CONTROL OF MOVEMENT BY THE BRAIN

A. PRIMARY MOTOR CORTEX:
- responsible for voluntary movements
- like somatosensory cortex, primary motor cortex show somatotopic organization (motor homunculus)
- disproportionate amount of cortex devoted to different parts of body (fingers, lips). WHY?

![Motor Homunculus Diagram]
Primary motor cortex receives information from the following 3 premotor areas:
- supplementary motor area: Internal stimuli
- premotor cortex: Guided by external stimuli
- cingulate motor areas: Guided by emotional states

Prefrontal cortex (very important for planning of movements); controls/oversees premotor areas;
- somatosensory cortex (important for feedback)

Prefrontal cortex receives information from association cortex of temporal and parietal lobes.
Descending pathways (ignore differences between lateral and ventral pathways)

1. **Corticospinal tract**: controls **contralateral** body muscles;
   - neurons originate in **primary motor cortex**;
   - contacts **alpha motor neurons or interneurons** in ventral spinal cord.
2. Corticobulbar tract:
- similar to corticospinal tract except axons of primary motor cortex end in **cranial motor nuclei** of medulla;
- controls muscles **above** neck;
- contacts **contralateral** cranial nuclei.
Additional motor tracts

3. **Corticorubral** and **rubrospinal** tracts:
   “rubro” = red nucleus in ventral midbrain
   - involved in **limb** movements (gross movements)

4. **Vestibulospinal** tract: upper legs and lower trunk muscles *(involved in control of balance).*

5. **Tectospinal** tract: upper trunk & neck muscles.

6. **Reticulospinal** tract: leg muscles *(programs or pattern generators in brainstem; species-specific motor programs).*
**B. BASAL GANGLIA**

**Main Function:** Regulates force of voluntary movements
- many cortical areas involved in movements send their axons to **caudate and putamen**, which also receive terminals from **substantia nigra** (dopamine);
- caudate and putamen neurons then send their axons to **internal globus pallidus**;
- in turn, GP axons contact the **thalamus (VA/VL)**, which feedback onto cortex to modulate movement force.

-Huntington’s Chorea

-Parkinson’s Disease
C. CEREBELLUM

Function: Acquisition and maintenance of motor skills
- likely uses **timing** and **feedback** functions for accuracy.
- **NEVER INITIATES MOVEMENT**

Cerebellum receives inputs from:

- **primary motor cortex**
- **vestibular nuclei**
- **somatosensory system (proprioceptors)**

Damage to different parts of cerebellum can produce:
- action tremors and many movement errors
  - examples: **range, force, direction, and timing**.
- these effects can be localized, as shown below.
SLEEP AND WAKEFULNESS

Sleep is a **circadian** biological rhythm.

**STAGES OF SLEEP**

1. **NON-REM** (slow wave sleep)
   - stage 1 = **lightest sleep**
   - stage 2
   - stage 3
   - stage 4 = **deepest sleep**

2. **REM** (**Rapid Eye Movement**) sleep
   - **when most vivid dreaming takes place**

The stages of sleep occur in a relatively **regular pattern or “cycle”** in normal humans and many animal species

- stage 1 > 2 > 3 > 4 > 3 > 2 > 1 > REM > repeat

- each cycle lasts approximately **90 min**

- as night progresses, spend **more time** in REM
Typical night’s sleep

SLEEP STAGES

REM sleep

Awake

EEG stage

Hours
ElectroEncephaloGram (EEG) is used to measure electrical activity of entire brain - gross summation of electrical activity over entire brain

1. Aroused awake: beta waves = low amplitude, irregular, high frequency waves

2. Drowsy, relaxed awake: alpha waves = high amplitude, regular, low frequency waves (8 - 12 Hz)

3. Stage 1: theta waves (3 - 7 Hz)

4. Stage 2: Sleep spindles, K complexes (12 - 14 Hz)

5. Stages 3 & 4: delta waves (1 - 2 Hz) = slow wave sleep - large, irregular slow waves

6. REM: “Paradoxical” sleep = low voltage, high frequency waves
EXAMPLES OF EEG ACTIVITY

- Awake: low voltage, random, fast beta waves
- Drowsy: 8 - 12 Hz alpha waves
- Stage 1: 3 - 7 Hz theta waves
- Stage 2: 12 - 14 Hz (Sleep spindles, K complexes)
- Stage 3 and 4: 1 - 2 Hz delta waves = slow wave sleep
- REM Sleep: low voltage, random, fast waves
COMPARISON OF REM vs SLOW-WAVE SLEEP

Slow-wave sleep (stages 3 & 4):
- more earlier in the night
- synchronized EEG
- slow/absent eye movements
- normal muscle tonus
- no sexual activation
- ponto-geniculo-occipital (PGO) waves absent
- passive, less-detailed (static) dreams

REM (paradoxical) sleep:
- more later in the night
- desynchronized EEG
- rapid eye movements
- flaccid muscle tonus
- sexual activation
  - penile erection and ejaculation
  - vaginal engorgement and secretions
- PGO waves present
- vivid, action-packed dreams
THEORIES OF SLEEP

Humans spend a third of their lives asleep. Why?

1. Passive theory:
   decrease of sensory stimulation associated with evening is simply conducive to sleep.

2. Adaptive theory:
   - sleep is an energy-conserving strategy to cope with time of low food supply.
   - sleep to keep out of trouble when vulnerable.
   - species have evolved very different sleep patterns (ex. herbivores vs. carnivores, dolphins, sea birds).

3. Restorative theory:
   - sleep period essential for either body "repairs" or elimination of "toxic" substances generated during waking (ex. of growth hormones, exercise, and some drugs)

4. Memory storage theory: some theories propose that either REM or Non-REM sleep is important for memory storage.
Early passive theory of sleep (Bremer, 1936) were quickly discarded in favor of more active sleep mechanisms in the brain.

- Moruzzi and Magoun (1949) electrically stimulated the "pontine reticular formation" in sleeping cats to either produce a desynchronized EEG in anesthetized cats or to "awake" normally sleeping cats.
- This region became known as the **ascending reticular activating system (RAS)**.

Sleep is partly regulated through circadian rhythm mechanisms which are entrained by the **suprachiasmatic nucleus of the hypothalamus**.
Additional brain regions involved in sleep

Two more regions, when electrically stimulated or otherwise active, produce a desynchronized EEG pattern:

1. Basal forebrain: large cholinergic neurons that send their axons throughout the neocortex;
   - contain the neurotransmitter **acetylcholine**

2. Median raphe: serotonin neurons of the pons that send their axons throughout the neocortex;
   - contain the neurotransmitter **serotonin**;
   - drugs that inhibit serotonin activity can produce **hallucinations** (LSD).
Brain regions specifically associated with REM sleep

1. Peribrachial area:
   - observed to be active during REM sleep
   - lesions of this area disrupt REM sleep
   - thought to excite PGO waves (pontine - geniculate - occipital)
   - has direct projections to MPRF

2. Medial pontine reticular formation (MPRF):
   - injections of cholinergic agonists (carbachol) increase REM sleep time
   - projects to subcoerulear nucleus - activates magnocellular nucleus of the medulla - atonia (paralysis)
   - projects to basal cholinergic system - desynchronized EEG of REM

3. Subcoerulear nucleus:
   - when lesioned in cats, observed to act their dreams.
DISORDERS of SLEEP (4 categories)

I. Initiating/maintaining sleep
   a) Insomnia: “unable to fall asleep”
      - prevalent causes of insomnia: situational events (life events, pain, etc), bad habits (reading, etc).
      - can often be cured by changing habits
   b) Sleep apnea: Breathing problems during sleep
      - most people stop breathing (10 s) during sleep, considered normal
      - but a physical condition wake people several times/night = fatigue
      - can sometimes be corrected with surgery
      - sleeping pills: are they that helpful?

II. Excessive somnolence
   Narcolepsy (main symptoms)
      1. Daytime sleepiness and sleep attacks
      2. Cataplexy: falling asleep uncontrollably
      3. Sleep paralysis: muscle atonia while conscious

III. Sleep/wake cycle disturbances
   a) Delayed sleep/wake syndrome
   b) Jet lag and work shifts

IV. Parasomnias
   a) Sleepwalking
   b) Bedwetting
   c) Night terrors
   d) Sleep talking

What are lucid dreams? Ability to control content and action of dream.