

BIOLOGY

Date: / /

Page No.

UNIT-4: NEUROBIOLOGY

Basics of Neurons (Nerve cell)

Neurons are the structural & functional unit of nervous system that generate & transmit nerve impulses.

① Action potential → Transmission of nerve signal

electrical →
within the neuron

chemical →
one neuron to next neuron.

- Neuron is different from other cells of body because →
- has branches or processes called dendrites & Axons.
- has nucleus but doesn't have centrosome (cannot divide)

② Types of neuron depending upon function:-

~~Sensory (afferent) neuron~~

Sensory (afferent) neuron

carry messages (impulses) from peripheral sensory organs to ~~CNS~~

~~CNS~~ (central nervous system)

~~Motor (efferent) neuron~~

Motor (efferent) neuron

carry messages (impulses) from CNS to peripheral effector

organs

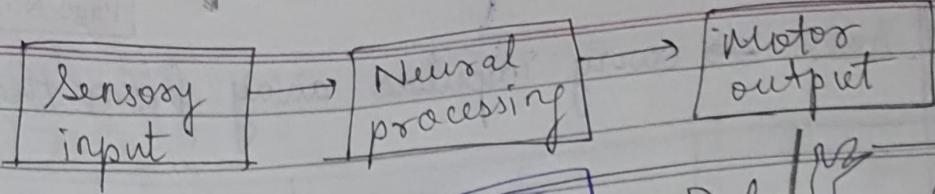
~~Interneuron~~

forms connection b/w sensory

& motor

neuron

(saves time)

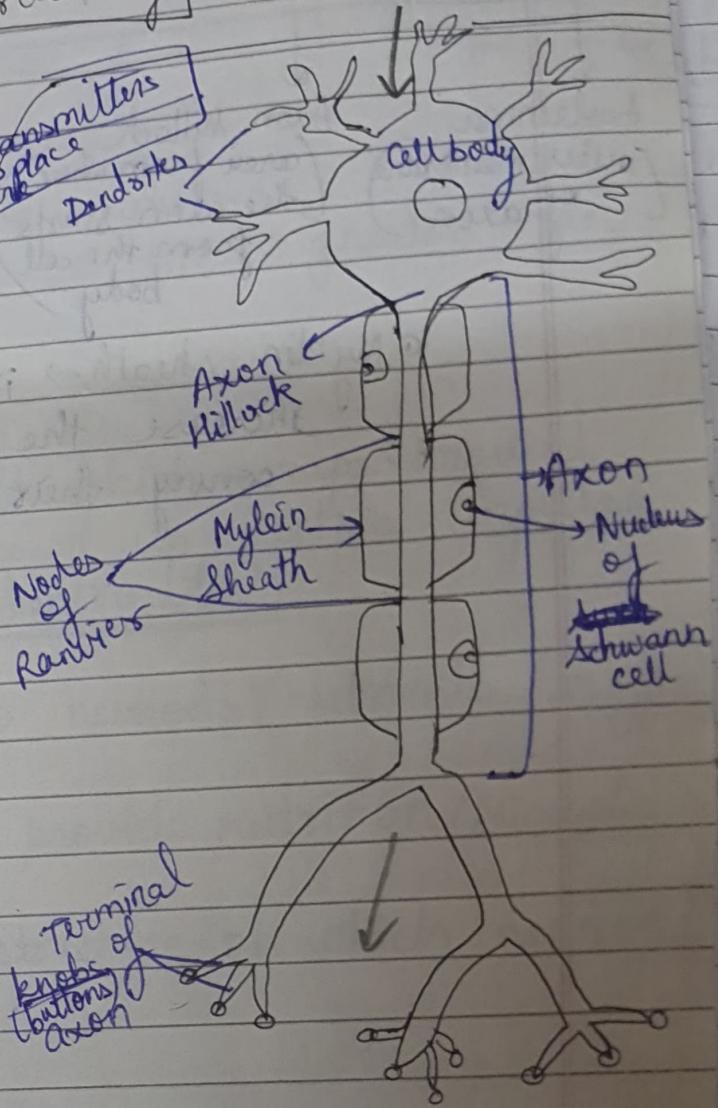


★ Structure of Neuron

1) Cell Body (Soma)

- irregular in shape
- neuroplasm (like cytoplasm)

- Nucleus
- Nissl bodies (like ribosomes)
(makes proteins)
- Neurofibrils
(transport synthesised proteins)
- Mitochondria
(generation of energy in form of ATP)
- Golgi Apparatus
(packing of synthesised proteins)



Neuron (Nerve cell)

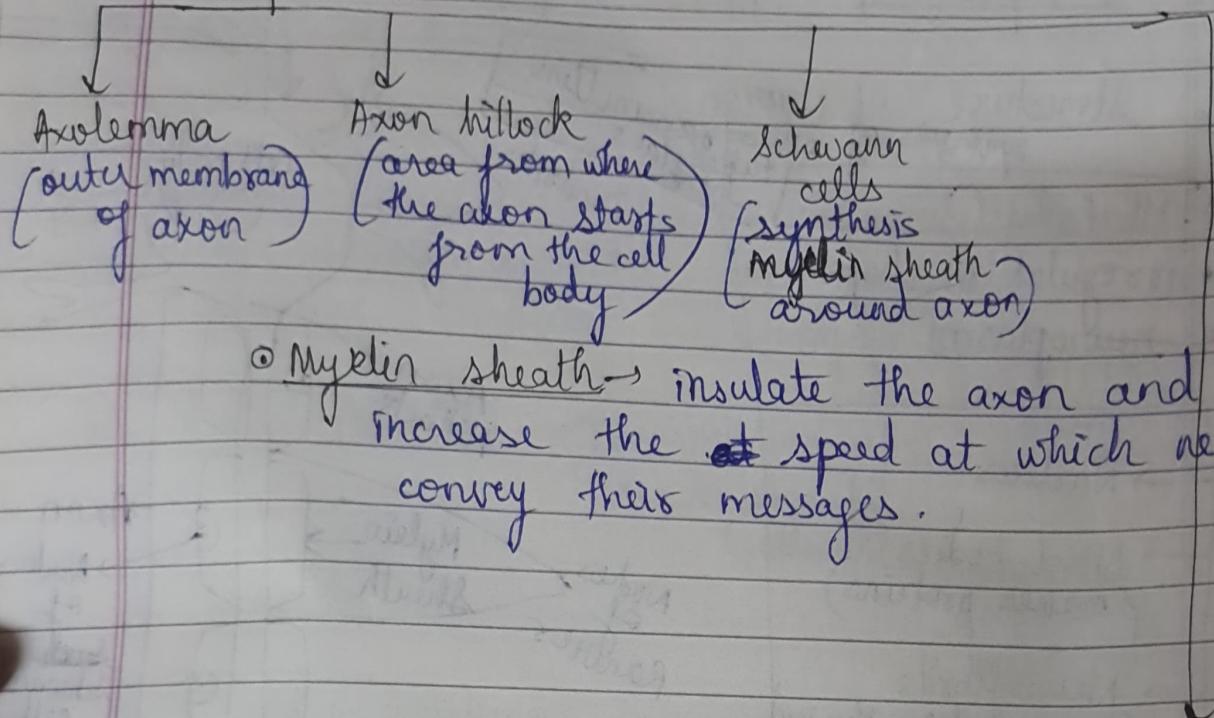
- cell body from the grey matter

present in

- ① sides of brain
- ② centre of spinal cord.

- 2) Dendrites → branches that receive & carry impulse towards the cell body.

3) Axon → carry impulses away from the cell body



④ Myelin sheath → insulate the axon and increase the ~~at~~ speed at which neurons convey their messages.

Nodes of Ranvier:

they contain Na^+ and K^+ ion channels allowing the action potential to travel down quickly down the axon by jumping from one node to the next.

(buttons)

Terminal knobs of Axon → Release chemicals called neurotransmitters that carry impulses from one neuron to the next neuron.

Neuroglia (glial cells)

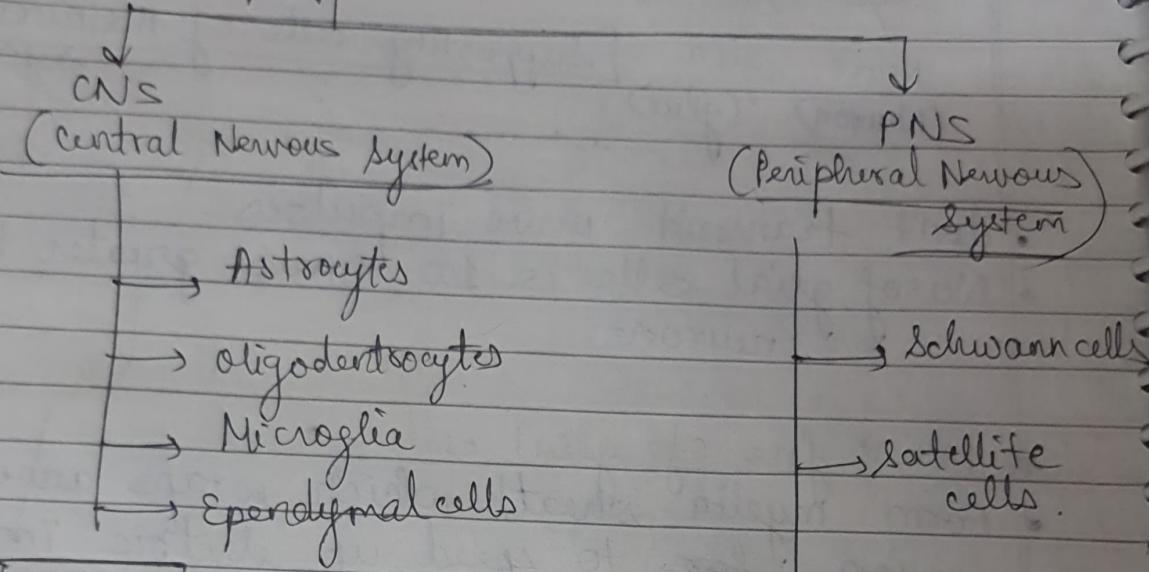
Neuro glia [supporting cells of the nervous system]
 (Neuron) (glue)

- don't transmit nerve impulses.
- No. of glial cells is 10 times greater than neurons.

★ Main function of glial cells →

- Form myelin sheath which wraps around axon ~~to~~ to speed up electric impulse conduction (oligodendrocytes)
- provide nutrition to neurons (nutrients & oxygen)
- destroy pathogens, provide nutrition (microglia)
- Provide a support structure on which neurons can sit (hold).
- maintain homeostasis.
- Play role in synapse ^{formation} (Astrocytes)
- Repair of neurons after injury (Schwann cells)

★ Types of glial cells



CNS

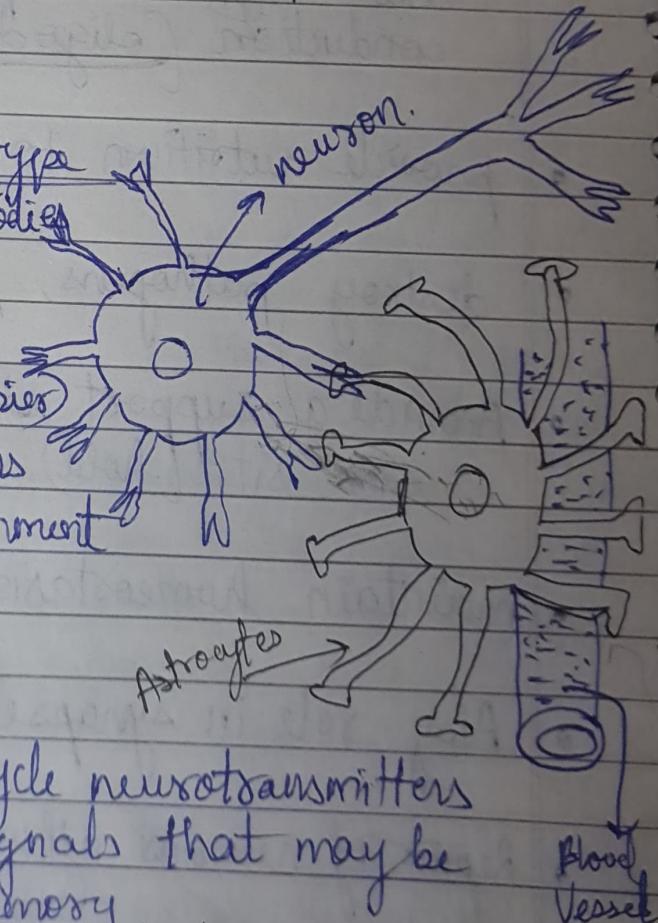
① Astrocytes

- most abundant glial cell-type
- irregular star-shaped bodies

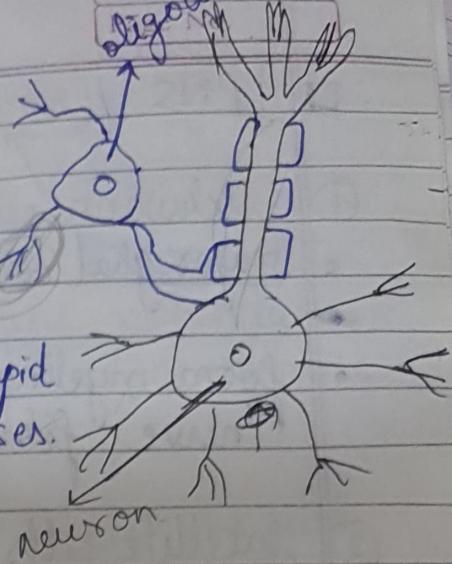
⇒ form BBB

(Blood-brain barrier)

- Take up & release ions to control the environment around neurons.
- synapse formation
- neural growth
- reuptake & recycle neurotransmitters
- propagate Ca^{2+} signals that may be involved in memory.



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 oligodendrocytes



② Oligodendrocytes

- Have few branches
- wrap their cell processes around CNS.
- produce myelin sheath for rapid conduction of nerve impulses.

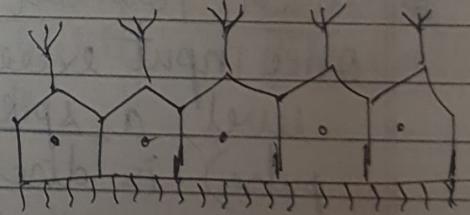
③ Microglia

- smallest and least abundant

- phagocytosis → macrophages of CNS.

- Engulf invading micro-organisms & dead neurons.
- derived from blood cells called monocytes.

④ Ependymal Cells



- form epithelial lining of ventricles of brain and the spinal canal.

- CSF ~~homost~~ homeostasis (cerebrospinal fluid)

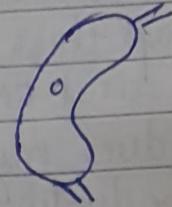
- Brain metabolism

- clearance of waste from the brain.

IPNS (same as oligodendrocytes)

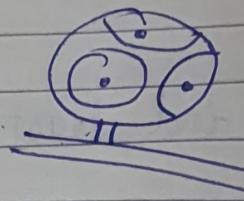
① Schwann cells

- major glial cells in PNS.
- form myelination around nerve fibres of PNS.



② Satellite cells

- Form exterior surface of PNS neuron.



- physical support to PNS neuron,

- regulate chemical environment of ECF (extra-cellular fluid)

excess input

→ Action Potential

Once input exceeds a critical level, a spike (electrical pulse) is discharged by neuron that travels

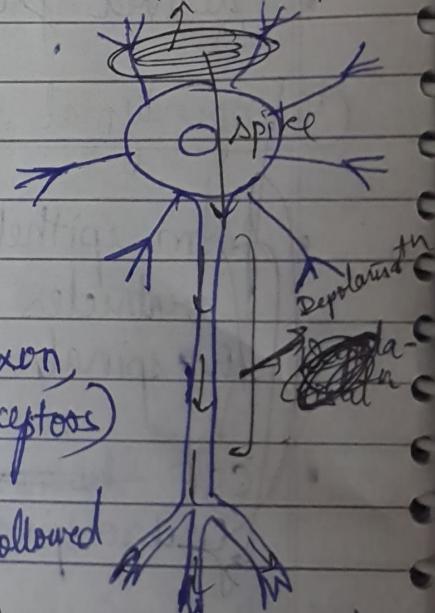
from the body, down the axon, to the next neuron(s) (or receptors)

→ This spiking event is called depolarisation and it is followed

by a refractory period,

during which the

neuron is unable to fire.



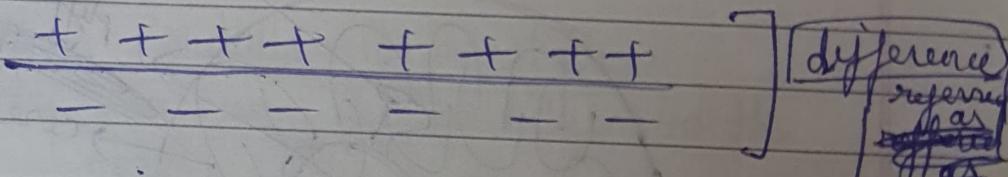
(during which the neuron is unable to fire)

➤ Membrane Potential

~~Note~~

- Neurons can respond to stimuli & conduct impulses because a membrane potential is established across the cell membrane.

there is an unequal distribution of ions on two sides of the nerve cell membrane



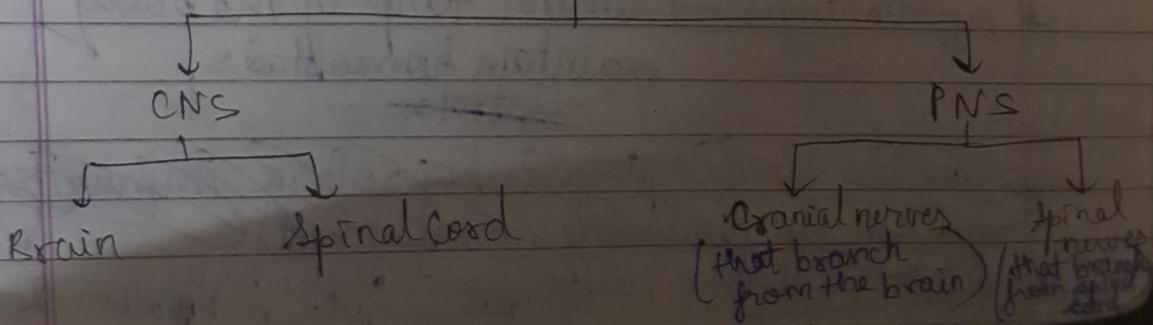
it occurs when a membrane is not being stimulated or conducting impulses.

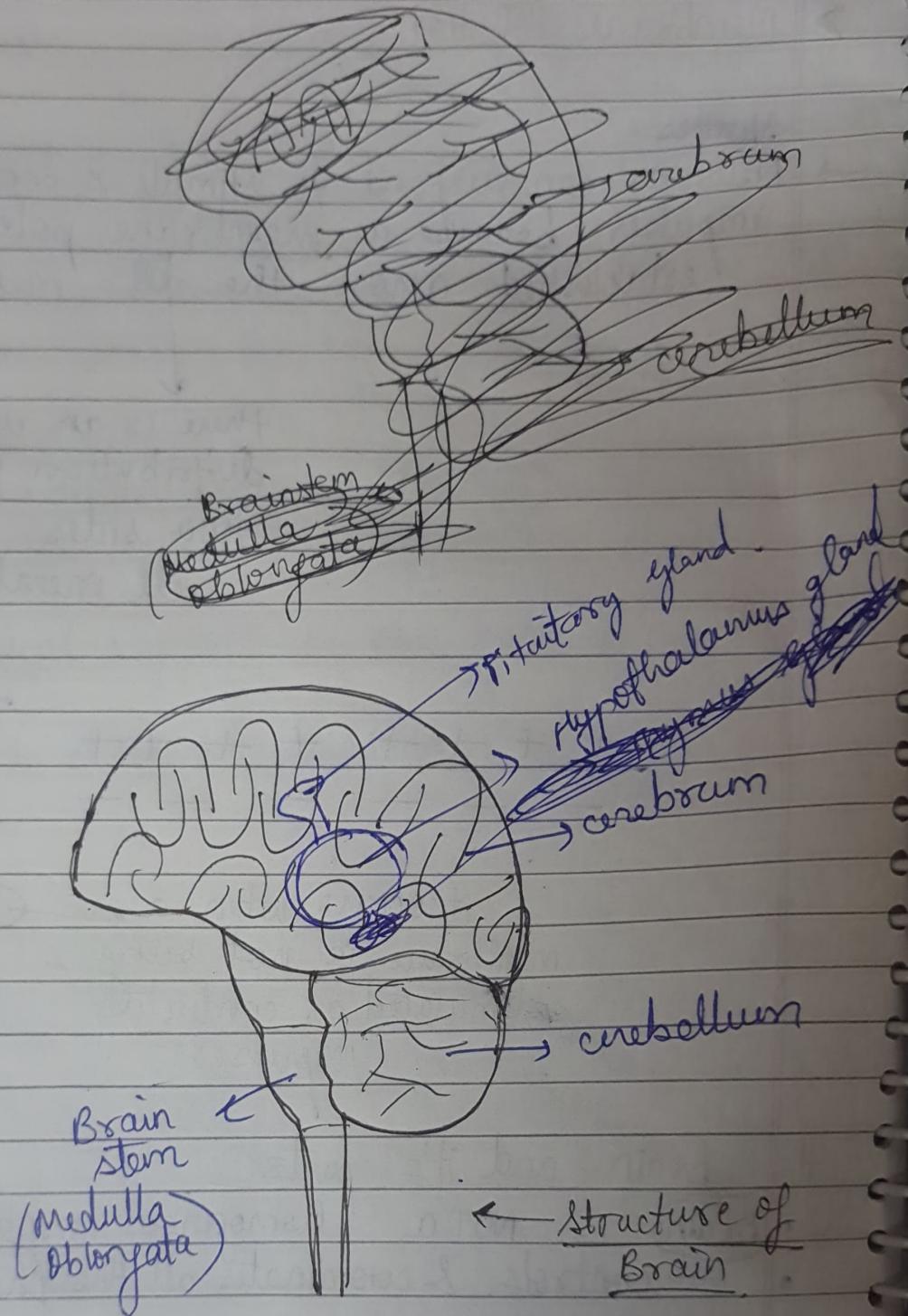
Resting
Membrane
Potential

Brain and its parts

- Brain is NOT a homogenous organ.
- controls & coordinates all the fns of body.

Nervous system





Hypothalamus → control temp of the body, maintain homeostasis, ~~control~~

Thyroid gland → plays a big role in immunity of the body by producing immune cells

Pituitary gland → "master gland" of the body regulates growth, metabolism &

D) Cerebrum →

~~part of~~
• forebrain

- largest part of the brain
- composed of right & left ventricles.
- touch, vision, hearing, speech, reasoning, emotions, learning.

~~can be subdivided into~~

2) Cerebellum →

- part of hindbrain
- located under the cerebrum.
- ~~it~~ maintains balance of the body, controls our posture.

3) Brainstem (Medulla oblongata) →

- connects cerebrum & cerebellum to the spinal cord.
- performs automatic fns such as:

- ↓
- breathing
- heart rate
- wake & sleep cycles
- digestion
- coughing
- sneezing
- vomiting
- swallowing

→ Each of these parts of brains are subdivided into many regions acc. to the fns performed by them.

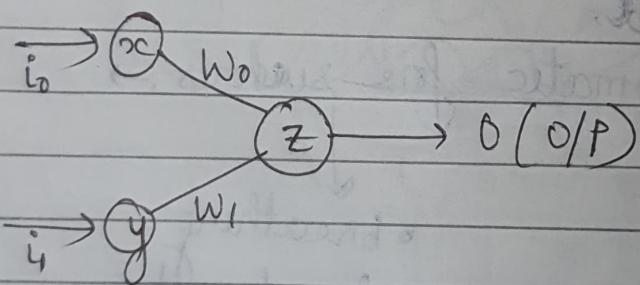
→ reproduction through the hormones that it produces

Artificial Neural Networks (ANNs)

(ANN) is an information processing paradigm that is inspired by the way of biological nervous system.

- configured for specific applications
 - (i) Data classification
 - (ii) Pattern Recognition
- ANN model
 - (i) interconnections (nodes)
 - (ii) Activation fns
 - (iii) Learning Rules

A simple model of ANN

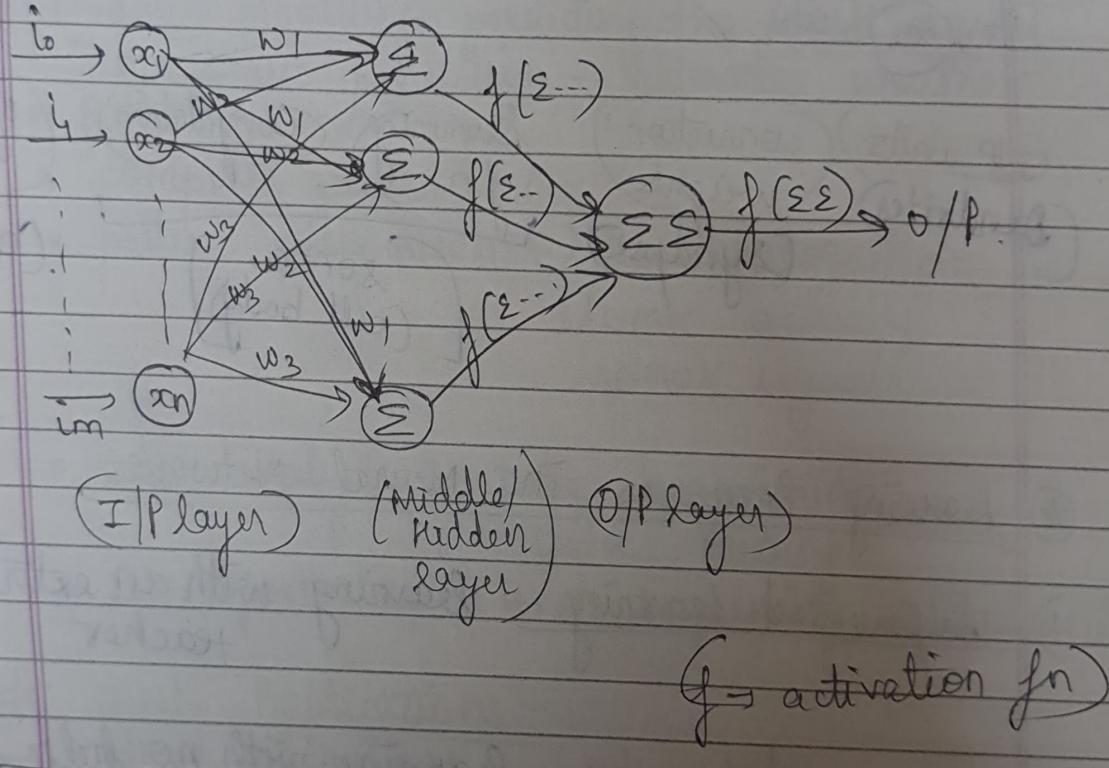


Input = weighted sum of each I/P
 (I) $= i_0 w_0 + i_1 w_1$

Output = $f(I)$
 activation fn

★ Characteristics of ANN →

- Neurally implemented mathematical model.
- Huge no. of interconnected processing elements called neurons for processing.
(Huge no. of neurons are there for processing)
- I/P signals arrive as processing elements through connections & connected weights.

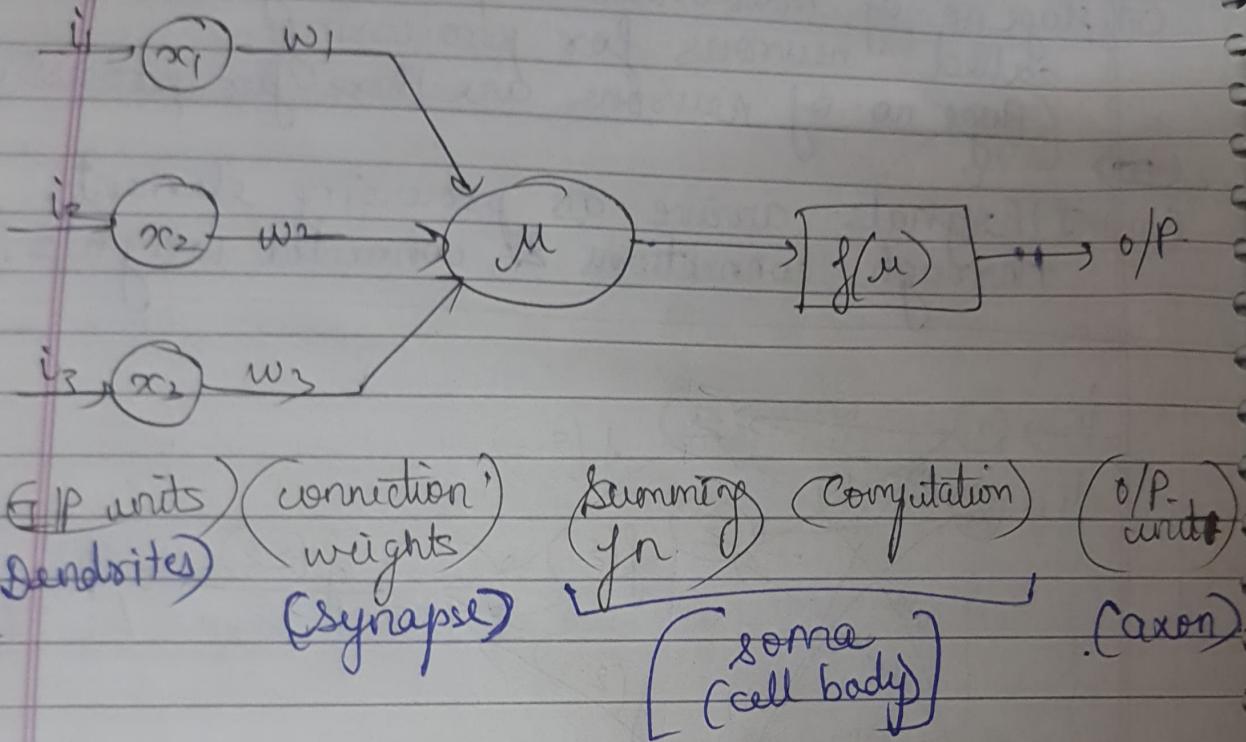


★ Advantages of ANN over conventional computers:

- Ability to learn & model non-linear, & complex relationships. introduced by activation fn.

- Easy generalization
- No restriction on I/P variable.

★ Model of a Neuron



★ Learning Processes in Neural Networks

- 1) Supervised learning \rightarrow learning with an external teacher
- 2) Unsupervised learning \rightarrow learning with no help.
- 3) Reinforcement learning \rightarrow learning with limited feedback.
(YouTube)

P.T.O. \rightarrow

Neural Network Applications

- ① Brain Modelling → helps our understanding of how the brain works, how behaviour emerges from interconnection of network of neurons what needs to get "fixed" in brain-damaged patients.

② Real World Applications

- Financial modelling predicting the stock market
- Time series prediction - climate, weather
- Robotics
- computer games
- pattern recognition - speech recognition, seismic activity, sonar signals
- Data analysis - Data compression, data mining
- Bio-informatics - DNA sequencing, alignment.

ANN Applications

- Medical Applications
- Chemistry
- Info. searching & retrieval
- Education
- Business & Management

- ① Total weighted input \geq threshold value \rightarrow O/P
- ② Total weighted input $<$ threshold value \rightarrow O/P

Learning a sol'n to a problem = changing the connection weight

Date: / /
Page No.

ANN v/s BNN

Artificial
Neural
Network

Biological
Neural
Network

ANN

- ① faster processing
- ② Response time → nanosecond

- ③ serial processing
(Zeh time par ek hi kaam!)

- ④ less size & complexity

- ⑤ info storage is replaced

- ⑥ Fault intolerant
(system can be damaged by corrupted info.)

- ⑦ corrupted info can't be retrieved.

- ⑧ New data can be added by deleting old one.

- ⑨ control unit for controlling activities.

BNN

- ① slower processing

- ② Response time → millisecond

- ③ Parallel processing
(multitasking!)

- ④ Highly complex.

- ⑤ Info. storage can't be replaced.

- ⑥ Highly fault tolerant
(gli baar ghti ko 23 E 112)

- ⑦ No damage to info.

- ⑧ Unlimited storage

- ⑨ No specific control unit.

Diseases of the Nervous System

1) Parkinson's Disease →

- b/w the age of 50 and 60
- cell bodies & neurons, producing dopamine are destroyed.
- Symptoms → tremors of hand, arms & head.

2) Dementia →

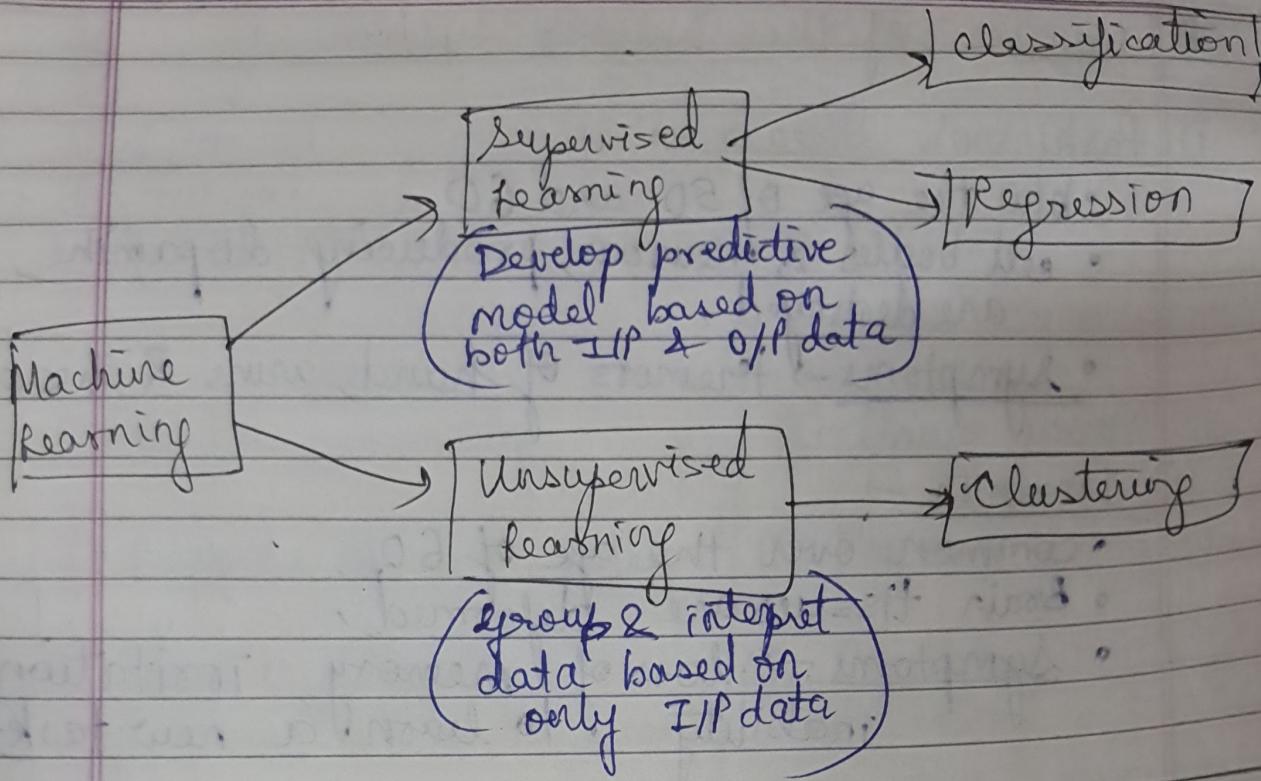
- common over the age of 60.
- Brain tissues are deformed.
- Symptoms → loss of memory, irritation, inability to learn a new task etc.

3) Alzheimer's Disease →

- age-associated disorder
- common in western countries.
- Symptoms → loss of memory, mood swings, language problem, confusion, poor judgement, changes in personality.

Machine Learning (ML)

- field of study that gives the computers capability to ~~program~~ learn without being explicitly programmed.
- ML and statistics are closely knit.



	Supervised Learning	Unsupervised Learning
Input Data	Uses known and labelled data as input.	Uses unknown data as input.
Computational complexity	Very complex	Less computational complexity
Real Time	Uses off-line analysis	Uses real-time analysis of data.
Number of classes	No. of classes are known.	No. of classes are NOT known
Accuracy of Results	Accurate & reliable results.	Moderately accurate & reliable results.

Machine Supervised Learning

Regression

- output variable is continuous
- ultimate goal

↓
to plot the best-fit line or curve b/w the data

- 3 main metrics used for evaluating the model

- ↓
- i) variance
 - (ii) bias
 - (iii) error.

Classification

- output variable contains discrete values.
- help in the prediction of class of the o/p variable.
- depends upon the no. of classes in O/P variable.
- binary classification, multi-class " ; etc

Unsupervised ML

clustering

↓

used to group data pts having similar characteristics as "clusters".

→ data-pts in the same cluster should exhibit similar properties & data-pts in the diff. clusters should be as dissimilar as possible.

Artificial Intelligence

The theory & development of computer systems able to perform tasks normally requiring human intelligence

Machine learning gives computers "the ability to learn without being explicitly programmed".

Deep learning ML algorithms with

brain-like logical structure of algos called ANNs

similar to neural network with multiple layers that try to mimic how the human brain thinks to solve the problem

① Applications of ML

- Classification & clustering of biological data.
- Selecting relevant features in biological data which are high-dimensional in nature.
- Structure prediction of proteins
- ~~stroke diagnosis~~ \rightarrow ML methods for the analysis of neuroimaging data are used to help diagnose stroke.

Data Mining in BIOLOGY \rightarrow

- extracting or "mining" knowledge from large amounts of data.
- science of finding new interesting patterns & relationships b/w huge amt. of data.
- process of discovering new meaningful ~~correlat~~ correlations, patterns, and trends by digging in large amt. of data stored in warehouses.
- also called \rightarrow
- Knowledge Discovery in Databases (KDD).
- Not specific to any industry.
- requires intelligent technologies & the willingness to explore the possibility of ~~but~~ hidden knowledge that resides in the data.

Diabetes → Most common endocrine disease

Date: disease
Page No.

Primary goal → prediction & description

Main tasks well-suited for data-mining are:-

- classification
- Estimation
- Prediction
- Association rules (Dependency modelling)
- clustering
- Description & visualization.

Synapse

- Transmission of an electrical signal from one neuron to

next is

effected by

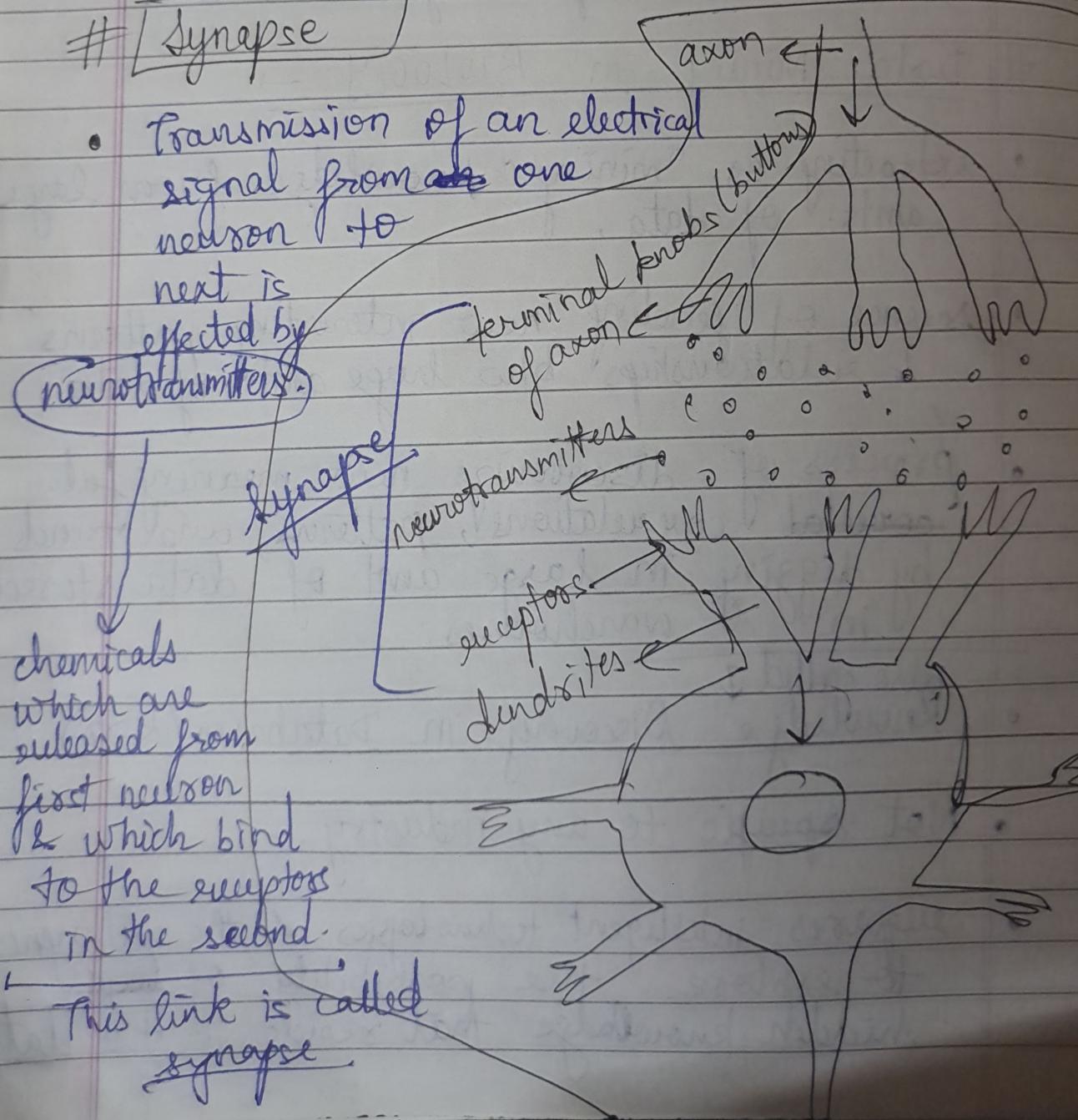
(neurotransmitters)

chemicals which are released from first neuron

& which bind to the receptors

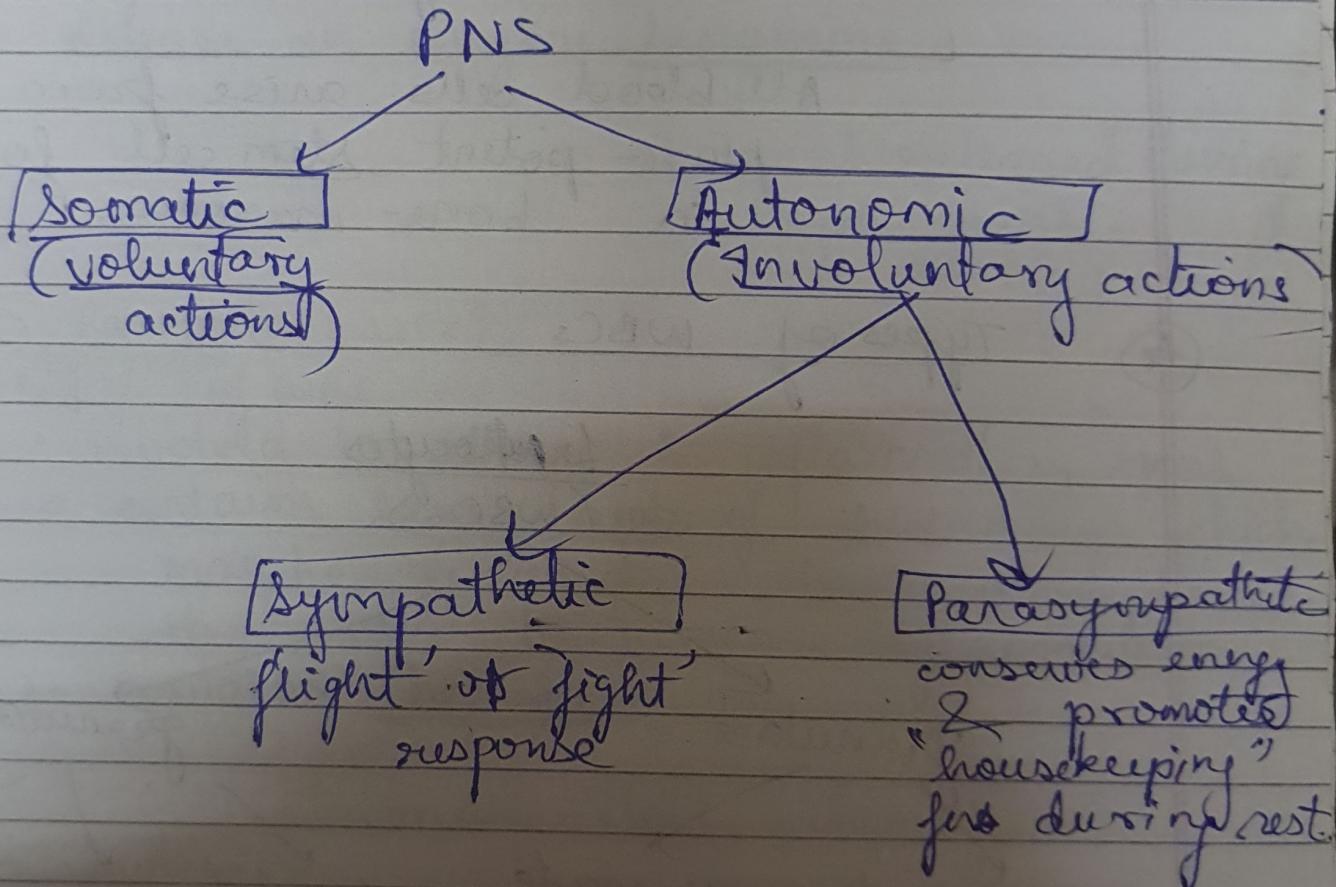
in the second.

This link is called synapse.



- ① extent to which the signal from one neuron is passed on to the next depends on many factors:-

} → amt. of neurotransmitter available.
 } → no. & arrangement of receptors
 } → amt. of neurotransmitter reabsorbed
 ; etc



UNIT-5

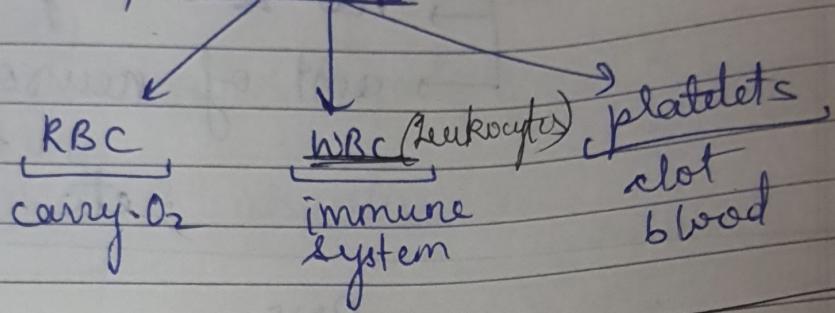
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Page No.

IMMUNOBIOLOGY

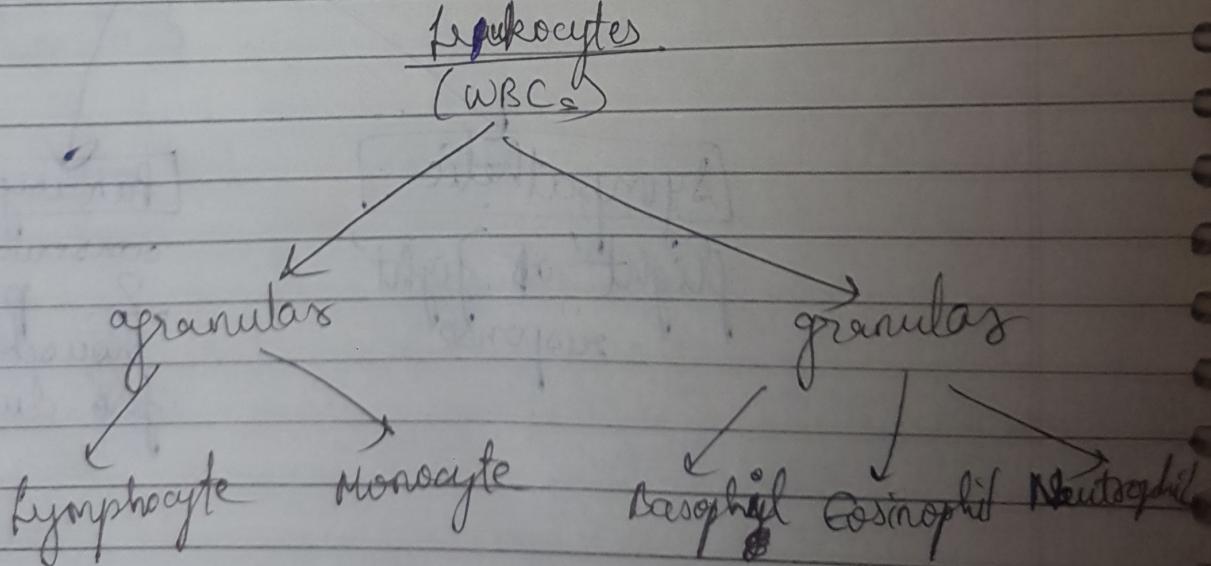
Blood

- Blood is 55% liquid (plasma) & 45% cellular.



All blood cells arise from pluripotent stem cell found in bone marrow.

Types of WBCs



■ granular

1) Neutrophil (neutral)

- 60% of WBC
- lifespan → 10 hours in blood
- 100 billion manufactured daily
- seek out & destroy ingested bacteria in connective tissues.

2) Eosinophil (acidic)

- 1-3% of WBC
- Help control allergic reactions.
- Release an enzyme histamine

↓
chemical released during
allergic reactions.

3) Basophil (basic)

~~less than~~ 1% of WBC

- involved in allergic & inflammatory reactions
- contains large amounts of histamines which may be released in the injured tissue in order to increase inflammation.
- contains heparin

↓
an anti-clotting chemical

■ agranular

1) Lymphocytes

- 30% of all leukocytes
- Made from stem cells, but are released from lymph nodes, thymus, spleen & bone marrow.
- Produce antibodies & destroy foreign cells found in infections mononucleosis.

2) Monocyte

- 6% of WBCs
- enter connective tissue
- eat bacteria, dead cells & other littering tissue.

Lymphatic system

→ The organs of your immune system are connected with one another and with other organs of your body by a network of lymphatic vessels.

lymphatic vessels

- closely follows the body veins & arteries
- Cells/fluids are exchanged b/w blood & lymphatic vessels, enabling the lymphatic system to monitor the body for invading micro-organisms.
- carry lymph a clear fluid that bathes the body tissue.

lymphatic nodes

- contain high level of immune cells.



Phagocytes → Remove debris & pathogens

Macrophages - Neutrophils

move by diapedesis



NK cells → Recognise cell-surface markers on foreign cells & destroy cells with foreign antigens.

move by chemotaxis

Immunity → defense mechanism of the body

Date : / /
Page No.

SMATE

Inflammation

Types of Immune Response

★ Innate Immunity

- Already present in body or womb.

- Non-specific
- Rapid response
- Always active

- No immunological memory is formed.

- Inherited from parents to offspring.

- Remains throughout life.

- composed of physical, chemical and cellular barriers.

Acquired Immunity (Adaptive)

- Develops after birth in response to foreign pathogen.

- Specific

- Slow response

- gets activated on exposure to antigen.

- presence of immunological memory

- Not inherited from parents to offspring.

- NOT remains throughout life.

- composed of B-cells and T-cells.

Bone marrow
Thymus

RBC → 120 days

WBC → 20 days (3 weeks)

Acquired (Adaptive) immunity

Active Immunity

- ① Developed by an individual own cell in response to an infection or a vaccine.
- ② Slow in action & provides slow relief.
- ③ Long-lasting.
- ④ No side-effects.
- ⑤ Generates an immunological memory.

Natural
(infection)

Artificial
(Vaccines)

- ① Developed by ~~ready-made~~ ^{Introducing} antibodies ~~introduced~~ from outside.

② Fast in action & provides fast relief.

③ Short-lived.

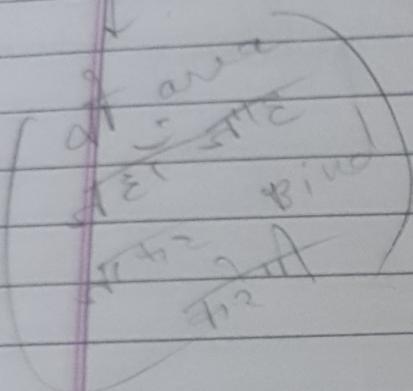
④ May cause side-effects.

⑤ Doesn't generate immunological memory.

Natural
(Maternal
antibodies)
(mother's milk)

Artificial
Monoclonal
antibodies

- Live → Non-Live Attenuated
- vaccination & its types now ^{now we} ^{say} ^{immun}
 - Immunoinformatics
 - Epitope Prediction Tools. (B-cell and T-cell)
 - Humoral and cell-mediated immunity.



tool / device / machine / instrument
for finding sequential data
of any organism

Helpful for format
of A B C

→ for transport
say in defense system

~~Thymus~~ Thymus → gland

Date : / /

Page No.

Antigen

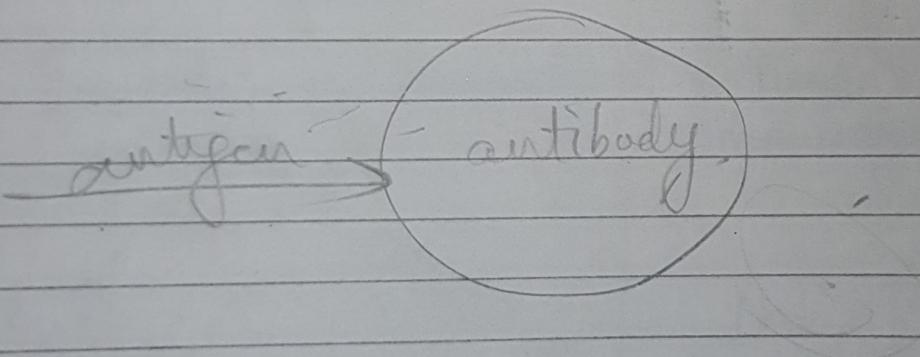
(B-cells)

Cell-mediated

(T-cells)

through vaccination
immunity is developed
throughout life

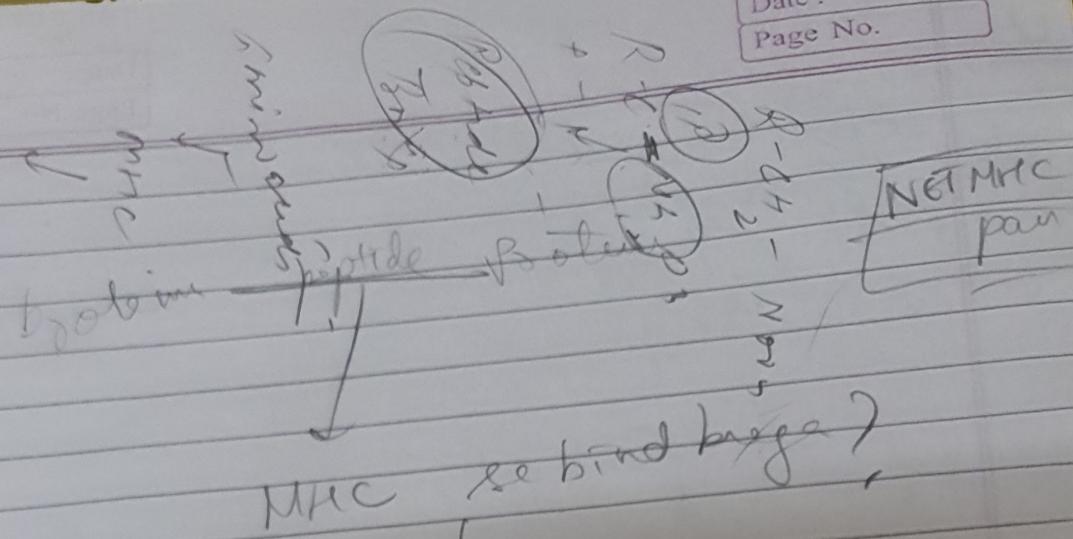
with help of all
medium is formed
that fights against
pathogens &
produce immunity



Coding, sequencing the pattern

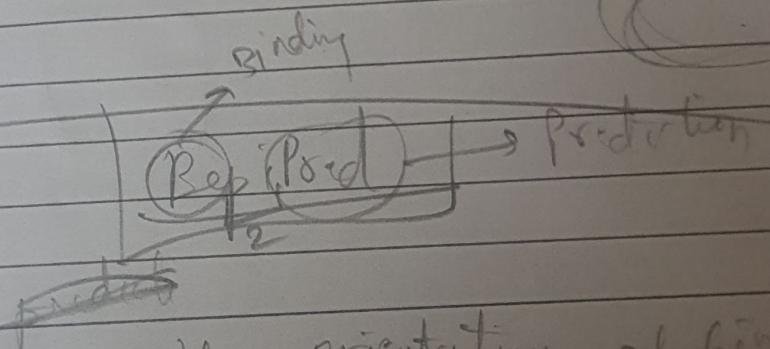
Information!

(July 20)



→ has all T cell networks?

Net MHC pair



checking the orientation of binding of
antigen & anti body

(3-D geometry)

major histocompatibility
complex