Central Nervous System
Brain & Spinal Cord

Brain
one of largest organs in body:

- men: 1,600 g (3.5 lbs)
- women: 1,450g (3.2 lbs)

[size is proportional to body size not intelligence
Neanderthals had larger brains than us!!]

early thoughts on function of brain:
ancient Greeks weren’t particularly impressed with the brain
where shot was generated
cooling device for blood

neurons divide only during prenatal development and a few months
after birth
after that they increase in size, but not numbers

one of most metabolically active organs in body
comprises only 2% of total body weight it yet

- gets 15% of blood
- consumes 20% of our oxygen need at rest
  (more when mentally active)

blood flow and O₂ increase to active brain areas

1-2 min interruption of blood flow may impair brain cells

>4 min w/o oxygen → permanent damage

besides O₂ must get continuous supply of glucose
very little in reserve

decrease in glucose:
dizziness
convulsions
unconsciousness

The Brain is Subdivided Into:

1. Cerebral Hemispheres (60% of brain mass)
   - “human” part: thought, creativity, communication

2. Diencephalon moods, memory, manages internal environment
   epithalamus
   thalamus
   hypothalamus

3. Cerebellum – coordinating movement and balance

4. Brain Stem – oldest and smallest region, basic bodily functions = vegetative functions
   midbrain
   pons
   medulla

Some General Terminology for CNS:

- **gray matter** = thin myelin; mostly cell bodies
dendrites & synapses
  - outer layer of brain = cortex
  - inner layer of spinal cord
- **nuclei**: small areas of gray matter deeper inside the brain

- **White matter** = thick insulation; mostly axons
  - inner layers of brain: nerve tracts = bundles of axons that interconnect various parts of the brain
  - outer layer of spinal cord

Brain Stem

1. Medulla

does not contain nerve tracts

- lowest portion of brainstem
- continuous with the spinal cord
- all ascending and descending tracts from spinal cord and brain = **white matter**
- most tracts cross over as they pass through the medulla
- helps control several vital functions
  - contains important autonomic reflex centers

- decreases in glucose:
  - cardiac reflex center
  - vasomotor control center
  - respiratory center

- also contains many nonvital reflex centers (nuclei):
  - speech
  - swallowing
  - vomiting
  - coughing
  - sneezing
  - hiccuping

2. Pons

  just above medulla

  - bridge connecting spinal cord with brain and parts of brain with each other
  - contains 2 centers that help to regulate breathing
    - pneumotaxic center
    - apneustic center

  - also contains nuclei that affect sleep and bladder control
3. **Midbrain**

   in the form of 4 lobes above and behind pons

   = **Corpora Quadrigemina**

   upper 2 lobes = **Superior Colliculi**
   control center for some visual reflexes:
   a. **pupillary reflex**
   b. reflex centers for coordinating eye movement with head and neck movement in response to visual stimuli

   lower 2 lobes = **Inferior Colliculi**
   control center for some auditory reflexes:
   a. reflex centers for movements of head and trunk in response to auditory stimuli to locate sound
   b. startle response to loud noises
   also contains:

   **substantia nigra** → suppresses unwanted muscle contractions

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**Parkinsons Disease**

progressive loss of motor function
begins in 50’s or 60’s

can be hereditary
due to degeneration of dopamine releasing neurons in **substantia nigra** (inhibitory neurons)
leads to hyperactivity of **basal nuclei** and involuntary muscle contractions
results in shaking hands, facial muscles become rigid, range of motion decreases
develops smaller steps, slow shuffling gait with forward bent posture and a tendency to fall forward
speech becomes slurred, handwriting illegible

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4. **Reticular Formation (~Reticular Activation System)**

diffuse system of interconnecting fibers extending through several areas of brain including brain stem

   -comprises a large portion of entire brainstem
   -extends into spinal cord and diencephalon
   -interlacing of gray and white matter

**Functions of RAS** - both sensory and motor

1. **Sleep and consciousness**

   maintains consciousness and awakens from sleep → alarm clock

   barbiturates depress RAS, decrease alertness & produce sleep

   amphetamines stimulate RAS producing wakefulness

   and intermediate mass

   mainly a sensory relay center

   → "Rome of the Nervous System"

   or "gateway to cerebral cortex"

   → main relay station for sensory impulses

   that reach cerebral cortex from spinal cord, brain stem and cerebellum

   eg. taste, touch, heat, cold, pain, some smell

   the only sensory signals that can reach the cortex without going through the thalamus are for sense of smell

3. **Hypothalamus**

   part of the brain most involved in regulating internal environment

   no blood brain barrier

   forms floor and part of lateral walls of 3rd ventricle

   **a. link between “mind” and “body”**

   controls and integrates activities of autonomic NS

   means by which emotions express themselves by altering body functions
opioids and endorphins are concentrated in limbic pathways

→ is site of action of many addictive drugs

Cerebellum

2nd largest part of brain

just below and posterior to cerebrum

only other part of brain that is highly folded

consists of 2 hemispheres

grey matter outside

white matter inside

= arbor vitae (tree of life)

Functions of Cerebellum:

helps to coordinate voluntary muscles:

but does not send impulses directly to muscles

1. acts with cerebrum to coordinate different groups of muscles

≈ role in psychosomatic illnesses

b. relays reflexes related to smell

c. manufactures and transports releasing hormones that control the “Master Gland”

→ anterior pituitary

e. regulates body temperature

has receptors that monitor blood temperature

f. regulates food and water intake

has receptors that monitor osmotic pressure

→ thirst center

other receptors monitor some hormone concentrations in blood

4. Limbic System

diencephalon is a main part of a diffuse group of structures called the Limbic System

includes thalamus, hypothalamus, hippocampus, midbrain, amygdala (cerebrum), mamillary body (relay center from limbic system to thalamus), fornix (connects hippocampus to mamillary body of hypothalamus)

= the emotional brain

limbic system perception & output is geared mainly toward the experience and expression of emotions

eg. pain, anger, fear, pleasure

continuous back & forth communication between limbic system and frontal lobes of cerebrum

→ much of the richness of your emotional life depends on these interactions

outward expression of these emotions requires participation of the hypothalamus

all sensory impulses are shunted through the limbic system

smell is directly wired to limbic system

produces a crude appreciation of some sensations; eg. pleasure, anger, pain

but can’t distinguish their location or intensity

eg. contains pleasure center

-rats pressing bar for stimulation of pleasure center

-ignore sleep, food, water, sexual partners

-continue until exhausted (50-100x/s/min)

-willing to cross electrified grid to seek reward (420 amps vs 60-180 amps for food)

in humans stimulates erotic feelings

opiates and endorphins are concentrated in limbic pathways

smooths and coordinates complex sequences of muscular activity needed for body movements

2. controls skeletal muscles to maintain balance

receives input from proprioceptors in muscles, tendons and joints and equilibrium receptors and eyes

→ compares intended movement with actual movement

3. learning and storing motor skills

eg. playing musical instrument, riding a bike, typing, etc

4. recent research indicates that the cerebellum also has roles in awareness, emotion and judging the passage of time

diseases of cerebellum produce Ataxia

eg. tremors

speech problems

difficulty with equilibrium

NOT paralysis

Cerebral Hemispheres

largest portion of brain (~60% of brain mass)

two hemispheres joined by tracts = corpus callosum

heavily convoluted: gyri and sulci
folding allows greater area of cortex in smaller space (area = 2,500 cm² = area of 4.5 textbook pages or 1 keg of beer)
also has larger grooves (= fissures) that divide each hemisphere into 4 main regions named after bones they lie under:

1. frontal
2. parietal
3. occipital
4. temporal

each hemisphere:

a. outer gray matter = cerebral cortex (2-4mm)
b. inner white matter = tracts
   - bundles of myelinated axons
c. nuclei = islands of gray matter in interior of brain
   - cell bodies and sometimes dendrites
      - eg. basal nuclei (=basal ganglia)
      - clusters of gray matter around thalamus (5)
      - help direct movements
      - overactivity due to lack of dopamine produces Parkinson’s disease

hemispheres connected by nerve tracts in corpus callosum

Function of Cerebral Cortex:

Each hemisphere is mainly concerned with sensory and motor functions of the opposite side of the body

- eg. left hemisphere controls right hand

B. Lateralization of Hemispheres

On top of this basic functions is "lateralization":

- a specialization of some cortical functions into each hemisphere
- a division of labor
  - each hemisphere takes on complementary functions

Left Hemisphere:

1. does all the talking
   - repository of language
   - processes many aspects of language: syntax, semantics, etc
   - also analytical skills, math, logic

Right Hemisphere:

1. mainly concerned with visuospatial tasks

Neurons of cortex are arranged into a highly organized, radial array of 6 cellular layers (=neocortex)

- differ in composition, functional properties, sets of connections

cortex has been systematically subdivided into >40 functionally distinct areas
cortex is responsible for our most "human" traits

   conscious mind
   abstract thought
   memory
   awareness

A. on simplest functional level, the cerebral cortex contains:

a. motor areas
   - that control voluntary motor functions
b. sensory areas
   - provide conscious awareness of sensations
c. association areas
   - integrate wide variety of information from several different areas of brain

2. nonverbal communication: interprets more subtle aspects of language - metaphor, allegory, ambiguity
3. also concerned with emotions, intuition
4. global holistic aspects of sensory processing
   - eg. does reality checks of new information
   - eg. holistic aspects of vision
      - "reading" facial expressions
      - recognize faces

There appears to be a gender difference in brain lateralization

- males process spatial tasks in right hemisphere by 6 yrs of age
- females spatial function is equally developed in both hemispheres until age of 13
- damage to rt hemisphere in childhood impairs language development in males more than females

Hemispheric Dominance:

Lateralization as described is true for 97% of all people

- for ~90% of these people
  - traits characteristic of the left hemisphere are dominant for verbal, analytical
all are right handed
for 7% of these people
> traits characteristic of right hemisphere are dominant
  visuospatial tasks
  these are left handed
  more likely to be males
for 3% of population functions are shared = bilateral (no dominance)
lateralization is reversed or reduced in bilateral folks
often ambidextrous
sometimes leads to confusion and dyslexia

C. Lobes of the cerebrum
fissures divide each hemisphere into 4 regions,
each with a specific set of functions:

1. **Frontal**
   personality
   control of voluntary movement

2. **Parietal**
   touch, stretch
   perception of somatic sensations

3. **Occipital**
   processing of vision

4. **Temporal**
   processing of sound and speech
   awareness of equilibrium

1. **Frontal** (& prefrontal)

   **Prefrontal:**
   elaboration of thought
   intelligence
   motivation
   personality
   abstract ideas
   judgement
   planning
   “civilizing behaviors”

damage:
  wide mood swings
  loss of attentiveness
  become oblivious to social constraints
  careless about personal appearances

prefrontal lobotomy
  reduced anxiety
  but lost initiative
  had mood swings

**Frontal**
  motor processing areas:

  a. **Motor Cortex**
     directs conscious individual muscle contractions
     large body zones → homunculus
     within each zone: neurons that control specific movements are scattered as combinations of muscles are arranged in useful ways
     damage causes paralysis

2. **Parietal Lobe**
sensory processing areas

  a. **Sensory Cortex**
     receives information from skin sensors
     when stimulated patient reports “feeling” in some part of body
     muscle, tendon and joint sensations, and touch provides feedback to motor cortex
     spatial discrimination
     motor and sensory cortex, like other areas are malleable
     eg. learning Braille
     the area representing touch in the finger used in somatosensory cortex expands into areas previously devoted to neighboring fingers

  b. **Vestibular (equilibrium) Cortex**
     awareness of balance

3. **Occipital Lobe**
  visual processing areas

  a. **Visual Cortex**
     image is 1st mapped here
     receives info from retinas of eyes
     analyzes image in terms of its elementary features
     orientation
     color
     texture
     depth
     presence of movement

4. **Temporal Lobe**

  a. **Auditory Cortex & Association Area**
     interprets sounds: pitch, rhythm, loudness

  b. **Vestibular (equilibrium) Cortex**
     awareness of balance

c. **Olfactory Cortex**
small area just above orbits
perception of odors, smells
Higher Brain Functions

**Integration** → interaction of several areas or processes occurring at the same time

most not hard wired, circuits constantly forming and reforming

these functions are much more complex than simple reflex arcs

→ often involve learning

just beginning to understand them and some of the programming involved

Examples:

Sleep/Wake Cycles
Language and Speech
Consciousness = Self Awareness
Emotions and Behavior
Memory and Learning
Abstract Thought
Intelligence

**Language and Speech**

language is closely associated with distinctly human brain functions

seems to be an innate process

→ world’s languages are all governed by the same universal grammar

→ all infants are born with the ability to learn all human languages

however this ability diminishes with age

integrated with memory and consciousness

it can't be all under conscious control since it happens so quickly

also, cant be all reflex

Language involves up to 6 areas in cerebral cortex:

1. **Broca’s speech area** (frontal lobe)
   motor aspects of speech and language
   active when speaking
   or when moving tongue and hands
   muscular coordination for speech

   damage: aphasia
   slow and poorly articulated speech
   loose ability to speak fluently and grammatically
   and to express ideas in writing
   comprehension not affected

2. **Wernicke’s Area** (temporal lobe)
   visual imprint of retinal image:
   from there it goes to ~30 areas in cortex for higher level processing
   
   comprehension of written and spoken word
   active in children while reading
   and in adults reading unfamiliar words
   speech integration
   impulses from visual and auditory assoc
   connects to Broca’s area

   damage: aphasia
   rapid, fluid speech
   no information content—"word salad"
   no comprehension of spoken or written language

   Wernicke’s area is reduced in size in dyslexics

3. neurons in Left frontal and midfrontal cortex
   responsible for semantics
   word associations
   symbolic processing

4. **Left Frontal Cortex**
   essential for enunciating verbs

5. **Left temporal cortex**
   "whips out" nouns

6. **Occipital Lobe**
   color concepts and associations

**Consciousness**

What exactly is consciousness?

little is actually known but some generalizations:

1. involves simultaneous activity of large areas of cerebral cortex

→ localized damage of specific region does not destroy consciousness but does alter it

2. is superimposed onto other types of neural activity

3. is totally interconnected

**Awareness**

one of the simplest forms of consciousness is awareness (= perception):

→ of surroundings
→ of sensations
→ of relationships to those stimuli

consciousness is often defined as "self" awareness

what is self? or self identity

→ requires interactions of numerous specific brain areas

one of most important senses that gives us information about our surroundings and interactions with it is vision

visual stimuli that reach brain are first mapped into visual cortex
visual imprint of retinal image:

from there it goes to ~30 areas in cortex for higher level processing
information from primary visual cortex is then relayed through 2 pathways:

- **How Pathway** to parietal lobe
to discern spatial layout of outside world
  allows you to reach out for objects, know where you are
- **What Pathway** to temporal lobe
to recognize and name individual objects
  and respond to them appropriately with emotion

  *(The man who mistook his wife for a hat?)*

**eg Neglect patients**

esp if Rt parietal lobe is damaged

The right hemisphere has broad “sphere of interest” encompasses both left and right visual fields

**If right is damaged**

- temporary neglect of left side of body
doesn’t pay attention to left side of space or anything in it
  
  eg. draw 1/2 of a picture
  (left doesn’t exist)
  eg. eat from only rt side of plate
  - one patient “knew something wasn’t right”
  - rolled wheelchair in huge circle (clockwise) till

representation of what is going on in the world

brain can “fill in” (eg. blindspot) by extrapolation
  
  eg. blind spot is filled in
  eg. Necker cube
  eg. faces/vase

some have larger areas of “blindness” due to damage and fill in with hallucinations:

- no reaffirming information to “squash” hallucinations
- sometimes patient “knows” they are hallucinating – but can’t get rid of them
  
  eg. monkeys in lab
  eg. cartoon characters

but, even your own body is a phantom

your brain temporarily constructs it for your convenience

it can be profoundly modified with simple tricks

  **eg. how deeply do denial patients believe they are not paralyzed**
  cold water in ear corrects delusions and denial about paralysis, etc

ck? dummy hand in front of 2’x2’ wall
  have friend stroke identical location on dummy and your hand

**Disorders:**

certain variations in levels of consciousness are normal:
  awake & alert
  relaxed & nonattentive
  sleep

**altered states** of consciousness also occur

- **anesthesia**
  induced by injury or disease
  no vocalizations, no spontaneous eye movements
  brainstem reflexes intact

- **coma**
  eg. LSD

- **meditation**
  eg yoga

- **confusion**
  alteration in perception of stimuli
  disorientation to time first, then to place, eventually to person
  shortened attention span

- **lithargy, stupor, obtundation**

- **locked-in state**
  motor nerves cease functioning; the body is completely paralyzed while the mind continues to function normally; patient may appear to be clinically dead

**synesthesia**

all of our senses contribute to consciousness
  *(not just vision)*
hallucinatory welding of senses:
2 or more sensations are comingled
sensory impulses not sent to appropriate sensory areas of cortex
eg. a musical note may taste like pickles
eg. a guitar chord may be felt as a brushing sensation on ankle
eg. the taste of chicken may feel "round"
eg. a boyfriend's kiss was seen as "orange sherbert foam"
eg. see brilliant blue after eating salty pretzel
eq. specific letters or number associated with specific colors
eq. feel pain in colors

these perceptions are consistent over time for one person
but not necessarily the same for other synesthetes
1 person in 2000 is a synesthete;
but may be even more common 1 in 300
more common in women: 6 women to 1 male

seems to run in families: genetic component

Is there a consciousness "center" in the brain?
does consciousness arise from specialized brain circuits?
→ brain lesions that produce the most profound disturbances in consciousness are due to "temporal lobe seizures"

→ the brain regresses as it matures
  eg. 3-11 yr old has 2x's energy/gm as 11-14 yr old
  eg. the cerebral cortex thickens in childhood, peaks and then thins again in adolescence
  → 2x's # synapses in certain areas of child's brain vs adolescent brain

b. angular gyri in cerebral hemispheres is important
  eg. we know damage to angular gyrus in left hemisphere can leave "intelligent" people unable to do simple subtraction (eg. 100-7)
  eg. we know damage to angular gyrus in right hemisphere leads to disruption of artistic skills

c. specific circuits are used for specific functions

Savants are mentally retarded yet some can:
→ replay any music when heard once
→ state exact time of day with no clock in sight
→ exact counts of numerous objects
eg. "rainman"
→ can tell you in span of 40,000 years, the day of the week any date you choose fell on

→ epileptic seizures sometimes produce profound experiences
temporal lobe is associated with:
  auditory hallucinations
  out of body experience
  "religious" experiences
  feelings of absolute omnipotence
  feelings of omniscience
  insights into "cosmic truths"
sense of truth and enlightenment derive from limbic structures rather than "thinking" part of the brain

Intelligence
what is anatomical/physiological basis for intelligence?
  brain mass
  # neurons in brain?, in cerebrum?
  # synapses?

where is it centered?
→ is our intelligence part of our cortex?

may be the ability to juggle lots of possibilities

working memory may play important role

What we know:
a. intelligence may have more to do with when and how the brain grows than with its overall size

→ most savants are not truly "creative"
  rote, not interpretive
d. there is lots of redundancy and plasticity in the brain in terms of intelligence

John Lorber asks:
"Is your brain really necessary?"
most of brains higher functions are mediated by cortex
→ we view the cerebrum as what makes us...
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human

he studies **hydrocephalic** patients

→ extremely large cavities in brain, brain mass, including cerebral cortex is greatly reduced

many hydrocephalics suffer intellectual and physical retardation

but of ~60 whose brain scans showed water cavities filled 95% of skull

→ ~ half had IQ’s > 100 (normal IQ=90-110)

eg. Hydrocephalic boy = honor student

had <20% of normal cerebral cortex

(his 1 mm (1/32’’), normal = 4.5 cm (1.75’’))

normal IQ = 90-110; his = 126

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**Spinal Cord**

located in the spinal canal of the vertebral column

17 – 18 inches long

extends from foramen magnum to lower border of 1st lumbar vertebrae

subdivided into **cervical, thoracic, lumbar, sacral** regions

spinal cord terminates in a bundle of nerves

= **cauda equina**

associated with cord in spinal canal are:

**meninges**

adipose cushion

**CSF**

**blood vessels**

space between vertebrae and dura mater

= **epidural space**

is occupied by blood vessels, adipose tissue and loose connective tissue

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**Cross Section of Spinal Cord:**

Post. Median Sulcus

Post. Horn of gray matter

Tracts

Central Canal

Lateral Horn of gray matter

Ant. Median Fissure

Ant. Horn of gray matter

**white matter:** myelinated, divided into columns and tracts; “highways”

**gray matter:** unmyelinated, cell bodies & dendrites, synapses

**Nerve Tracts**

numerous tracts can be identified in the spinal cord

spinal cord tracts serve as 2-way conduction paths between peripheral nerves and brain

each tract is composed of bundles of axons

ascending tracts & descending tracts

eg. spinothalamic tract

all axons originate from cell bodies in spinal cord and terminate in thalamus of brain

all are sensory (ascending)

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**Protection of CNS**

both brain and spinal cord are heavily protected:

1. **bone:** skull and vertebral column

2. **adipose cushion** around spinal cord

3. **meninges:** tough flexible covering

4. **liquid cushion:** cerebrospinal fluid

**Meninges**

composed of 3 layers:

1. **dura mater**

   strong fibrous connective tissue

   outer layer in skull is periosteum of cranial bones

2. **arachnoid layer**

   delicate cobwebby layer

   **subdural space** = between dura mater and arachnoid membrane

   **subarachnoid space** = between arachnoid layer and pia mater

3. **pia mater**
transparent
adheres to outer surface of brain and cord
contains blood vessels

3 extensions of the meninges form partitions between various parts of the brain:

- **falx cerebri**
  - largest partition between cerebral hemispheres

- **falx cerebelli**
  - separates cerebellar hemispheres
  - not in sheep brain

- **tentorium cerebelli**
  - separates cerebrum from cerebellum

Meninges continues around spinal cord and extends beyond the end of the spinal cord

- safer site for lumbar puncture to get CSF

**Meningitis** = inflammation of arachnoid, pia and CSF usually bacterial or viral; may lead to encephalitis

**Encephalitis** = inflammation of brain tissue itself

**Cerebro Spinal Fluid**
as further protection against damage the brain and spinal cord have a cushion of fluid around and within

- brain actually "floats" in CSF (~140 ml of CSF)

CSF provides buoyancy and protection to delicate brain tissues also produces chemical stability

CSF mainly in:

- **brain ventricles and ducts**
- **central canal** of spinal cord
- **in subarachnoid space of the meninges**
  - space between arachnoid layer and pia mater

**Ventricles**

ventricles are fluid filled cavities inside brain:

1. **1st & 2nd** in side cerebral hemispheres = lateral ventricles
2. **3rd** small slit at base of brain inside diencephalon (thalamus)
3. **4th** diamond shaped expansion of central spinal canal in brainstem

**Circulation of CSF**

fluid moves to **central canal** of spinal cord

fluid moves out to **subarachnoid space** around cord and brain

reabsorbed from subarachnoid space into **arachnoid granulations**

if circulation is blocked by tumor or other means during fetal development may cause **hydrocephalus**

- fluid is still produced but can’t circulate and be reabsorbed

surrounded by **astrocytes** (blood brain barrier)

each **choroid plexus** secretes CSF into ventricles

- produces ~500ml of CSF/day
  - only 100-160ml at a time in circulation

isolated by "**Blood Brain Barrier**"

capillaries are much less leaky than normal capillaries
  - tight junctions
  - astrocytes help regulate flow into CSF

some substances easily, rapidly passed:
  - glucose, O₂, CO₂, alcohol, caffeine, nicotine, heroin, anesthetics

others cross more slowly; creatinine, urea, most ions (Na⁺, K⁺, Cl⁻)

larger molecules cannot cross at all; proteins, antibodies

- difficulty getting drugs to brain tissue
- any trauma to head may damage BBB
Aging Central Nervous System

reaches peak development ~30

by age 75 average brain weighs slightly half its 30 yr weight

- gyri are narrower
- sulci are wider
- cortex is thinner
- more space between brain and meninges

neurons show signs of slower metabolism, accumulate neurofibrillary tangles and lipofuscin pigment

less efficient signal conduction and transmission

myelin sheath degenerates

fewer synapses

less NT produced, fewer receptor proteins

language skills and long term memory hold up better than motor coordination, intellectual function and short term memory

Disorders of the Central Nervous System

migraine headaches:
- often debilitating and excruciating headaches
- 10-12% of US ≈ 28M in US suffer;
- ~70% are women
- 92 M workdays lost/yr; $11 B/yr (AAS 97)

2 kinds:

Classic (with aura)
- some or all of symptoms:
  - seeing zigzagging lines
  - tingling or numbness in face, arm, leg
  - seeing blind spots and tunnel vision

Common (without aura)
- pain on one or both sides of head
- nausea
- sometimes vomiting
- sensitivity to light, smell or noise
- throbbing, intense pain

may be due to:
- a. fluctuations in levels of serotonin
  - imitrex increases serotonin levels to stop headache
- b. excessive levels of dopamine
- c. may be a genetic component

Tourette’s Syndrome

recurrent involuntary muscle contractions = tics
- eg. eyeblinking, nose twitching, facial grimacing, head shaking, shoulder shrugging

usually begins in childhood between ages of 2 – 15 worldwide, all races; males more than females

may affect 1 in 2000, worldwide; US ~100,000 affected

may be due to chemical abnormality in basal ganglia

Alzheimers Disease

affect 11% in us over 65; 47% by 85
- ~half of all nursing home admissions

leading cause of death among elderly

AD may begin before 50 with very mild, undiagnosed symptoms
-one of 1st symptoms is memory loss, esp of recent events
-progresses with reduced attention span, disorientation, muddy, confused, paranoid, combative or hallucinatory
-may lose ability to read, write, talk, walk, and eat
-death usually from pneumonia or other complications of confinement and immobility

Parkinsons Disease

progressive loss of motor function

begins in 50’s or 60’s
- can be hereditary
- due to degeneration of dopamine releasing neurons in substantia nigra (inhibitory neurons)

leads to hyperactivity of basal nuclei and involuntary muscle contractions

results in shaking hands, facial muscles become rigid, range of motion decreases

develops smaller steps, slow shuffling gait with forward bent posture and a tendency to fall forward
-speech becomes slurred, handwriting illegible