1. Sensory Systems (Ch13)

http://eebweb.arizona.edu/eeb_course_websites.htm

Housekeeping, 08 February 2008

Upcoming Readings

today: Ch13
Mon 11 Feb: Ch13
Wed 13 Feb: Ch13
LAB Wed 13 Feb: none
Fri 15 Feb: Exam 1, through Ch13

Lab discussion leaders: 20 Feb
1pm – Virsheena, Mathew S. Arturo
3pm – Kat, Clif, Amber

Lab discussion leaders: 27 Feb
1pm – Steve & Steve
3pm – Kevin & Jennifer
The Edges of Life – 7pm at Centennial Hall

Wednesday, February 13
Life's Cognitive Edge: The Role of the Mind and What it Means to be Human
Anna Dornhaus, Assistant Professor, Ecology and Evolutionary Biology

Our human mind distinguishes us from other animal life—or does it? Recent research has revealed culture and social learning, tool use, complex communication, self-recognition, and planning for the future are not unique to the human experience. With these new findings, science is finally getting closer to understanding exactly what makes us human.

Wednesday, February 20
Life's Human Edge: Changing Perspectives on the End of Life
Michael Gill, Associate Professor, Philosophy

Nothing looms with more certainty than the final edge of one's own life. But in fact, the edge between life and death is anything but clear. This lecture will address the attempts that have been made to define the line between life and death and will explore the biological, legal, ethical, and spiritual debates that have raged around that line.

Wednesday, March 5
Life's Technological Edge: The Singularity is Near: When Humans Transcend Biology
Ray Kurzweil, via Teleportec/Teleporter
Founder, Chairman and Chief Executive Officer, Kurzweil Technologies

Humanity is on the edge of a vast transformation, when what it means to be human will be both enriched and challenged. Inventor and futurist Ray Kurzweil will introduce this radically optimistic singularity, an era when we break our genetic shackles to create a nonbiological intelligence trillions of times more powerful than today. In this new world, humans will transcend biological limitations to achieve entirely new levels of progress and longevity.

This lecture co-sponsored by: UA College of Engineering and UA College of Science

These do not count as physiology lectures.
Star-Nosed Mole

(↑ # neurons, ↑ subtlety)
(receptor field size?)

External Chemoreception (Taste and Smell)

- Taste
  ~ direct contact

- Smell
  ~ distant signal source

- Chemoreception very sensitive

- *Bombyx* moth antenna example:

  Male responds to female pheromone at low [ ] of 1 molecule in $10^{17}$!
Taste Chemoreception

-Taste

Usually oral cavity
Some fish fins!

4-5 qualities:
1. Salt
2. Sour
3. Sweet
4. Bitter
5. Umami
   ("savory" or "meaty")

Differing Receptor Properties

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Taste

- microvilli
- basal cells give rise to new receptor cells every 10 days
Figure 10.14 Taste buds (a) The taste buds for different sensations are located in specific regions on the dorsal or face of the tongue. The circumvallate papillae (not shown) are located in the back of the pharynx. (b) A light micrograph of a taste bud. (c) Each taste bud is composed of taste receptor cells and support cells, joined near the apical surface with tight junctions. Taste ligands bind to the receptors and activate calcium signals that release neurotransmitters onto primary sensory neurons.

Figure 10.15 Taste transduction Bitter and sweet ligands signal transduction via cGMP-sensitive membrane receptors. Transduction begins with cGMP from intracellular stores. Glibaids activate cAMP second messenger pathways that close K⁺ channels. Bitter ligands alter ion channels and depolarize the taste receptor, which allows Ca²⁺ entry from the extracellular fluid. For all taste ligands, the Ca²⁺ signal triggers exocytosis of neurotransmitter.
Taste

Outer tongue
- Quasi Labelled lines
- multiple receptor types/neuron

Inner tongue

Smell
Smell/ Olfaction

- **1 Nasal Cavity**
  - turbinates (↑s.a.)

- **2 Vomeronasal organ**
  - usually conspecific communication

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Smell/ Olfaction

- Nasal and Vomeronasal:

  - Epithelial tissue origin
  - Cilia or Microvilli covered in mucus
  - Receptor proteins with 7-transmembrane helices
  - Coupled to G-protein cascade
Smell/ Olfaction

- Nasal and Vomeronasal:

- Thousands of receptor proteins (general & special)
  - but different for nasal and vomeronasal
- Receptor cells contain axons
  - Glomeruli in olfactory bulb/accessory olfactory bulb

Olfactory bulb (info processing in brain)

Glomeruli (similar odor receptor synapses)

Sensory neurons (~ odor specific)

Mucus from epithelial glands

7-21 Randall et al. 2002
Olfactory Neurons

In humans, $10^7$ olfactory receptor neurons

In dogs, $2 \times 10^8$

Human auditory nerve: $10^4$
Human optic nerve: $10^5$
A new study from the University of New Mexico found that, on average, strippers make the most money in tips during the most “fertile” days of their monthly cycles, Psychology Today reports.

Researchers also found that women who take the birth control pill make less in tips overall than women who do not take the pill, $37 an hour versus $53 an hour, respectively. For their research, psychologist Geoffrey Miller and colleagues visited local gentlemen's clubs and counted tips made on lap dances.

Dancers made about $70 an hour during their peak period of fertility, versus about $35 while menstruating and $50 in between. Researchers attributed the fluctuation in tips to the changes in body odor, waist-to-hip ratio and facial features that occur throughout a woman's cycle.

**Mechanoreception**

- Several Types:

  1. Undifferentiated nerve endings in connective tissue
  2. More specialized
     - e.g., Pacinian Corpuscle
     - e.g., Muscle stretch receptors
  3. Hairlike sensory receptors

    Activated by stretch or distortion of plasma membrane
Whiskering

Are these the hair cells we are talking about?

Mechanoreception

- **Hair Cells in cupula**
  - one Kinocilium (or none)
  - many stereocilia

  e.g.,
  - lateral line system in fish and amphibians
    - (motion/electricity)
  - hearing and equilibrium
Hearing and Equilibrium

- Both are functions of the ear

**Equilibrium:**

- 2 chambers
  - Sacculus
  - Utriculus w/ 3 semicircular canals in three perpendicular planes

These three planes can detect movement in any direction as endolymph moves and cilia are bent

**Sacculus and Utriculus**

also contain patches of hair cells that detect position relative to gravity via otoliths
Hearing (in a nutshell...1)

- **external** ear funnels sound

- sound is **oscillating air pressure**

- funneled to **tympanic membrane** (ear drum)

- **auditory ossicles** transfer sound across air-fluid boundary to **oval window** (another membrane)
  - [auditory ossicles are **malleus**, **incus**, **stapes**]

- tympanum area **19x** oval window area
  - = **amplification**
Hearing (in a nutshell...2)

- **cochlea** is fluid filled chamber on other side of oval window and it contains **hair cells**

- hair cells in cochlea bathed in **endolymph** (high in $K^+$)

- when cilia bent, ion channels for $K^+$ open and cell **depolarizes**, causing **transduction**

- different **hair cells** (and location in cochlea) for different **frequencies** of sound
Hill et al. 2004, Fig 13.29&30

Mammalian Cochlea
Konishi and Knudsen (1977) identified an area in the midbrain containing cells called space-specific neurons that fired only when sounds were presented in a particular location. Astonishingly, the cells were organized in a precise topographic array, similar to maps of cells in the visual cortex of the brain. Aggregates of space-specific neurons, corresponding to the precise vertical and horizontal coordinates of the speaker, fired when a tone was played at that location.

[Image of Barn Owl]

Northern Saw-whet Owl

http://people.eku.edu/ritchisong/birdbrain2.html