Cranial Nerves and Special Senses
All 12 Pairs
Introduction

- I = Olfactory
  - Test with tobacco, coffee, cloves, peppermint, cinnamon

- II = Optic
  - Test with appropriate tests for vision
• III = Oculomotor

• With complete paralysis, eyes deviate inferiorly oblique to the lateral

• IV = Trochlear

• Eye deviates superiorly when paralyzed
• V = Trigeminal
  • Motor:
  • bilateral paralysis, mouth will not close tightly
  • Unilateral paralysis: mandible deviates TOWARDS the weak side when the mouth is open
  • Sensory: test touch, pain, temp

• VI = Abducens
  • Paralysis: eye[s] may converge – no lateral movement
• VII = Facial

• Motor paralysis: flaccidity = Bell’s Palsy; unable to whistle or puff out cheeks

• Sensory paralysis: test taste (anterior $^{2/3}$)
VIII = Acoustic or Auditory or Vestibulocochlear -- Cochlear Portion:
Tests for Hearing

- Weber’s Test: vibrating tuning fork in skull mid-line
- Lateralization of sound to one side means bone conduction loss on that side
- Rinne’s Test: vibrating tuning fork on mastoid process. After sound not heard, place fork by ear and listen. Tones here are normally heard 2X as long as on the mastoid – test for air conduction.
Application: Hearing

• Rinne’s test: place a vibrating tuning fork on the mastoid process and time it until the person doesn’t hear it there; place in front of ear and time until person doesn’t hear any more.
• Normal: person hears it twice as long in front of the ear as on the mastoid process.
VIII = Acoustic or Auditory or Vestibulocochlear – Vestibular Portion

- Balance tests – spin on stool
IX and X – Glossopharyngeal and Vagus

• Tested together

• Open mouth and say “Ahhhhhhhh”
  – If uvula doesn’t elevate, bilateral paralysis
  – Unilateral elevation: uvula deviates to strong side (away from side of lesion)

• Gag reflex – present or absent
• XI = Spinal Accessory
• Raise shoulders against resistance – check for tense trapezius
• Turn head back to midline against resistance – check for tense SCM

• XII = Hypoglossal
• Stick out tongue – if paralyzed, tongue deviates to weak side
• Test lingual speech: “round the rugged rock the ragged rascal ran”
<table>
<thead>
<tr>
<th>Cranial Nerve</th>
<th>Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olfactory</td>
<td>On</td>
</tr>
<tr>
<td>Optic</td>
<td>Old</td>
</tr>
<tr>
<td>Oculomotor</td>
<td>Olympus'</td>
</tr>
<tr>
<td>Trochlear</td>
<td>Tiny</td>
</tr>
<tr>
<td>Trigeminal</td>
<td>Tops</td>
</tr>
<tr>
<td>Abducens</td>
<td>A</td>
</tr>
<tr>
<td>Facial</td>
<td>Finn</td>
</tr>
<tr>
<td>Acoustic</td>
<td>And</td>
</tr>
<tr>
<td>Glossopharyngeal</td>
<td>German</td>
</tr>
<tr>
<td>Vagus</td>
<td>Viewed</td>
</tr>
<tr>
<td>Spinal Accessory</td>
<td>Some</td>
</tr>
<tr>
<td>Hypoglossal</td>
<td>Hops</td>
</tr>
</tbody>
</table>
Sensory Nuclei

- 1-Aqueduct of Sylvius
- 2-Pons
- 3-V
- 4-VII
- 5-VIII
- 6-IX
- 7-X
- 8-Spinal nucleus of V
- 9-Primary Sensory nucleus of V
- 10-Mesencephalic Nucleus of V
- 11-Vestibular nucleus
- 12-Cochlear nucleus
- 13-Nucleus of Tractus solitarius
- 14-Commissural Nucleus
- 15-Foramen of Magendie
- 16-4th ventricle
- 17-Central canal
- 18-Medulla
Motor over Sensory Nuclei
<table>
<thead>
<tr>
<th>Cranial Nerve Description</th>
<th>Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Olfactory</td>
<td>Sensory</td>
</tr>
<tr>
<td>II: Optic</td>
<td>Sensory</td>
</tr>
<tr>
<td>III: Oculomotor</td>
<td>Motor</td>
</tr>
<tr>
<td>IV: Trochlear</td>
<td>Motor</td>
</tr>
<tr>
<td>V: Trigeminal</td>
<td>Both</td>
</tr>
<tr>
<td>VI: Abducens</td>
<td>Motor</td>
</tr>
<tr>
<td>VII: Facial</td>
<td>Both</td>
</tr>
<tr>
<td>VIII: Acoustic</td>
<td>Sensory</td>
</tr>
<tr>
<td>IX: Glossopharyngeal</td>
<td>Both</td>
</tr>
<tr>
<td>X: Vagus</td>
<td>Both</td>
</tr>
<tr>
<td>XI: Spinal Accessory</td>
<td>Both</td>
</tr>
<tr>
<td>XII: Hypoglossal</td>
<td>Motor</td>
</tr>
</tbody>
</table>
Olfactory Nerve: I – Sensory: Smell

- Exits skull via cribriform plate
- Terminates in temporal lobe
- ~20 fibers spread over the nose:
  - inner group of fibers over the upper third of septum
  - outer group of fibers over superior turbinate and surface of ethmoid
- Anomaly: Loss of smell with secondary loss of taste
Optic Nerve: II – Sensory: Sight

- Exits skull via optic foramen; terminates in occipital lobe
- Optic tract exits brain in 2 bands
- Optic tract crosses at optic chiasm with 2 sets of fiber
- Anomaly = blindness – complete or incomplete
II, Cont’d
Optic tract exits brain in 2 bands

- **External Band**
  - Partly continuous with superior colliculi
  - Coordinates movement of eyeball and head, regulates focusing, adjusts size of pupils

- **Internal Band**
  - Partly continuous with inferior colliculus
  - Coordinates movement of head and trunk due to audio stimulus
II – Cont’d

• 2 sets of fibers cross at chiasm
  – Crossed in greatest numbers
  – Left crosses right and right crosses left

• Uncrossed
  – Left stays left and right stays right

• Right tract supplies right half of EACH eye; left tract supplies left half of EACH eye
• Flip it upside down
• Rotate it horizontally 180°
• Split it vertically
Nerve Anomaly #1

- Tract lesion
- Have half central vision
- Leaves left peripheral vision
Nerve Anomaly #2

- Chiasm Lesion
- Left all central vision
- No peripheral vision
External Eye -- Anterior

1. Sclera
2. Iris
3. Lacrimal ducts
4. Lacrimal gland
5. Eye lid
6. Outer canthus
7. Pupil
8. Nasolacrimal duct
9. Inferior meatus in nose
10. Lacrimal canals
11. Lacrimal sac
12. Inner canthus
13. Lacrimal puncta
External Eye -- Lateral

1. Orbicularis oculi
2. Iris
3. Eyelashes
4. Palpebral fissure
5. Cornea
6. Palpebral conjunctiva
7. Pupil
8. Ocular conjunctiva
Internal Eye -- Anterior

1. Anterior chamber
2. Posterior chamber angle
3. Lens
4. Angle closure (closed angle glaucoma = tunnel vision)
8. Anterior chamber angle

- Anterior cavity filled with aqueous humor
- Anterior cavity = 1 & 2
- Suspensory ligaments attached to ciliary muscles/body
- Canal of Schlemm at #8 filters/drains to veins

- Sclera
- Cornea
- Choroid
- Iris
Interior Eye -- Posterior

5. Posterior cavity (filled with vitreous humor)
6. Optic disk (blind spot)
7. Fovea centralis (sharpest vision)

Retina
Choroid
Sclera
Vision – Normal: image projected **onto** the fovea

- Myopia = near sighted
- Hypermetropia = far sighted
- Presbyopia = “old age” trombone syndrome
Astigmatism

- Irregularly shaped cornea
- Irregularly shaped lens
Accommodation

- For distances $d < 6\,\text{m}$, the lens thickens and the ciliary bodies relax.
- For distances $d \geq 6\,\text{m}$, the lens thins out and the ciliary bodies tense.
The very top image represents a view of the retina from a person with glaucoma. This vision loss pathology causes people to develop tunnel vision.
The very top image represents a view of the retina from a person with diabetic retinopathy. This vision loss pathology causes people to have a “shot-gun patterned view” of the world.
The very top image represents a view of the retina from a person with macular degeneration. This vision loss pathology causes people to lose their central vision.
Oculomotor Nerve: III – Motor: Movement of Eye

- Exits skull via superior orbital fissure
- The deep origin is beneath the floor of the Aqueduct of Sylvius (connects 3\textsuperscript{d} and 4\textsuperscript{th} ventricles)
- The nerve bifurcates
  - Superior bifurcation innervates the levator palpebrae and superior rectus
  - Inferior bifurcation innervates medial rectus, rectus inferior, inferior oblique; ciliary muscle and iris sphincter
Terms

- **Levator palpebrae**: raises upper eyelid

- **Ciliary muscle and Iris sphincter**: permits accommodation (adjusting the eye to the vision of near objects via ciliary muscle) and allows the anterior surface of the lens to become more convex with slight pupillary contraction (iris sphincter)

- **Anomalies**

  - **Ptosis**: paralysis of levator palpebrae
  
  - **External strabismus due to no innervation of external rectus by III**
  
  - **Pupillary dilation due to sphincter (iris) paralysis**
  
  - **Loss of accommodation**
III, Cont’d

- Motor functions: accommodation, raise the upper eyelid, pupil dilation/constriction, eyeball movement in all directions EXCEPT inferiorly laterally and laterally.
III, Cont’d – Wiring Diagram

1. To levator palpebrae
2. To superior rectus
3. To rectus medialis
4. Rectus inferioris
5. Inferior oblique
6. To ciliary muscle and iris
7. Lenticular ganglion
Trochlear Nerve: IV – Motor: Inferolateral Movement of Eyeball

- Exits skull via sphenoidal fissure
- Apparent origin behind corpora quadrigemina
- Deep origin in floor of Aqueduct of Sylvius beneath 3\textsuperscript{rd} nerve (\& continuous with)
- Supplies/enters orbital surface of superior oblique
  - Trochlea = pulley
- Smallest of the cranial nerves
- Anomaly: unable to turn eye down and out due to superior oblique paralysis and leads to diplopia
Abducens Nerve: VI – Motor: Lateral Eye Motion

- Exits skull via superior orbital fissure
- Superficial origin close to pons;
- Deep origin upper part of the floor of the 4th ventricle
  - Passes into the 3rd nerve
- Supplies external rectus (rectus lateralis)

- Anomalies: this nerve has the highest frequency of involvement in basilar fractures than any other cranial nerve; result is convergent squint; also leads to secondary pupillary contraction because of other fibers passing with VI: [III](#)
Extraocular Muscles
Extraocular Muscles: Origins
Cardinal Eye Movements

1. Inferior oblique (III)
2. Rectus lateralis (VI)
3. Superior oblique (IV)
4. Rectus inferioris (III)
5. Medial rectus (III)
6. Rectus superioris (III)
Trigeminal Nerve: V – Motor and Sensory

- Superficial origin in the anterolateral pons
- Deep origin of sensory long tract in medulla
- Deep origin of motor upper part of floor of 4th ventricle and side of aqueduct of Sylvius

- Three branches (hence “tri”):
  - Ophthalmic – pure sensory
  - Maxillary – pure sensory
  - Mandibular – sensory and motor
• **Ophthalmic Branch**
  • Exits via sphenoidal fissure
  • Supplies eyeball, lacrimal gland, conjunctiva, nasal mucosa and skin of eyebrow, forehead and nose
  • Smallest of the 3 subdivisions

• **Maxillary Branch**
  • Exits via foramen rotundum
  • Enters orbit and traverses suborbital canal exiting at infraorbital foramen
  • Supplies temple, side of forehead, malar cheek skin, maxillary teeth (individual branches to each tooth), skin and conjunctiva of lower eyelid with sensation, skin of side of nose, upper lip and mucous membrane of mouth
• Mandibular Branch
  • Exits via foramen ovale
  • Has two roots: large (sensory) and small (motor)
  • Supplies teeth and gums of mandible, skin of temple and external ear, lower face and lower lip, muscles of mastication, submandibular and sublingual salivary glands and tongue (anterior $\frac{2}{3}$)
Trigeminal Nerve: V
Wiring Diagram: V

1. To forehead/scalp
2. To lacrimal gland
3. To nose tip/septum and ciliary body and iris
4. To temple/cheek
5. To chin/lower lip
6. Mylo-hyoid and anterior digastricus
7. Anterior dental
8. Mid-dental
9. Posterior dental
10. To masseter
11. To external pterygoid
12. Buccinator
13. To internal pterygoid
14. Inferior dental
15. Labial
V: Anomalies

• **Sensory**
  • Anesthesia to half of face (except over parotid)
  • Destructive inflammation of cornea
  • Dry nose, decreased secretion of lacrimal/salivary glands

• **Motor**
  • Paralysis of muscles of mastication
Facial Nerve: VII – Motor and Sensory

• Motor nerve of all muscles of expression in the face
• Nerve of taste for anterior $\frac{2}{3}$ of tongue
  • Vasodilator nerve for submandibular and sublingual glands
• Supplies muscles of facial expression, platysma and buccinator, external ear, posterior belly of digastricus and stylohyoid, anterior $\frac{2}{3}$ of tongue, “sub” salivary glands
• Exits skull via internal auditory meatus through petrous portion of temporal bone to stylo-mastoid foramen
• Superficial origin is upper end of medulla
• Deep origin lower part of pons anterolateral to VI
VII, Cont’d – Anomalies -- More frequently paralyzed than any of the other cranial nerves

- **Paralysis depends on**
  - **Central causes** (clot, tumor which increases pressure on nerve before it enters internal auditory meatus)
  - **In the petrous bone** due to middle ear disease or fracture (loss of taste – patient unable to differentiate between bitters and sweets, acids and salines – mouth dry because of no salivary flow)
  - **At or after exit** from the stylomastoid foramen (after exit from stylomastoid foramen all muscles of expression are paralyzed = smooth forehead; patient unable to frown, ptosis, tears run down cheek constantly; nostril can not be dilated; mouth is drawn to the healthy side; effected corner of mouth sags; unable to whistle; partial loss of taste; called Bell’s palsy – may be idiopathic; may clear up spontaneously)
VII

Temporal
Zygomatic
Buccal
Mandibular
Cervical
Acoustic, Auditory or Vestibulocochlear Nerve: VIII -- Sensory

• For hearing and balance
• This nerve for balance and hearing
• Has a few fibers from the inferior colliculi
• Exclusive to the inner ear – has 2 roots
  – Vestibular – enters medulla from semi-circular canals
  – Cochlear – external to vestibular root at medulla

• Anomalies:
  – If torn due to fx, deafness PERMANENT
  – If bruised or pressed on by blood, deafness temporary
  – Loud explosions cause deafness due to compression (“soft” nerve)
Ultrasound

- Wavelengths greater than 20,000 Hz are called ultrasound.
- These sounds can not be heard by humans.
- Cool mist nebulizers are to be used with caution around newborns – “crush” VIII
- Application: Pulmosonic
The Ear

diagram showing various parts of the ear including the helix, fossa of helix, auricle, anti-helix, concha, anti-tragus, malleus, stapes, semi-circular canals, vestibular branch, cochlear branch, round window, oval window, External auditory meatus, tympanic membrane, and Eustachian tube.
Middle Ear Structures
Middle Ear Muscles

- **Tensor tympani**
  - Insertion: medial malleus
  - Origin: cartilaginous wall of auditory tube
  - Action: malleus pulled inward
  - Paralysis: leads to difficulty hearing because the TM gets “floppy”

- **Stapedius**
  - Insertion: posterior stapes
  - Origin: inner wall of tympanic cavity (~2 mL, BTW)
  - Action: stapes pulled outward
  - Paralysis: results in hyperacusia – abnormally sensitive hearing
Tympanic Reflex

- Protective mechanism that reduces pressure from loud sounds – these loud sounds would damage hearing receptors otherwise

- Works with contraction of both T. tympani and stapedius and leads to a rigid bridge of auditory ossicles which results in a $2^\circ$ loss of effectiveness of vibratory transmission, aka “damping”

- Elicited in about 0.1 seconds following a loud external sound

- Rapid noises such as a gunshot are too fast

- Slow noise like the roar of thunder elicit this reflex

- Also elicited by people singing or speaking

- Muffles the lower frequencies of these sounds and improves the hearing of the higher frequency sound (common in human voices)
Inner Ear Structures – Light Physiology

- Oval window
- Round window

Cochlea

Region of greatest sensitivity

2.0 TM
Sound Waves

- A wavelength is the distance from the top or bottom of one wave to the top or bottom of the next
- Amplitude is the height of a wave’s crest above the average level (black line)
  - Frequency equals the number of wavelengths/time

\[
\frac{1}{\text{sec}} = 1 \text{ Hz} = 1 \text{ cps}
\]
Sound

- In order to transmit sound waves through air, it must be condensed and rarified:
  - **Condensed** = compresses air in front of sound wave (pushes ear drum in)
  - **Rarified** = thins the air behind the sound wave ("pulls" ear drum out); vacuum or decompression
Terms: Sound

- **Pitch** = frequency
- The higher the pitch the higher the frequency
- The lower the pitch, the lower the frequency

- **Highest** pitch on the right of a piano and is about 8300 Hz
- **Lowest** pitch on the left of a piano and is about 28 Hz
Different Perspective on Closed Tube
Sounds – Physiological Effects

- HR & BP
- Cholesterol
- Vasoconstriction (cold hands)
- Ulcers
- Epi & NE
# Decibel Scale

A scale based on multiples of 10

<table>
<thead>
<tr>
<th>Source</th>
<th>Intensity (dB)</th>
<th># times &gt; TOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOH</td>
<td>0</td>
<td>$10^0$</td>
</tr>
<tr>
<td>Whisper</td>
<td>20</td>
<td>$10^2$</td>
</tr>
<tr>
<td>Normal Talking</td>
<td>60</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Vacuum Cleaner</td>
<td>80</td>
<td>$10^8$</td>
</tr>
<tr>
<td>Walkman max’d out</td>
<td>100</td>
<td>$10^{10}$</td>
</tr>
<tr>
<td>Pain threshold</td>
<td>130</td>
<td>$10^{13}$</td>
</tr>
<tr>
<td>F-14 taking off</td>
<td>140</td>
<td>$10^{14}$</td>
</tr>
<tr>
<td>Instantly perforate TM</td>
<td>160</td>
<td>$10^{16}$</td>
</tr>
</tbody>
</table>
Decibels, again

• If one sound is $10^x$ times more intense than another sound, then it has a sound level $10 \cdot x$ more decibels than the less intense sound.
The Ear -- Hearing

1 - EAM
2 - sound wave
3 - ear drum
4 - hammer
5 - anvil
6 - stirrup
7 - scala vestibuli
8 - cochlea
9 - vestibular membrane
10 - cochlear duct (endolymph)
11 - tectorial membrane
12 - continuing around
13 - scala tympani
14 - spiral organ (hair cells)
15 - basilar membrane
16 - round window bulges

* perilymph
Time to Hearing Loss
Audiograms
Tympanometry: Impedance Audiometry

- TM compliance is inversely proportional to the impedance
- **Compliance** = property to alter size and shape due to an applying force, wt or release from an applied force; in electricity = conductance

- **Impedance** = acoustically: resistance to sound wave transmission; in electricity = resistance to electron flow
- **Compliance** is measured as mL or cc change
How Audiometry “works” -- sorta

- Give a 220 Hz tone from a probe towards the TM and vary the pressure from -400 mm H₂O to +400 mm H₂O and record the reflected energy.
- Is very reliable with the young due to being easy, non-invasive, automatic, painless.
- With bulging TM due to effusion, conduction mechanism stiff and reflects sound.
- Sound absorbed in case of disconnected mid-ear bones.

Diagram:
- Ear plug 3 tubes
- Air tight seal
- Speaker aimed @ TM
- Microphone to detect reflected sound
Type A Tympanogram

- Normal
- Good Eustachian tube function
- Absence of effusion
Type B Tympanogram

- Middle ear effusion
- Non-mobile TM
- Hard-packed cerumen
- Perforated TM
- Patent tubes
Type C Tympanogram

- Primarily associated with retracted TM with or without effusion
- Eustachian tube obstruction
- 1 in 5 present with effusion
- Goes with bronchitis, too – even recovery phase
Semi-Circular Canals

Diagram showing the semi-circular canals, posterior, lateral, oval window, round window, cochlea, and other related structures. The diagram is annotated with terms such as utricle, saccule, maculae, and cochlear duct.
Static Equilibrium: Macular

• Maintains balance and posture
• Relaxes/contracts skeletal muscles when head and body are motionless
• Stabilizer
Dynamic Equilibrium: Ampullar

- Maintains balance when
- Head is suddenly moved or rotated, or
- Body is suddenly moved or rotated
Glossopharyngeal Nerve: IX – Motor and Sensory

• Exits skull via jugular foramen
• Superficial origin is upper part of the medulla
• Deep origin is lower floor of 4th ventricle and lower part of medulla

• Nerve is distributed to posterior 1/3 of tongue (taste for here)
• Nerve of sensation to mucous membranes of pharynx, fauces and tonsils and uvula
• Sensory to pressure receptors in carotid artery
IX, Cont’d -- Anomalies

• Injury and/or inflammation causes impairment of swallowing and taste – specifically of sour and bitter (primarily the latter)
IX, Cont’d
IX, Cont’d
Vagus (Pneumogastric) Nerve: X – Motor and Sensory

- Pneumogastric and cardiac innervation
- Exits skull at jugular foramen accompanying IX
- Superficial origin below IX
- Deep origin lower part of floor of 4th ventricle
- 11 branches to the body
- Motor and sensory to organs of voice and respiration
- Motor to pharynx, esophagus, stomach and heart

- Anomalies
- Sensory
  - Superior laryngeal trunk pressed upon (goiter or aneurism) causes a particularly dry, brassy cough; when paralyzed, patient has a deep, hoarse voice
- Motor
  - When inferior laryngeal trunk paralyzed, the voice is altered and weak due to same side paralysis and strong side vocal cord compensation crossing over the mid-line of the glottis
X, Cont’d
Spinal Accessory Nerve: XI – Motor and Sensory

• Accessory to X;
  • SCM and trapezius innervation, as well
• Enters the skull via foramen magnum then exits the skull via the jugular foramen

• Two Parts:
  1. Accessory to Vagus
    • Superficial origin side of medulla below vagus roots
    • Deep origin traced to back of medulla
    • Distributed to pharyngeal and superior laryngeal branches of X
  2. Spinal
    • Superficial origin lateral tract of cord as far down as C6
    • Deep origin is gray matter of cord
    • Pierces SCM and deep surface of trapezius
XI, Cont’d -- Anomalies

Motor

- Hyperactive XI causes spasmodic torticollis (wry neck)
- To treat torticollis requires excision or division of a portion to correct
XI, Cont’d
Hypoglossal Nerve: XII – Motor Nerve of Tongue

- Exits skull via anterior condyloid canal (hypoglossal canal)
- Superficial origin 10-15 filaments off of medulla
- Deep origin is a nucleus of grey matter on floor of 4\textsuperscript{th} ventricle
- Passes into tongue all the way to the tip

- Anomalies
  - When paralyzed unilaterally, tongue is twisted to weak side
XII, Cont’d