Today
The Auditory system
The _______________________________ system
The chemical systems

Properties of sounds
Sounds are waves
_________________________________: loudness
_________________________________: pitch

The ear
Outer ear
Pinna

_______________________________

Anatomy of the ear
Middle ear
_________________________________: Ear drum
Oscicles
Malleus (Hammer)
Incus (_________________________________)
Stapes (Stirrup)

_______________________________

Anatomy of the ear
Inner ear
Cochlea

_______________________________
Hair cells

The basilar membrane
Hair cells translate _______________________________ from the sound waves into

Higher pitches are processed closer to the _______________________________
Lower pitches are processed closer to the _______________________________
Tonotopic organization

Transduction
The hair cells move
Opens _______________________________
Leads to the perception of a signal
Different hair cells move depending on the frequency of the incoming sound
**Hair cells**

Hair cells

Noise, infections, genetic diseases, aging

________________________________________ frequencies are harder to hear as you age

______________________________

Can occur in birds and some invertebrates

Generally ___________________________ occur in humans

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**The Pathway to the brain**

The auditory nerve

______________________________

Superior olivary nucleus

The ____________________________

Thalamus (medial geniculate nucleus)

______________________________

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**In the superior olivary nucleus**

Information from the ears is first ____________________________ here

May have some role in localization of sounds

________________________ organized

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**Organization of the MGN**

Similar to the ____________________________ for vision

Different layers have different inputs

________________________ become more specific

Tonotopically organized

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**Organization of A1**

Tonotopically organized

Just like the cochlea, superior olivary nucleus, and MGN, different tones are processed in

______________________________

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**After A1**

Like vision: A2, A3, A4…

Two pathways

________________________________________ “where” pathway

________________________________________ “what” pathway

Researchers try and relate auditory systems to

________________________________________

Some similarities have been found, but nothing is certain

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**Is the auditory system contralaterally organized?**

Somewhat

________________________________________ information into each auditory cortex is from the ____________________________ ear and ____________________________ is from the ipsilateral ear

Why the combining of the incoming information from the two ears?
Spatial cues
We need information from both ears to locate a sound is in space
Two main cues
  Interaural difference (IID or ILD)
  Interaural difference (ITD)
Also our provides information about how vertical a sound is

Interaural Intensity Differences
The ear that is closer to the sound hears a than the ear that is farther from the sound
The difference in here is a difference in intensity
Our head provides a shadow effect over the far ear
Based upon the difference in intensity, our brain can calculate

Interaural Time Differences
The ear that is closer to the sound hears the sound than the ear that is farther from the sound
Based upon the our brain can calculate where in space the sound was

IIDs and ITDs
Only provide information about where a sound is along the

We use our pinnas to locate where a
  Head related transfer functions

Interesting Note
Changing the shape of the pinna changes abilities
Eventually subjects learn to localize sounds properly

The somatosensory system
The System
Touch

Pain

The Vestibular System
Fluid filled cavities

Otoliths
  Saccule
  Utricle
Found near the ear and
How the vestibular system works

Contain hair cells
  Sensitive to direction of movement
  Either ________________ or depolarize
  Provide information about the location in ____________________________
Semicircular canals
  Provide more information about the ____________________________

Pathway to the brain
Auditory nerve
Pons, medulla, cerebellum
______________
Ventral posterior thalamus
Primary ____________________________cortex and primary motor cortex

The vestibular system
Information is highly integrated with information from the
______________
Also, projects to the ____________________________ for feedback regarding posture

Touch
The Sensory inputs
  Meissner’s corpuscles
  ____________________________
  Merkel’s disks
  Ruffini’s endings
  ____________________________
  Hair follicle receptors

Differences between receptors
Size of ____________________________
  Small
    Meissner’s corpuscles
    Merkel’s disks
  Large
    Pacinian corpuscles
    Ruffini’s endings

Differences between receptors
  Fast
    Meissner’s corpuscles
    Pacinian corpuscles
  Slow
    Merkel’s disks
    Ruffini’s endings
Differences between receptors

Shallow in the skin
- Meissner’s corpuscles
- Merkel’s disks

Deep in the skin
- Pacinian corpuscles
- Ruffini’s endings

Differences between receptors

Pressure
- Meissner’s corpuscles
- Merkel’s disks
Pressure and vibrations
- Pacinian corpuscles
Stretch
- Ruffini’s endings
Pain and temperature
- Free nerve endings

Pathway to the brain
Spinal cord

Ventral posterior nucleus of the thalamus
S1

Organization of S1

Cortical organized
The amount of cortex devoted to your hand is more than the amount of cortex devoted to your torso, even though your torso is larger
Why?

Somatotopy
Your hand is much more sensitive to
Same with face, mouth, eyes, etc…

Other types of receptors
Free Nerve Ending Receptors

Respond to warmth or cold
Respond to __________________________ pain, extreme heat, or both

The chemical senses
Senses that use __________________________ receptors
Olfaction: Smell
Olfactory _________________________________ detects molecules in the air
Taste
Saliva dissolves food into _________________________________

The olfactory system
The nose
_________________________________
Olfactory receptor cells synapse onto _________________________________
within the olfactory bulb

Smelling…..
1000 different _________________________________
Each receptor detects a broad range of smells
Based upon the _________________________________ of activity from the receptors,
our brain _________________________________ the smell

The olfactory system
Pathway to the brain
Olfactory bulb axons form the _________________________________
Olfactory cortex
Thalamus: _________________________________ nucleus
Projects to all over the brain
Various _________________________________ areas

Taste
The tongue
Four different taste buds
Sweet, _________________________________, salty, _________________________________
______________________________ : savory
Possibly a fifth type of taste bud
Papilla
_______________________________ on the tongue
Each contains up to 100 _________________________________

Pathway to the brain
Tongue: taste fibers – _________________________________ –Thalamus: ventral posterior medial nucleus – _________________________________