NEURAL ORGANIZATION

All cells are irritable (i.e. respond to exogenous stimuli)

Neurons are specialized to:

1. respond in a differential manner to particular stimuli, and
2. transmit the response in an orderly, predictable form

A neuron is composed of functional parts:

1. Axon - transmission
2. Cell body - regeneration
3. Dendrite - reception and integration
4. Synapse - signal modification

Nervous system composed of functional parts; most basic:

1. Sensory (afferent neurons) - input from sensory organs
2. Central (interneurons) - storage, decisions
3. Motor (efferent neurons) - output to muscles & glands

How a Neuron Works?

AXON (electrical/ionic)

Terms to define:

1. resting potential (50-90 mV)
2. anion (-)/cation (+)
3. sodium (Na)-potassium (K) pump
4. polarization
5. depolarization
6. action potential/nerve impulse/spike
7. hyperpolarization
8. refractory period
    a. absolute (0.5 ms – 1,000 A.P./ s upper limit)
    b. relative
9. electrotonic spread (self-propagating)
10.. all-or-nothing response
11. threshold (min. stimulus intensity for an A.P.)

12. accommodation (axon)/adaptation (sensor)
    a. tonic
    b. phasic
13. myelinated (saltatory conduction, 100 m/s)

AXON CHARACTERISTICS

1. Has a threshold (no Action Potential unless stimulus intensity is greater than Threshold)
2. All-or-Nothing response
3. All Action Potentials the same regardless of stimulus intensity
4. All Action Potentials conducted w/o decrement
5. Stimulus intensity carried by a Quantified Code
   [Number of Action Potentials/unit of time]

   Stimulus quality conveyed by
   LINE LABELLING

How does the SYNAPSE and DENDRITE work?

Some terms to define:

1. synapse
2. presynaptic/postsynaptic
3. chemical transmitter
4. synaptic vesicles
5. inhibitory synapse (IPSP)
6. excitatory synapse (EPSP)
7. graded potential

SYNAPSE CHARACTERISTICS

1. Chemical transmission of nerve impulse
2. Usually one-way transmission
3. Inhibitory synapses hyperpolarize the dendrite
4. Excitatory synapses polarize the dendrite
5. Generally acts as a FILTER

DENDRITE CHARACTERISTICS

1. When stimulated, shows a GRADED RESPONSE
2. No action potential, no all-or-nothing response, no refractory period
3. Functions to integrate multiple input signals

A few of the 100+ chemical transmitters

acetylcholine		
epinephrine		
norepinephrine		
serotonin	neuromodulators	
dopamine		
gamma-amino butyric acid (GABA)	Inhibitory	
glycine		
glutamate		Excitatory
aspartate		
enkephalins		Opiates
endorphins		

Note: neurotransmitters also occur in non-brain areas (e.g. gastrin, lipotropin) – gut, adrenals, sex organs

Neurology not limited to the brain. ('mind in the body"? "gut feelings"?)

ACETYLCHOLINE

- Excitatory (cholinergic)
- Released by
  - Autonomic → Parasympathetic
    - → Sympathetic (fight/fright)
  - Synapses to skeletal muscles
- Common in CNS
- Cell death in hippocampus (memory, learning cognition) Assoc. w/ Alzheimer's disease (not old age)
- Nicotine mimics Ach in low conc., blocks receptors in high conc. (insecticide)
- Curare blocks Ach receptors at muscle junctions

EPINEPHRINE

Excitatory (adrenergic)

Released by

Autonomic → sympathetic

Adrenal medulla

NOREPINEPHRINE

Excitatory or inhibitory (adreneric modulator)

Released by

Autonomic → sympathetic

High levels assoc with manic phase of manic-depressive bipolar disorder, low during depressive phase

Amphetamines stimulate release of Nor-Epinephrine - chronic use depletes synaptic vesicles, leads to psychosis

SEROTONIN

Excitatory or inhibitory

Brain stem (100,000 neurons), innervate throughout brain (blood press., vascular & respir. activity, aggression, eating, sleeping, attention/arousal)

Inhibited by MELATONIN from Pineal gland

< light, > melatonin, < serotonin

Affects gonadotrophins, 24 hr rhythms

Assoc with SAD (seasonally affected syndrome)

Assoc with manic-depressive disorder (w/nor-epi), obsessive-compulsive disorder

Prozac blocks serotonin uptake into presynaptic membrane, keeps more serotonin in synapse to counter depression

LSD disrupts serotonin modulation (cross-modulation) to forebrain (e.g, visual centers), limbic system

(mood swings) and to spinal cord (tremors, dizziness, nausea)

DOPAMINE

Excitatory or inhibitory (modulator, in concert with other neurotransmitters) in CNS

D1-D5 receptors in central NS & peripheral NS. neurohormone (prolactin inhibitor), neurotransmitter in basal ganglia (smooths muscle movements), frontal lobe (memory, attention, problem solving), limbic structures (pleasure & pain associations, emotional responses), peripheral NS (blood flow, kidney filtration)

Too much: disinhibition (Tourettes syndrome), euphoria, elaborate stereotypes (psychosis, schizophrenia)

Too little: Parkinson's disease, ADHD-linked (attention deficit hyperactivity disorder), anxiety, depression

Amphetamines, cocaine promote > release of dopamine, block re-uptake of dopamine, & < storage in vesicles

Cosmology -- philosophy dealing with the origin and structure of the universe (i.e. nature & **ourselves**)

How do we perceive our own origins and our own state?

Three views in western culture (from Collingwood, 1957, The Idea of Nature):

1) Greek view (e.g. Socrates, Plato, Aristotle)

Nature as organic - a body in motion, due to intrinsic vitality (soul), but also orderly and self-directed (mind). Paradoxically, Socrates expounds a dualistic doctrine of independence between the material body and the psychical entity of soul/mind.

2) Post-renaissance view (e.g. Descartes, Berkeley, Locke, Hume, Newton)

Nature as a machine – nature is now devoid of intrinsic vitality and intelligence, and the movement and orderliness of nature are externally imposed. Body parts are designed, put together, and set into motion for a definite purpose by an intelligent prime mover. [the metaphysical basis for "intelligent design" argument] This cosmology also wrestles with the "body/mind" conundrum, where nature is a by-product of an autonomous and self-existing activity of mind. Soul and mind supersede matter.

3) Modern view (e.g. Bergson, still forming)

Nature as a process -- change & development the natural outcome of the process (nature always a work in progress). Resolves an ancient conceptual dualism between changing and constant elements in nature, where only the latter were believed to be knowable. This cosmology, in its most radical state, eradicates the concept of unchanging elements.

Outcomes: 1) change is not cyclic, but progressive; 2) nature is no longer mechanical; 3) teleology is reintroduced – nature attempts to preserve its own becoming: the process engaged ensures what is will become something else; substance resolved into function

Darwinian evolution is but one example of this cosmology.

CONSCIOUSNESS/FREE WILL/

St Augustine (4th cent.) - free will

Descartes (17th cent.) - mind (soul)/body

Perceptual outcomes of nervous system (e.g. sensory qualities, consciousness, cognitive processes)

FOREBRAIN

LIMBIC SYSTEM ("reptilian brain") Several limbic structures interfacing with the cerebrum have been implicated in “consciousness” and “will”

Thalamus (Pulvinar region)

Karen Quinlan case

Cingulate Sulcus

Alien hand syndrome

HUMAN BRAIN - Structure/Function

HINDBRAIN

1. Medulla & Pons

   Cardiac center, respiratory center, vasomotor center

2. Cerebellum

   Muscular coordination, posture, muscle tone

MIDBRAIN

1. Connect hindbrain w/ forebrain
2. Controls some visual & auditory functions

FOREBRAIN

1. Limbic System (“reptilian brain” – brings “feelings” to the “thoughts” of the cerebral cortex – provides emotional content)
   a. Hypothalamus

      Emotional centers (perception of pain, pleasure, fear, rage, etc.)

      Sexual center (responses to tactile inputs, perception of orgasm)

      Body temperature (“thermostat”)

      Food intake (perception of hunger & satiation)

      Osmotic balance (thirst, antidiuretic hormone)

      Biological clock (sleep-wake cycles, other biological rhythms)

      Releasing tropic factors for anterior pituitary hormones (“hormonostat")

b. Thalamus (gateway to the cortex)

Integrate sensory input

Reticular Formation

filters 99% of redundant or inconsequential sensory input. Amplifies unique or unusual input

Arousal center for cerebral cortex and other brain areas (damage results in coma)

Involved in memory processing

c. Subcortical Structures

Hippocampus (short term memory, spatial perception)

Amygdala (aggression & fear)

Cingulate Gyrus (interface between limbic system and cortex)

d. Pineal Body

Sets circadian (24 h) and cirannular rhythms

Induces sleep, gonadotropic responses, mood

2. Olfactory Lobe

3. Cerebral Cortex

a. Prefrontal lobe (intellect, complex learning ability, personality, linked to emotional centers of limbic system) – assembles new experiences into "stories" based on past experiences (facilitating parables, legends, oral traditions)

b. Frontal lobes

Precentral gyrus (motor area controlling voluntary motor functions, damage results in paralysis)

Premotor cortex (controls learned motor skills)

Broca's area (coordinates muscles critical to speech)

Actions related to personality

Memory, reasoning, judgement, planning, emotional expression

c. Temporal Lobe - auditory

Wernicke's area

Contains word concepts and syntax that is related to Broca's area for motor output

Stores auditory & visual memories

d. Occipital lobe - vision

Object recognition, visual interpretation, including associations with visual experiences

e. Parietal Lobe - sensory

Identifies body region being stimulated

Integrates and evaluates sensory input (e.g. identify object in pocket)

f. Associative areas (memory)

A metaphor

ARMY ANTS - Collective Intelligence

Epiphenomenon

100 ants vs 500,000 ants

Single ant (<100,000 neurons) shows no info for

temp regulation

compass bearing

cooperative prey transport

choosing colony parents

nest architecture

foraging systems

economic strategies

Intelligence - involves the rational manipulation of symbolic information

[Army ants are intelligent (pheromones)]

Insect evolution from individual, hard-wired, high-grade processing unit (e.g. solitary wasp) to society of large numbers of simpler individuals linked by sophisticated patterns of communication (super-organism)

Caste

Majors

Defense, huge head and ice tong mandibles,

Kamikaze role - mandibles close in death lock

Submajors

Porters, long legs

Minims

Brood caring, small body size

Mediums

Jack-of-all-trade

Raids

200,000 ants, 20 m front, all day, 14 m/hr, 30,000 prey, constant retrieval rate, self-appointed teams

Cycle

Nomadic Phase (15 days)

Larva grow, colony moves & raids every day

Statary Phase (20 days)

Larvae pupate, colony stationary

Raid about 2/3 of days (123° angle)

NERVE NETWORKS - TWO EXAMPLES

I. PATTERN-GENERATING NERVE NETWORK

[Outputs more organized (information richer) than their inputs]

e.g., locust flight (Wilson) – randomly stimulate control neuron into "central pattern generator", and a patterned output appears in motor neurons innervating wing muscles

Components

command neuron

thoracic ganglia

central pattern generator

coordination of hind and forewings

coordination of left and right side wings

power strokes (angle of attack) and beat frequency

proprioceptor feedback

wing hinge stretch receptors

campaniform sensilla of wings

hairs on feet and head capsule

ocelli and compound eyes

II. FILTERING or PATTERN RECOGNITION NERVE NETWORK

e.g., Noctuid moth ears (Roeder) – built-in response criteria for receptors or a neural template to ignore most stimuli and differentially respond to specific stimuli

Moths produce no sounds for communication, yet they have

a pair of ears (rear of thorax)

Simple ear consisting of two auditory receptors, A1 & A2

Both receptors tuned to frequency band of bat echo-location vocalizations (FM sweep and/or CF signals, 20-100 kHz)

Hunting bats detect prey by perceiving returning echo

Angular size (loudness)

Absolute size (echo delay + angular size)

Azimuthal angle and elevation angle decoded

from asynchrony between paired receptors and ear shape

Velocity of bat versus prey (Doppler effect, especially CF)

Signal pulses become more frequent and decrease in duration for best resolution after detecting a moth

Moth ear: A1 has lower threshold than A2. A1 fires when bat sound faint. Input steers moth away from signal source before bat begins detecting a returning echo. Moth ear can respond to azimuth and elevation of sound source from asynchrony between paired receptor and relative signal wow from wing position. When A2 fires (high threshold), bat is very close. A2 input disrupts flight pattern generator, resulting in erratic or paralyzed wing movement.