

Principles of Neuroscience
(NEUR30003)
Study Notes

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1.3

Neural communication and plasticity

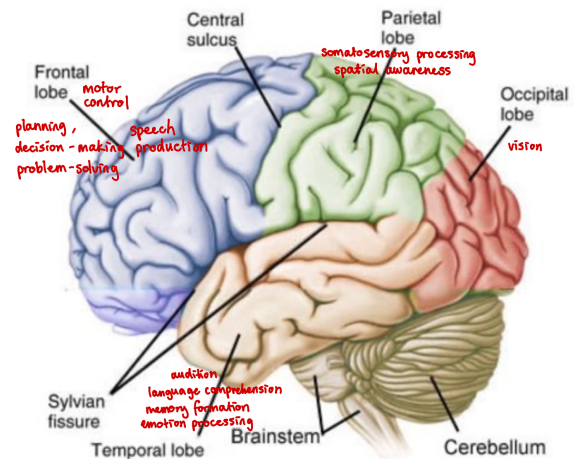
→ Not much extracellular space in brain

Cerebellum

→ 2 almost-symmetrical hemispheres

Late 19th century

- Words to describe NS introduced
- Advancements in microscopy
- Questions of neural connectivity:
 - ◆ Are neurons fused or discrete?
 - ◆ How do they communicate?



- Some people used NMJ to observe that motor axons form club-like terminations
 - ◆ For fusion: terminations were points of physical fusion between neuron and muscle
 - ◆ Against fusion: discrete branches suggested discrete neurons

Evidence for functional junctions

- Sherrington discovered:
 - ◆ NS degeneration involved discrete & demarcated patterns of loss
 - ◆ Reflex responses were slower than explainable by nerve conduction
 - ◆ Reflex conduction was unidirectional
- He suggested the word 'synapsis' (to clasp) but couldn't prove without electron microscopes

Early insights

- Knowledge came from studying peripheral, skeletal & autonomic innervation
- Different divisions could cause opposite effects in the same organ

Loewi discovers Vagusstoff

1. Stimulated vagus nerve of frog heart #1, causing slower HR
2. Collected fluid surrounding heart #1
3. Applied this fluid to heart #2, which also slowed
4. This fluid was later identified as ACh

Signalling mechanism underlying LTP (eg. glutamate)

1. Glutamate binds to AMPA & NMDA receptors
 2. AMPA activation opens Na^+ channel
 3. With enough activity, Mg^{2+} ion moves out of NMDA channel, allowing it to be a Ca^{2+} channel
 4. Ca^{2+} may add more AMPA receptors or change nature of channels, changing excitability over time
- LTP will be less efficacious over time if a protein synthesis inhibitor is added

2.1

Glial cells

- Macroglia: astrocytes, ependymal cells, oligodendrocytes, satellite cells & schwann cells
- Quadpartite synapse: a synapse where macroglia & microglia are closely associated

Functions of macroglia

Passive functions	Active functions
→ Energy metabolism → Maintenance of blood retinal barrier → Siphoning of K^+ → Uptake & recycling of neurotransmitters	→ Controlling neural function

Neurotransmitter recycling

1. Glial cells express GABA and glutamate transporters
 2. Glutamate is inactivated into glutamine while GABA is shunted into the Krebs cycle
- If transporters are blocked, neurotransmitters will accumulate in synapse

K^+ siphoning

1. When neurons depolarise, extracellular K^+ accumulates
2. Glial cells express inward rectifying K^+ channels
3. K^+ distributes throughout glial cells and travels to vascular, where K^+ concentration is low
4. Neuron MP remains normal

Gliotransmission

1. Calcium waves in glial cells may be initiated by: inflammatory mediators, neurotransmitters, spontaneously or trauma
2. When glial cells have high Ca^{2+} , they release gliotransmitters, like ATP
3. ATP binds to A1 receptors on neurons, hyperpolarising them

Macroglia control vasculature

1. Neural activity releases Ca^{2+} signals that are sensed by macroglia
2. Glial cells can change the diameter of blood vessels their end-feet physically contact
3. This regulates blood flow & maintains vascular function

Microglia control of vasculature

1. In response to injury, neurons release signalling molecules (eg. fractalkane), which bind to microglia
2. Microglia release vasoactive mediators that influence vascular tone, changing local blood flow

Loss of glial function → disease

- Loss of neurotransmitter uptake
 - ◆ Leads to excessive neural stimulation & death

5.1

ANS 1

Purpose of the ANS

- Controls bodily functions, including regulating all organs & most tissues
- Homeostasis: maintaining internal set points critical for survival
- Allostasis: maintaining homeostasis through adaptive change of internal environment, to meet perceived & anticipated demands

Cellular targets of ANS

- Epithelial transport of ions
- Hormone & mucous secretion
- Immune system
- Metabolism
- Smooth & cardiac muscle

Questionable definitions of ANS

- Involuntary motor system: but ANS can be modulated
- Involuntary nervous system: includes sensory a motor system
- Visceral motor system: blood vessels& sweat glands aren't in visceral

Functions of nerves

- Simple reflexes
- Coordinated regulation of multiple sites
- More complex behaviour

Functional anatomy of the ANS

Sympathetic NS	Both	Parasympathetic NS
→ 1st neuron is thoracolumbar → Ganglia are closer to CNS → 2nd neuron: ◆ 20% release Ach onto muscarinic receptors ◆ 80% release NA onto organs	→ Involve have CNS & PNS neurons → Need CNS to function → Defined by location of preganglionic neurons → 1st neuron releases Ach onto nAChRs	→ 1st neuron is craniosacral → Ganglia are near/within organs → 2nd neuron releases ACh onto muscarinic receptors

Enteric NS

- Neuronal cell bodies embedded within GIT
- Can function without CNS
- Contains complete reflex circuits
- May be influenced by ANS

Current view of neurotransmitters

- Many types of neurotransmitters, including ACh & NA, which have many subtypes

11.1

Evolution of the nervous system 2

5 steps of evolution (Max Bennett)

1. Steering: development of bilateral symmetry & motivated motor system
2. Object recognition (from different perspectives)
3. Mental representation: making internal models of the world, mind
4. Simulating: internally testing actions before acting
5. Language: communicating models of the mind

Why are brains bigger?

- Benefits of social organisation
- Intelligence enhances survival
- More energy available

Costs of a big brain

- Birth is difficulty
- Complexity (genes & mutations)
- Large energy expenditure & heat production
- Needs long gestation & parental care

Has the development of high culture caused the brain to evolve?

- Proposal: more complex environments now favour higher cognition
- But australopithecines:
 - ◆ Had long childhoods (longer brain development)
 - ◆ Had a more posterior lunate sulcus, suggesting larger non-visual cortex (including association cortex)

Australopithecus sediba

- Mix of australopithecine & homo erectus features:
 - ◆ Small brain
 - ◆ Wider pelvis (but not due to brain size)
 - ◆ More complex frontal cortex

Homo naledi

- Mix of archaic & modern features:
 - ◆ Small brains
 - ◆ May have used tools
 - ◆ May have overlapped with homo sapien ancestors

Oldest hominin out of africa

- Short with small brains
- Used oldowan tools
- Did not follow prey out of Africa (could adapt to local fauna)
- Showed social cohesion (took care of old & toothless people)

Modern humans

- Have some neanderthal ancestry
- Genetic diversity negatively correlated with distance from africa

H. floresiensis

- Found in Indonesia (suggests that H. sapiens & H. erectus weren't the only species to migrate out of africa)