

## Ch. 11 Nervous System

Begins formation on 18<sup>th</sup> day of gestation (notochord)  
Controls & coordinates entire body from that point on  
Sensory input – integration - motor output

### I. Parts

- a. CNS – central nervous system
  - i. Brain
  - ii. Spinal cord
  - iii. Support = neuroglia = brain glue
- b. PNS (peripheral nervous system)
  - i. Autonomic (ANS) = automatic
    1. sympathetic
    2. parasympathetic
  - ii. Somatic = voluntary
  - iii. Support = schwann cells = myelin – insulate & protect



### c. Overall plan

- i. Sensory afferents = info in
- ii. Motor efferents = info out
- iii. Interneurons = connect the two
  1. especially in CNS
  2. 99% of all neurons

### II. Neural anatomy

- a. Nerve = bundle of neurons
  - i. Neuron – neurilemma (if myelinated) – endoneurium – perineurium (around fascicle) – epineurium (Fig. 13-2 pg. 461)
  - ii. Neuron picture & parts (pg. 367)
    1. dendrites, cell body, axon hillock, axon, axon terminal
  - iii. Nerve tissue properties
    1. conduct impulses
    2. extreme longevity
    3. high metabolic rate
    4. amitotic???

- III. Nerve transmission
  - a. Pg. 373 basic principles of electricity
  - b. Resting membrane potential (-70 mV inside:outside)
    - i. Na<sup>+</sup> outside, K<sup>+</sup> inside, neg proteins inside
    - ii. Na/K pump keeps potential by negating natural diffusion
    - iii. Depolarization = potential gets closer to zero
    - iv. Hyperpolarization = gets more negative (-90)
  - c. 2 signals produce change in membrane potential
    - i. graded potentials
      - 1. depolarize over short distances
        - a. dendrites to cell body
      - 2. magnitude varies with strength of stimulus
    - ii. action potential
      - 1. depolarize down axon (long distances)
      - 2. harder to achieve
      - 3. start at axon hillock – after add up graded potentials
      - 4. Na channels opened & flows in
        - a. K starts out = repolarization
        - b. Na/K pump restores
      - 5. Fig. Pg. 379
        - a. Threshold & all-or-none phenomena
        - b. Graded potentials summate
          - i. Temporal summation
          - ii. Spatial summation
        - c. ~15mV above resting potential – AP will form
        - d. All AP are the same & travel whole neuron
        - e. How tell if stimulus is strong or weak?
          - i. Frequency of stimulation
  - d. **Timing is everything in the nervous system**
  - e. Nerve velocities
    - i. 1 m/s to 150 m/s
    - ii. larger axon diameter = faster
    - iii. myelin sheath = faster
      - 1. *saltatory conduction* = signal leaps from node to node rather than depolarize whole neuron
  - f. Synaptic continuation of nerve signal
    - i. Neurotransmitters (table 14-3, pg 505) – exocytosis
      - 1. 3 ways they are removed to stop signal
        - a. enzymes
        - b. reuptake proteins on presynaptic nerve
        - c. diffusion
- IV. CNS (ch. 12)
  - a. Brain
    - i. General Anatomy
      - 1. Cerebral hemispheres
        - a. Corpus callosum connects
      - 2. gyrus/gyri = ridges
      - 3. sulcus/sulci = shallow grooves
        - a. central – separates frontal from parietal

4. fissures = deeper grooves
  - a. longitudinal = R & L hemispheres
  - b. transverse = occiput & cerebellum
5. Lobes
  - a. Frontal (1), parietal (2), temporal (2), occipital (1), cerebellum (1)
6. Brain stem
  - a. Midbrain, Pons, Medulla Oblongata
7. Cortex
  - a. Top part
  - b. Gray matter (non-myelinated interneurons)
  - c. Controls consciousness, perception, understanding, voluntary movements
  - d. 3 general sections
    - i. motor
    - ii. sensory
    - iii. association
  - e. contralateral (opposite) body sensation & motor
  - f. lateralization of function
    - i. both sides not equal jobs
    - ii. areas do overlap and work together
  - g. HTM – hierarchical temporal memory
- ii. Motor areas (pg. 412 fig. 12-10)
  1. Primary motor cortex
    - a. Precentral gyrus
      - i. Before central sulcus
        1. in frontal lobe
      - ii. controls skeletal muscle
      - iii. homunculus pg. 414
  2. premotor cortex
    - a. skilled activities (play instrument)
      - i. coordinate multiple muscles
    - b. injury
      - i. loss of programmed skill but muscle still works and you can use it
        1. could physically type but not as fast until you relearn
  3. Broca's area
    - a. Speech
    - b. Probably in both hemispheres but classically in left
  4. Frontal eye field
    - a. Voluntary eye movement (not sight!!)
- iii. Sensory areas
  1. Primary somatosensory cortex
    - a. Post-central gyrus (parietal lobe)
    - b. Sensation
    - c. Proprioception
      - i. Spatial discrimination

2. Somatosensory associational area
  - a. Posterior to primary sensory area
  - b. Recalls from memory what the touched item is.
    - i. Ex. Keys in pocket
  - c. Damage = would have to see the object every time to know what it is.
3. Visual area
  - a. Occipital lobe
  - b. Sense of vision/sight
4. Visual associational area
  - a. Surrounds visual area
  - b. Recalls from memory
  - c. Damage = see it and can't recall what it is
5. Auditory area
  - a. Temporal lobes
6. Olfactory cortex
  - a. Smell
  - b. Temporal lobe (fig 12-8b)
7. Gustatory cortex
  - a. Taste
  - b. Parietal lobe
- iv. Associational areas
  1. Prefrontal cortex
    - a. Personality, abstract thought, reasoning
      - i. Biggest difference between man & animals
    - b. Prefrontal lobotomy
      - i. 1930s-1950s
      - ii. lose judgment, personality changes
  2. General interpretation area
    - a. Crosses temporal, parietal & occipital
    - b. Gathers info from all associational areas and creates memories associated with sensation
    - c. Gives overall understanding/single thought to situation – i.e. **danger**
    - d. Injury = Imbecile = lose ability to interpret entire situation
- v. Pg. 396 – Closer Look, cocaine addiction
  1. Answer following questions
    - a. How can the “wisdom of the body” and the way it responds to neurotransmitter like chemicals be related to antibiotic use/overuse?
    - b. Why is cocaine addictive? (how does it work?)
    - c. What is crack?
    - d. Can you see any problems with treating someone with Manzindol?
    - e. How does an overdose of Heroin kill?
    - f. Can you experience constant pleasure (for years), physiologically and psychologically? Why or why not?

## vi. Hypothalamus

1. ANS control (homeostatic mechanisms)
  - a. HR, RR, BP, Pupils, digestion, etc...
  - b. Body temp regulation
    - i. Thermoreceptors
  - c. Food intake
    - i. Hunger & satiety
  - d. Water balance & thirst
    - i. Controls kidneys
  - e. Sleep/wake cycles
  - f. Endocrine system
    - i. Hormone release
2. Emotional response
  - a. Along with Limbic System (several parts of brain – picture pg. 429)
    - i. Fear, pleasure, rage, sex drive
    - ii. *Closer Look* pg. 511 – ***Learned Fear: How Scary Things get That Way***
      1. amygdala – links emotions to memories & situations (ex. Fear)
      2. prefrontal cortex – crucial for unlearning fear behaviors.
        - a. Interesting that ‘lower’ animals don’t have a large prefrontal cortex & always are skittish. (ex. Iguana)
      3. hypothalamus – stimulates cortisol release – preps body defenses (stimulates gluconeogenesis and enzyme making)
      4. Overall, fear increases cortisol, increases feeling of vulnerability and suppresses reasoning skills of prefrontal cortex - phobias
      5. People deal with fear various ways.
        - a. Anxiety disorder people may have brain problem causing excess cortisol secretion. (improper feedback mechanism)
3. Tie all functions of hypothalamus together and infants deprived of love may not sleep or eat & may die.

## vii. Thalamus

1. Gateway to cerebral cortex
  - a. Relay station that sorts information and sends to appropriate spot in cortex.
    - i. Like switchboard operator

- viii. Brain stem (pg. 422)
  - 1. Gives rise to most cranial nerves
  - 2. More basic life functions & responses
  - 3. Midbrain
    - a. Visual & auditory reflexes
      - i. Turn and look at something we see out of the corner of our eye
      - ii. Eyes and head coordinate to follow that object.
      - iii. “Startle reflex” – when hear sound
        - 1. test for baby’s hearing
    - b. Contains substantia nigra
      - i. Controls dopamine release
      - ii. Parkinson’s disease
  - 4. Pons
    - a. Relay station between cerebrum & cerebellum
  - 5. Medulla Oblongata
    - a. Blends into spinal cord
    - b. Area of most cross-over of motor neurons
      - i. ‘Decussation of pyramids’
    - c. Cardiovascular center
      - i. HR and BP
    - d. Respiratory center
- ix. Cerebellum
  - 1. Subconscious proprioception & coordination
    - a. read pg. 427 ‘Cerebellar Processing’
      - i. *Cerebrum* decides what it wants to do.
      - ii. Cerebellum figures out where body is in space & tells *cerebrum* which muscles to move to not hurt self and keep coordinated.
  - 2. Balance
    - a. Ears, eyes and cerebellum keep balance
      - i. Cerebellum = postural control so you don’t fall over.

**summary on pg. 428, table 12.1**

- x. Closer Look – “He-Brain” versus “She-Brain”
  - 1. Pg. 437 – Write down differences between male & female brains.
- b. Spinal cord
  - i. Anatomy (figure 12.29 pg. 442)
    - 1. Anterior horn – motor
      - a. Ventral root
    - 2. Posterior horn – sensory
      - a. Dorsal root & ganglion
    - 3. Spinal nerve
      - a. Ventral & dorsal root come together

4. White matter
  - a. Tracts
    - i. Carry common information
      1. touch or pain or temp.
  - b. Myelinated
    - i. Ant. & post. Horn – gray
      1. cell bodies & interneurons
5. Meninges – 3 layers of covering
  - a. Dura mater
    - i. Outermost
    - ii. ‘hard mother’
    - iii. strongest, leathery
  - b. Arachnoid mater
    - i. ‘spider’
    - ii. web-like extensions to pia mater
  - c. Pia mater
    - i. innermost
    - ii. ‘gentle mother’
    - iii. clings tightly to brain
  - d. Subarachnoid space – between pia & arachnoid
    - i. Area of CSF flow (cerebrospinal fluid)
      1. protects brain & spinal cord
      2. reduces brain weight by 99% so doesn’t crush itself
      3. removes waste products
      4. 150ml (½ cup) total – replaced every 3-4 hours.
      5. Hydrocephalus = drainage obstructed
        - a. Adult = pressure damage
        - b. Infant = head swells
        - c. Tx = shunt into neck veins
        - d. Fig. 12.25 pg. 433
  - e. Meningitis = inflammation of Meninges
    - i. Bacterial or viral
    - ii. Can spread into CNS
      1. encephalitis – infl. of brain
        - a. die due to pressure
    - iii. Spinal tap
    - iv. Myelomeningocele
      1. Pg. 450 picture
6. Spinal reflexes (pg. 487 & 489)
  - a. Stretch reflex
    - i. Stimulate muscle & inhibit antagonist
  - b. Crossed extensor reflex
    - i. Same on one side as stretch
    - ii. Opposite side, stimulate extensor and inhibit flexor
    - iii. Ex. someone pulls on your arm and you jerk one arm back and push away with the other.

## 7. Terminology

- a. Paraesthesia = sensory loss
- b. Paralysis = motor loss
  - i. Flaccid paralysis (LMNL)
  - ii. Spastic paralysis (UMNL)
- c. Paraplegia = 2 limbs affected
  - i. Spinal cord severed below T-1 and both legs
- d. Quadriplegia = 4 limbs affected
  - i. Cervical cord transection
- e. Hemiplegia = one side of body
  - i. Usually brain injury (precentral gyrus)

## c. Homeostatic Imbalances

### i. Cerebral Palsy

#### 1. Lack of O<sub>2</sub> to the brain

- a. Bad delivery, pregnant mother - smoking/alcohol
- b. UMNL – spastic paralysis, loss of voluntary motor control, vision, deafness, seizures, mental retardation ( ½ the cases)
  - i. Does not get worse with time but irreversible
- c. #1crippler of children – 6/1000 births.

### ii. Anencephaly

#### 1. ‘Without a brain’

- a. Cerebrum & brainstem don’t fully develop
- #### 2. Death occurs soon after birth
- a. Some have strangely survived

### iii. Spina bifida

#### 1. Incomplete formation of vertebral arches

- a. Usually lumbar spine
- #### 2. Occulta – less serious (hidden)
- a. Small dimple and tuft of hair (fawn’s beard)
- #### 3. Cystica – more serious

- a. Sac-like cyst protrudes from spine
  - i. Meningocele or myelomeningocele
- b. 90% of the time accompanied by hydrocephalus

## d. Developmental aspects

### i. Premature babies

#### 1. Hypothalamus is one of last areas to mature

- a. Must keep them warm with incubator

### ii. 5 days old & thalamus & primary somatosensory cortex are active but visual cortex is not.

#### 1. Respond to touch but not sight.

### iii. 11 weeks – more cortex and can reach for a rattle

### iv. 8 months – can think about what he/she sees

### v. Neuromuscular coordination & myelination continue throughout childhood.

### vi. Then neurons continue to die

- 1. Other neurons can make new synaptic connections and learning can continue
  - vii. Less than 5% over 65 have true senility
    - 1. Most senility is reversible (poor nutrition, drug effects etc...)
  - viii. Boxing & alcohol cause brain atrophy
- V. PNS (b/w spinal cord & body or brain (cranial nerves) & body)
  - a. Sensory
    - i. From body and viscera
  - b. Motor
    - i. Autonomic & Somatic Nervous System
      - 1. Automatically controlled via what part of brain?
        - a. hypothalamus
      - 2. Somatic Nervous System (soma = body)
        - a. Motor
          - i. Voluntary control
  - c. Dermatomes
    - i. Sensory innervation areas of body go to particular cord level
    - ii. Spine divided into cervical, thoracic, lumbar & sacral regions.
    - iii. Fig. 13-11 pg 483
      - 1. C2-C4 = neck
      - 2. C5-T1 = arm
      - 3. T2 = sternal notch
      - 4. T4 = nipple level
      - 5. T7 = xiphoid process
      - 6. T10 = umbilicus
      - 7. L1-S1 = legs
    - iv. Test with pinwheel
  - d. Cranial Nerves
    - i. 12 pair arising from brain or brain stem.
      - 1. Numbered via roman numerals (I – XII)
    - ii. Mostly control special senses.
    - iii. Names = olfactory, optic, oculomotor, trochlear, trigeminal, abducens, facial, vestibulocochlear, glossopharyngeal, vagus, accessory, hypoglossal.
      - 1. Numbers 3, 7, 9, & 10 are also part of parasympathetic nervous system (part of ANS)
    - iv. Cranial Nerve I – Olfactory
      - 1. Runs from nasal cavity through cribriform plate of ethmoid bone (pgs. 194&201) to olfactory bulb (after that it is part of brain & not cranial nerve).
        - a. Fig. 16-2 pg. 540
      - 2. Purely sensory (no motor)
      - 3. Test = smell various substances
      - 4. How it works
        - a. Smell must be dissolved in air.
        - b. Molecules diffuse through air and bind to receptors on roof of nasal cavity.

- i. Air must make a 90 degree turn to go to receptors
  - 1. Sniffing intensifies smell.
- ii. Very sensitive
  - 1. Only requires a few molecules.
  - 2. We can differentiate 10,000 different smells.
    - a. Likely have around 1,000 different receptors that are bound by particular molecules in different combinations.
  - 3. Polar bear can smell a seal under 3 ft of snow over 1/2 mile away.
    - a. There are 1,000s of receptors in his nose due to an internal curling and undulating that increases the surface area much like the folding gyri of our brains.
- iii. Some smell is actually pain
  - 1. Activates pain receptors – ammonia, chili peppers
  - 2. Travel a different pathway (via CN V, trigeminal)
- iv. Depolarize olfactory nerve
- v. Olfactory tract to brain
  - 1. Temporal & frontal lobe for interpretation.
  - 2. Hypothalamus, amygdala and limbic system.
    - a. ANS responses – salivate when smell food.
    - b. Emotional responses (smoke, skunk, memories)

## 5. Homeostatic imbalances

- a. Anosmias – trouble smelling (without smell)
  - i. Fracture ethmoid bone or damage fibers.
    - 1. Cold, smoking, drug use, polyps (block smell)
  - ii. Some people have smell hallucinations.
    - 1. Due to brain damage or after brain surgery.
    - 2. Some epileptics have them before seizures
    - 3. Odor usually unpleasant (rotting meat)
- iii. Zinc is an important mineral for smell.
  - 1. Growth factor for receptors.

v. Cranial Nerve II – Optic

1. Runs from the retina of the eye to the optic chiasma. Then info is carried via the optic tract to the optic radiations to the occipital lobe visual cortex.
2. Purely sensory
3. Test
  - a. Eye chart, visual field, ophthalmoscopic exam
    - i. Look at retina, blood vessels & papilledema.
    - ii. Pg. 549
4. How it works
  - a. Parts of the eye (pg. 546)
    - i. Cornea – clear covering over iris and pupil.
    - ii. Sclera – white of eye
    - iii. Conjunctiva – covering of sclera and inside of eyelid
      1. Produces mucus to lubricate eye
      2. Protects eye
        - a. Contacts sit in this area and don't wrap around eyeball to back of eye socket
      3. Conjunctivitis
        - a. Inflammation
        - b. Pinkeye – bacterial or viral
    - iv. Iris – colored part (smooth muscle to change pupil size)
      1. Color – contains only brown pigment
        - a. Depends on amount and depth of pigment
        - b. Babies – blue due to underdeveloped pigment
    - v. Pupil – hole in center of iris
      1. Dilates & constricts in response to light & emotions
    - vi. Lens – focuses light
      1. Ciliary muscles – control shape of lens for focus
    - vii. Retina
      1. Back of eye
      2. Contains rods and cones
        - a. Rods – black & white, more sensitive
        - b. Cones – color, more acuity
          - i. Red, green & blue cones
      3. Optic disc – spot where optic nerve enters.
        - a. No photoreceptors = blind spot
        - b. Brain fills in (pg. 549 test)

4. Macula lutea
  - a. Region of retina with highest concentration of cones = see most detail.
- viii. Aqueous humor & vitreous humor
  1. Aqueous – anterior chamber – drained and new produced.
  2. Vitreous – post. Chamber – have all of your life.
  3. Help focus light
- b. Seeing
  - i. If you were in a room and there was an apple on the table one foot in front of you and the lights were turned off so that NO light could enter the room. How long would it be before you could make out the shape of the apple on the table?
  - ii. Light reflects off an object and passes through the cornea, aqueous humor, pupil, lens, vitreous humor to retina.
  - iii. Activates rods and cones which depolarize optic nerve fibers.
  - iv. Info to optic chiasma, tract, radiations, occipital lobe (and midbrain & hypothalamus)
    1. Midbrain for tracking reflexes
    2. Hypothalamus for sleep/wake cycles via day/night lighting.
    3. Pg. 561
    4. Stereoscopic vs. panoramic vision
      - a. Stereoscopic
        - i. Visual fields overlap and crossover is incomplete. Both sides of the visual cortex see parts of the same image, brain puts it together and gives depth perception (3D)
      - b. Panoramic
        - i. Visual fields don't overlap & crossover is complete. See 2 totally different visual fields.
        - ii. Rabbits & lizards
        - iii. Squid can squish head around to do both.

- v. Visual association area tells you if you've seen it before.

## 5. Homeostatic Imbalances

- a. Blindness
  - i. Two things to account for – visual acuity and field
    - 1. Acuity – see detail
      - a. 20/20 – normal
      - b. 20/200 = blind
    - 2. Field – peripheral vision
      - a. Normal – 180 degrees
      - b. 20 degrees or less = blind
- b. Myopia – near sightedness
  - i. Lens focuses in front of the retina.
    - 1. Eyeball is too long (25% of Americans)
    - 2. Lens cannot flatten enough.
    - 3. Radial keratotomy – laser to flatten cornea to diverge light.
- c. Hyperopia – far sighted
  - i. Focus behind retina
    - 1. Eyeball is too short
- d. Astigmatism
  - i. Lens is unequally curved
  - ii. Requires special lenses
- e. Cataracts
  - i. Clouding of the lens
    - 1. Crystalline protein deposits
  - ii. Due to inadequate nutrient delivery to lens fibers
    - 1. Diabetes, smoking, UV radiation
- f. Glaucoma
  - i. Aqueous humor drainage blocked and increase pressure in eye
  - ii. Slowly lose vision by compressing retina and damaging optic nerve.
    - 1. Tunnel vision
  - iii. Check intraocular pressure by puff of air or actually touching cornea and measuring deformation/counter-pressure.
  - iv. Treat with eyedrops that increase drainage.
- g. Diplopia
  - i. Double vision
    - 1. See two visual fields
  - ii. Non coordinated eye muscles
    - 1. Weakness or paralysis
    - 2. Can be due to intoxication

- h. Detached retina
  - i. Retina is torn and vitreous humor seeps in and behind it.
  - ii. Due to trauma to head or sudden reversal of motion
    - 1. Bungee jumping, car accident
  - iii. S & S = curtain drawn across the eye or spots and light flashes
  - iv. Will cause blindness if not treated
  - v. Treat with laser or cryosurgery before photoreceptor damage becomes permanent
- i. Color blindness
  - i. Due to lack of one or more cone types
  - ii. Congenital – sex linked
    - 1. Who gets more often? Males
      - a. 8-10%
    - 2. Usually red-green
      - a. Can use other cues such as intensity differences to tell colors apart.
    - 3. [Ishihara tests](#)

#### 6. Optical Illusions

- a. Thought problem – how do we know that the color you see as red is the color I see as red?
- b. Blind spot pg. 549
- c. Relative brightness pg. 563
- d. Relative size
- e. Spinning disc
- f. Online illusions <http://www.grand-illusions.com>
  - i. Geometrical optical illusion
  - ii. Intriguing 'after image'
  - iii. Green & white checkerboard (relative brightness)
  - iv. Spots before your eyes
  - v. Pictographic ambiguity
  - vi. Find the missing people

#### vi. CN III – Oculomotor

##### 1. Function

- a. Part of autonomic nervous system
  - i. Controls pupil constriction via iris
    - 1. Test with penlight
- b. Extrinsic eye muscles
  - i. Levator palpebrae
    - 1. raises upper eyelid
    - 2. Ptosis – drooping if problem
  - ii. Medial rectus, superior rectus, inferior rectus & inferior oblique
    - 1. Works with CN IV & VI
    - 2. Picture – pg. 545

- vii. CN IV – Trochlear
  - 1. Function
    - a. Controls superior oblique muscle
      - i. Runs through ‘trochlea’
      - ii. Moves back of eye up and in so front goes down and out
- viii. CN VI – Abducens
  - 1. Function
    - a. Controls lateral rectus
      - i. ‘Abducts’ eye laterally
  - 2. Testing all 3 cranial nerves
    - a. Follow pen or finger in figure H
  - 3. Problems
    - a. Strabismus
      - i. Internal or external depending on weak eye muscle
        - 1. Ex. cross-eyed
      - ii. Slight cases can be given exercises
      - iii. Severe problems the brain may disregard the non-controllable eye and person becomes functionally blind
    - b. Diplopia
      - i. Double vision
- ix. CN V – Trigeminal (pg. 470)
  - 1. Runs from pons, near TMJ, and branches into three divisions – ophthalmic, maxillary and mandibular.
  - 2. Function
    - a. Sensory impulses of touch, temperature & pain of face, nasal mucosa, cornea, teeth (Novocain), lips and tongue (**not** taste buds)
    - b. Motor control of muscles of mastication
      - i. Masseter, temporalis, medial pterygoid, lateral pterygoid
  - 3. Testing
    - a. Brush face, sharp/dull, corneal reflex (along with CN VII), hot/cold, clench teeth/move jaw.
  - 4. Homeostatic imbalance
    - a. Tic douloureux (trigeminal neuralgia)
      - i. Inflammation of trigeminal nerve
      - ii. **Extraordinarily** painful – stabbing pain for seconds to minutes many times a day.
        - 1. Tic refers to wincing in pain
        - 2. People have committed suicide
      - iii. Provoked by brushing against face
        - 1. Brushing teeth or even a breeze
      - iv. Can cut nerve but also lose sensation
- x. CN VII – Facial
  - 1. Runs from pons, through inner ear and to lateral aspect of the face where it branches out.

2. Functions
  - a. Controls skeletal muscles of the face
    - i. Except chewing muscles = CN V
  - b. Controls tears and salivation
  - c. Taste buds of anterior 2/3 of tongue
    - i. Sweet, salty & sour.
    - ii. Not bumps on tongue = papillae – buds are down in the crevices of the papillae
    - iii. Read pgs. 537-539
3. Testing
  - a. Drop substances on tongue for various tastes. (sugar, salt, vinegar)
  - b. Check symmetry of face.
    - i. Have perform various activities – smile, frown, whistle, raise eyebrows, close eyes tightly etc...
4. Homeostatic imbalance
  - a. Bell's Palsy
    - i. Paralysis of facial muscles and taste on one side.
      1. Eyelid droops, corner of mouth droops, eye tears, eye won't close.
    - ii. Often rapid development
    - iii. Not sure of cause but may be Herpes simplex I inflaming nerve.
    - iv. No real treatment but may disappear spontaneously.
- xi. CN IX – Glossopharyngeal
  1. Functions
    - a. Sensory
      - i. Taste – bitter – back of tongue
      - ii. Sensation in pharynx
    - b. Motor
      - i. Part of pharynx – swallowing
      - ii. Salivary gland
  2. Testing
    - a. Uvula position
    - b. Swallow
    - c. Gag reflex
    - d. Taste
- xii. CN X – Vagus
  1. Only cranial nerve to go beyond head and neck
  2. Parasympathetic fibers to organs
    - a. HR, digestion, breathing etc...
  3. Testing
    - a. Same as CN IX
  4. Problems can lead to hoarseness, difficulty swallowing &/or death due to organ control.

- xiii. CN XI - Accessory
  - 1. Cranial root & spinal root (C1-C5) – so neck problems can interfere with this nerve.
  - 2. Function – trapezius and sternocleidomastoid muscles
    - a. Shrug shoulders & turn head
  - 3. Test – same as function
  - 4. Problem – face turns toward side of injury due to SCM
- xiv. CN XII - Hypoglossal
  - 1. Tongue muscles & movement
    - a. Chewing, swallowing, talking
  - 2. Test – protrude & retract tongue
  - 3. Problem – tongue deviates toward affected side
- xv. CN VIII – Vestibulocochlear
  - 1. Purely sensory
    - a. Equilibrium & sound
  - 2. Parts of the ear (superficial to deep) (pg. 564)
    - a. Outer ear
      - i. Auricle (pinna), lobe, external auditory canal
    - b. Middle ear
      - i. Tympanic membrane (ear drum), malleus, incus & stapes (ossicles), oval window, pharyngotympanic auditory tube
        - 1. Tube equalizes pressure when yawn or swallow.
        - 2. Also drains fluid into throat.
    - c. Inner ear
      - i. Semicircular canals, cochlea
  - 3. How it works
    - a. Hearing
      - i. Sound wave caught by outer ear and funneled to auditory canal.
      - ii. Vibrates tympanic membrane which puts ossicles in motion.
      - iii. Malleus – incus – stapes – oval window
        - 1. Why transmit to a second window?
          - a. Increases power of signal 20x.
      - iv. Push fluid in cochlea
        - 1. Moves hair cells which depolarize and send signal down cochlear part of CN VIII.
        - 2. Closer to oval window = high pitch; deeper = low pitch
          - a. Different animals can detect higher pitches
          - b. Much lower than us = hear molecules crashing together.
      - v. Protection against loud sounds - Tensor tympani and stapedius muscles tighten to stop vibration of eardrum and ossicles respectively (pg. 565)

- vi. We are better at localizing higher tones than base tones = why subwoofer can be anywhere
  - vii. Spontaneous otoacoustic emissions
    - 1. Your own ear makes noise (like buzz)
      - a. Some so loud that others can hear it standing next to you.
    - 2. Occurs in some people & don't know why not in all. (also in Chinchillas – noise is around 4000Hz so brain starts to ignore all sounds at that frequency and causes a deafness in that range)
  - viii. Test
    - 1. Use tuning fork
    - 2. Test bone conduction & air conduction.
- b. Equilibrium
- i. Semicircular canals oriented in 3 directions. (pg. 566)
  - ii. Fluid in canals moves hair cells.
    - 1. 3 hair cells and kinocilium.
      - a. Move toward = depolarize; away = hyperpolarize
  - iii. Info from 3 canals interpreted by brain.
    - 1. Travels directly to brainstem for quick action.
    - 2. Goes to cerebellum for fine tuning control.
  - iv. Page 577 – 3 things that input balance and orientation
    - 1. eye, ear, proprioceptors (muscles, skin)
    - 2. Info interpreted by cerebellum & vestibular nuclear complex in the medulla.
    - 3. Sends info for motor corrections via CNs to eyes and neck muscles.
  - v. Motion sickness – info from eyes & ears disagree
    - 1. Drugs reduce vestibular input.
4. Homeostatic imbalances
- a. Otitis media
    - i. Inflammation of the middle ear.
    - ii. Most often **not** caused by bacteria but by fluid build up.
      - 1. Young children – auditory tube is horizontal so doesn't drain well.
      - 2. Blockage due to upper neck problem/swelling can give earache.
        - a. What happens to young children that could cause neck problems?
          - i. Childbirth to falling etc...
        - b. Also can be food allergy – Milk is a common one.

### iii. Treatment

1. Antibiotic treatment is often not the best idea
  - a. Those tx with antibiotics are many times more likely to have recurring infections.
2. Myringotomy
  - a. Cut eardrum and put tube in ear to drain fluid.
  - b. Falls out in ~ 1year.
  - c. Associated with increased scarring and hearing loss
3. Upper cervical adjustments & removal of milk is often best route.

### b. Deafness

#### i. Conduction

1. Interfere with conduction of sound to inner ear.
  - a. Ear wax, marble in ear, perforated eardrum, otosclerosis (fused ossicles)

#### ii. Sensorineural

1. Damage to inner ear hair cells or CN VIII
2. Single loud noise or prolonged exposure.
  - a. Tears or stiffens hair cells.
3. Can have cochlear implant but not as sensitive – like robotic voice.

### c. Tinnitus

- i. Ringing in ears.
- ii. Inflammation of middle or inner ears & side effect of some medications (aspirin)

### d. Meniere's syndrome

- i. Semicircular canal and cochlea are messed up.
- ii. Howling tinnitus & can't stand up.
  1. Dizzy, nausea

### e. Nystagmus

- i. Flipping of eyes back and forth.
- ii. Normal right after you get spun around.