a) Presynaptic facilitation

1. Modulatory neuron releases serotonin onto presynaptic sensory neuron

2. Serotonin binds to metabotropic serotonin receptors = activate G-protein

3. G-protein activates adenylyl cyclase = produces cAMP which binds to protein kinase A (PKA)

4. PKA phosphorylates K+ ion channels = prevents opening

5. AP arrives at synaptic terminal; reduced K+ prolongs depolarisation of AP

6. Ca2+ channels stay open longer = increase in Ca2+ = prolonged release of Nt

b) Presynaptic inhibition

Mechanism 1)

1. Modulatory neuron releases GABA = binds to ionotropic GABAa receptors = allow Cl- into cell

2. AP arrives; increased Cl- = counteracts depolarisation

3. Fewer Ca2+ channels open = decreased Ca2+ = less Nt release

Mechanism 2)

1. Modulatory neuron releases GABA = binds to metabotropic GABAb receptors = G-protein inhibits Ca2+ channels

2. AP arrives; depolarisation occurs but fewer Ca2+ channels open = reduced Nt release

Homosynaptic (intrinsic) plasticity = changes in strength of synapse due to own activity

a) Short term enhancement

1. Paired-pulse facilitation = increased amplitude of PSP by AP that arrives w/i few ms of previous AP

1. Ca2+ into cell is fast; Ca2+ return is slow

2. More Ca2+ = more Nt released into synaptic cleft. Effect lasts few ms

2. Augmentation & Post-tetanic Potentiation = repetitive high frequency & long lasting stimulation

1. Increased Ca2+ due to repeated depolarisation = activates enzymes to increase number of vesicles released into synaptic cleft

2. More Nt released. Effect lasts several s (augmentation) or mins (post-tetanic potentiation)

b) Long term potentiation (LTP) = amplitude of PSP increased after brief but intense stimulation of presynaptic neuron

1. Single AP

1. AP in presynaptic cell = glutamate release = AMPA channels on postsynaptic cell open

2. Influx of Na+ = depolarisation = generation of EPSP; NMDA receptors blocked by Mg2+ ions

2. Multiple APs

1. AP in presynaptic cell = glutamate release = AMPA channels on postsynaptic cell open

2. Influx of Na+ = depolarisation = generation of EPSP

3. Spatial & temporal summation of EPSPs = large depolarisation = Mg2+ ions forced out of NMDA receptors

4. Influx of Ca2+ ions by NMDA receptors = released kinases cause:

- AMPA receptors stay open longer = more Na+

- Insertion more AMPA receptors

- Release of retrograde messengers, e.g. NO = more glutamate release

- Physical changes, e.g. synapse gets bigger

- Highly specific = activity on 1 pathway induces LTP on that synapse & not inactive synapses from different pathways

- Associativity = weak stimulus on 1 pathway does not produce LTP, but if strong stimulus present on nearby pathway, both pathways show LTP

c) Short term depression

1. Paired-pulse depression = decreased amplitude of PSP by AP that arrives w/i few ms of previous AP
    1. 1st AP depolarises = increase in Ca2+ = Nt release
    2. Subsequent AP weaker = reduced number of Nt vesicles = reduced Nt release

2. Post-tetanic depression = reduction in amplitude of PSP during & after repeated stimulation
    1. Inactivation of presynaptic Ca2+ channels in response to repeated stimulation
    2. Reduced Ca2+ influx = reduced Nt release

d) Long term depression = reduction in pathways showing errors; strengthening of important pathways; important for learning

1. Low frequency stimulation = increased Ca2+ influx; slow, small & long lasting
    - In cerebellum: increase in Ca2+ = activates kinases to phosphorylate AMPA receptors = AMPA receptors removed = less Nt release
    - In hippocampus: increase in Ca2+ = activates phosphatases to dephosphorylate AMPA receptors = AMPA receptors removed = less Nt release

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Central Nervous System (CNS)

- Astrocytes (CNS): transport nutrients from blood vessels (bvs) —> neurons; remove Nt; regulate EC K+ concentrations
- Oligodendrocytes (CNS): generate myelin sheath = saltatory conduction
- Microglia (CNS): immune effector cells; promote regrowth of damaged neural circuitry
- Ependymal cells (CNS): produce cerebrospinal fluid (CSF)

Spinal nerves:

- Dorsal root (ascending tracts) = afferent (sensory) PNS —> CNS
- Ventral root (descending tracts) = efferent (motor) CNS —> PNS

Grey matter of spinal cord:

- Lamina IX in ventral horn = alpha motor neuron somata
- Anterior = extensor muscles, posterior = flexor muscles
- Lateral = distal muscle groups, medial = proximal muscle groups

Myencephalon (hindbrain):

- Medulla oblongata: autonomic functions
    - Respiration:
        - Central chemoreceptors= monitor CO2 & pH

    - Dorsal respiratory group (inhalation) = rhythm, send impulses to motor nerves innervating diaphragm & intercostal (IC) muscles
    - Ventral respiratory group (inhalation & exhalation) = send impulses to motor nn innervating throat, diaphragm, IC muscles, abdominal muscles
    - Activity modified by pontine respiratory centres
  - Nuclei for efferent fibres CN VIII-XII
  - Controls balance & posture
    - Vestibular nuclei = receive inputs re: balance & spacial orientation from vestibular apparatus in inner ear via CN VIII
      - Send signals to motor neurons controlling head, neck, trunk & limb muscles

Metencephalon

- Pons: sleep, swallowing, bladder control, hearing, equilibrium, taste, eye mvmt, facial expression & sensation, posture
  - Relays signals from forebrain —> cerebellum
  - Nuclei for efferent fibres CN V-VIII
  - Pontine respiratory centres
    - Pneumotaxic centre = rate of breathing
    - Apneustic centre = depth of breathing; works w/ pneumotaxic centre to coordinate breathing
    - Modulate respiratory nuclei in medulla
  - Cerebellum: posture & balance, timing & force of muscles during voluntary mvmt, motor learning, eye mvmt
- **Mesencephalon (midbrain):**
  - Tectum:
    - Superior colliculi (SC): visual input from thalamus (lat geniculate nucleus), coordinate eye mvmt, orientation of eyes & head
    - Inferior colliculi (IC): auditory input from thalamus (med geniculate nucleus), auditory signal integration, frequency recognition, pitch discrimination
  - Tegmentum:
    - Red nucleus: motor coordination of shoulder & upper arm
    - Basal ganglia: eye mvmt, reward seeking, addiction, mvmt planning
    - Ventral tegmental area: dopaminergic neurons, reward, pleasure
    - Periaqueductal grey matter: mvmt in fighting & mating
- Brainstem: heart rate, breathing, sleeping, eating, consciousness