon	Medulla

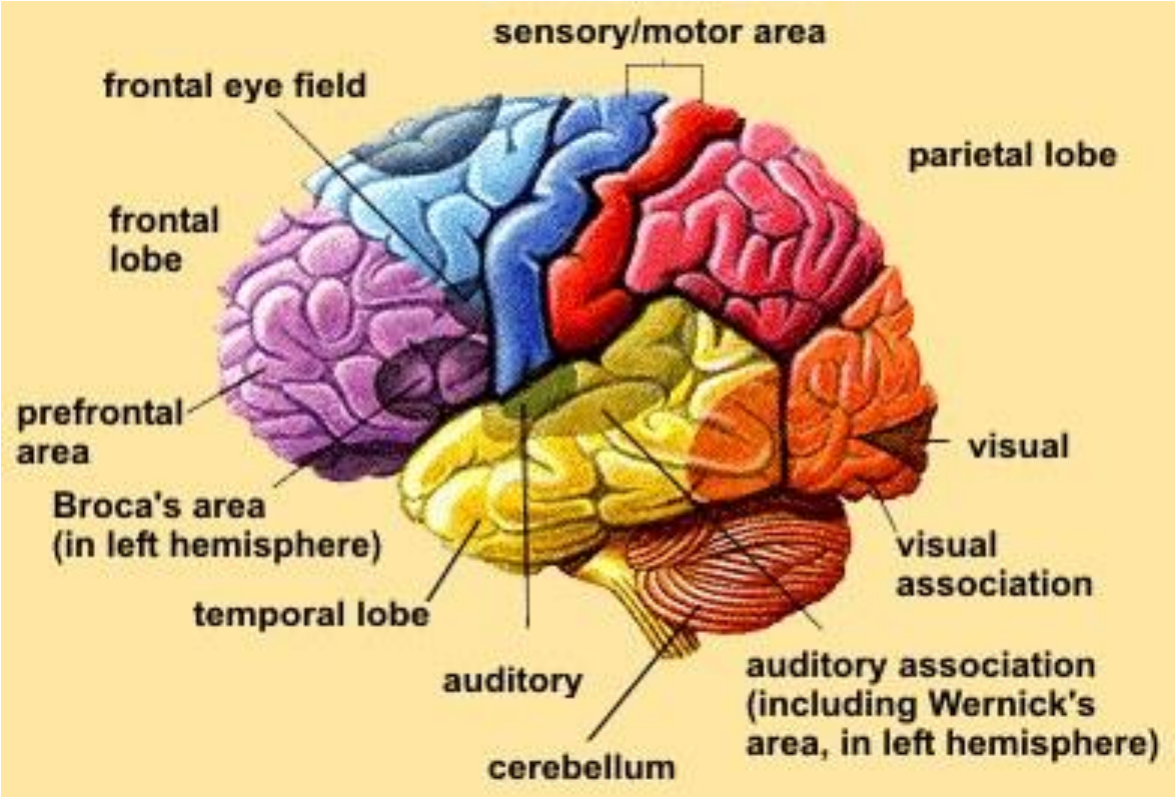
Basic Organization of Brain

- Brodmann divided 47 areas in the cerebral cortex each has an assigned function.
- 3 processing blocks distinguished:
  - Brain Stem and thalamic reticular activating system provides arousal and set up attention.
  - Posterior Cortex - integrates perception and generates language.
  - Frontal Cortex - generates programmes and execute plans of action

Cortical Sites (Cerebral Lobes)

- Frontal lobes
- Parietal lobes
- Temporal lobes
- Occipital lobes

Cerebral lobes & Areas



Frontal Lobe Functions

- Behavior in general, Inhibition, Initiative
- Abstract thought processes, Problem solving
- Creative thinking
- Working memory
- Attention
- Judgment
- Coordination of movements
- Generalized and mass movements, some eye movements
- Skilled movements and some motor skills
- Sense of smell
- Libido (sexual urges)

Frontal Lobe

- The frontal lobe contains most of the dopamine-sensitive neurons in the cerebral cortex
- The dopamine system is associated with reward, attention, long-term memory, planning, and drive.
- Dopamine tends to limit and select sensory information arriving from the thalamus to the fore-brain.
- Reduced dopamine activity in the prefrontal cortex is claimed to be found in conditions of poor performance and functioning of that brain region during working memory tasks, and slightly increases risk for schizophrenia.

Frontal lobes damage results in:

- Impaired mental flexibility and spontaneity, but IQ is not reduced.
- Talking may increase or decrease dramatically.
- Perceptions regarding risk taking and rule abiding are impaired.
- Socialization can diminish or increase.
- Orbital frontal lobe damage can result in peculiar sexual habits.
- Dorsolateral frontal lobe damage reduces sexual interest.
- Creativity is diminished as well as problem solving skills.
- Distraction occurs more frequently.

Frontal Lobe Damage results in (cont…):

- The dorsolateral frontal cortex is concerned with planning, strategy formation, and executive function.
- Patients with dorsolateral frontal lesions tend to have:

➢ apathy, personality changes, abulia, and lack of ability to plan or to sequence.

➢ poor working memory for verbal information (if the left hemisphere is affected)

➢ Poor working memory for spatial information (if the right hemisphere is affected).

Frontal Lobe Damage results in(cont...):

- The frontal operculum contains the center for expression of language.
- Patients with left frontal operculum lesion may demonstrate Broca aphasia and defective verb retrieval,
- Patients with exclusively right opercular lesions tend to develop expressive aprosodia.

Frontal Lobe Damage results in (cont...):

Patients with orbitofrontal lesions tend to have:

- **disinhibition, emotional labiality, and memory disorders.**
- **personality changes include: impulsiveness, sexual disinhibition, and complete lack of concern for others.**

- **Patients with superior mesial lesions typically develop akinetic mutism.**
- **Patients with inferior mesial (basal forebrain) lesions tend to manifest anterograde and retrograde amnesia and confabulation.**

The parietal lobe

- Integrates & comprehend sensory information from different modalities, particularly determining spatial sense and navigation.
- Sense of touch (tactile sensation) &Appreciation of form through touch (stereognosis)
- Response to internal stimuli (proprioception)
- Manipulation of objects.
- Some language and reading functions
- Knowledge of numbers and their relations.
- Portions of the parietal lobe are involved with visuospatial processing

Parietal lobe damage results in:

- impairment of tactile sensation
- impairment of proprioception, i.e. postural sensation and sensation of passive movement
- loss of ability to identify objects based on touch (astreognosis)
- sensory and visual neglect syndromes, i.e. inability to pay attention to things in certain parts of the person's sensory or spatial environment. This can be as extreme as denial of a limb.
- loss of ability to read (dyslexia), write (dysgraphia) or calculate (dyscalculia)
- loss of ability to find a defined place (geographical agnosia)

Temporal lobe

- Involved in speech, memory, and hearing.
- The superior temporal gyrus includes the (primary auditory cortex) involved in hearing.
- Adjacent areas in the superior, posterior and lateral parts of the temporal lobes are involved speech (left temporal lobe in particular).
- Wernick's area, which spans the region between temporal and parietal lobes, also plays a key role in speech
- The functions of the left temporal lobe extend to comprehension, naming, verbal memory and other language functions
- Sound processing.

Temporal Lobes

- Ventral part of the temporal cortices involved in visual processing of complex stimuli such as faces and scenes, and in object perception and recognition.
- The medial temporal lobes are thought to be involved in episodic memory (*memory* of autobiographical events (times, places, associated emotions) and declarative memory (*memory* that stores facts) .
- The hippocampi seem to be particularly important for transference from short to long term memory and control of spatial memory and behaviour.

Temporal lobe damage results in:

- Disturbance of auditory sensation and perception
- Disturbance of selective attention of auditory and visual input
- Disorders of visual perception
- Impaired organization and categorization of verbal material
- Disturbance of language comprehension
- Impaired long-term memory
- Altered personality and affective behaviour
- Altered sexual behaviour

Occipital Lobe

- Harbours the primary visual centre
- If one occipital lobe is damaged, the result can be homonymous vision loss from similarly positioned "field cuts" in each eye.
- Occipital lesions can cause visual hallucinations.
- Lesions in the parietal-temporal-occipital association area are associated with colour agnosia, movement agnosia, and agraphia.

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

Hypothalamus

- The hypothalamus contains a number of small nuclei with a variety of functions. located below the thalamus just above the brain stem.
- Links the nervous system to the endocrine system via the pituitary.
- The hypothalamus is responsible for certain metabolic processes and other activities of the autonomic nervous system.
- It synthesizes and secretes neurohormones, often called hypothalamic-releasing hormones, and these in turn stimulate or inhibit the secretion of pituitary.
- The hypothalamus controls:

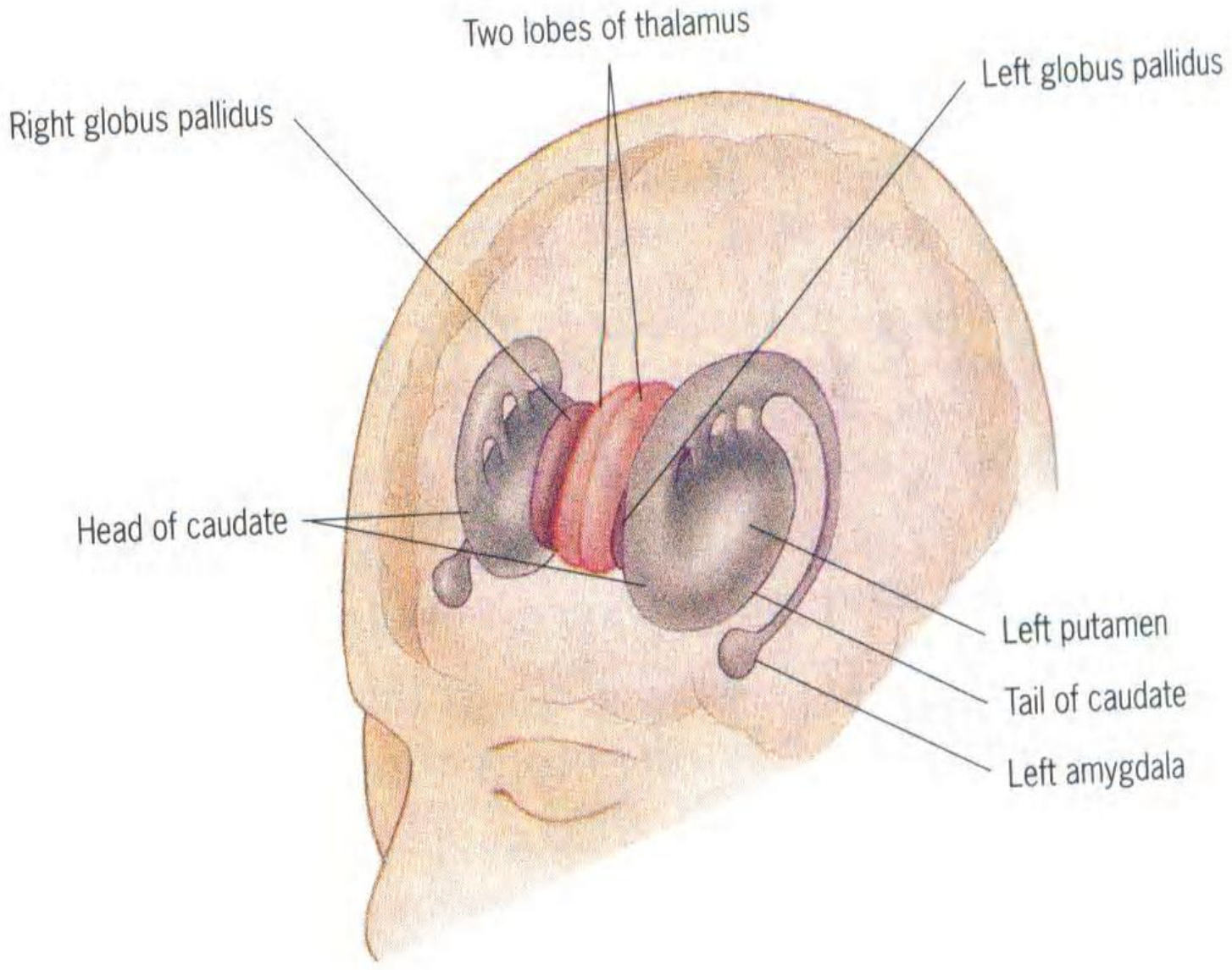
  Body temperature, hunger, thirst, fatigue, anger, and circadian cycles, mood and motivation, sexual maturation, and hormonal body processes

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



Pituitary Gland

- Hormonal body processes
- Physical maturation
- Growth (height and form)
- Sexual maturation &Sexual functioning

Pineal Body

- Also called the "third eye".
- Is a small endocrine gland in the brain. It is shaped like a tiny pine cone (hence its name), and is located near to the centre of the brain, between the two hemispheres,
- It produces melatonin (a derivative of Tryptophan), a hormone that affects the modulation of wake/sleep patterns and photoperiodic (seasonal) functions
- Melatonin is involved in circadian rhythms of biological functions.
- Melatonin secretion during sleep at night is important for regeneration of cerebral neurons

Thank You