Lecture 10, 08 Feb 2008

Vertebrate Physiology
ECOL 437 (MCB/VetSci 437)
Univ. of Arizona, spring 2008

Kevin Bonine & Kevin Oh

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

Upcoming Physiology Seminar

PHYSIOLOGY & UA ADVANCE

Christine Maric, Ph.D., FAHA, FASN

Director, Diabetes Research
Center for the study of Sex Differences
Assistant Professor of Medicine
Georgetown University Medical Center

"Sex hormones in the pathophysiology of diabetic renal disease"

Friday February 8, 2008 11 a.m.

Room 5403, Arizona Health Sciences Center

"This lecture is co-sponsored by the UA ADVANCE program, a program funded by the National Science Foundation under Grant No SBE-0548130, featuring young female scientists."

The Edges of Life – 7pm at Centennial Hall

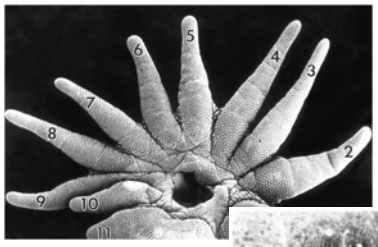
The Edges of Life Lecture Series

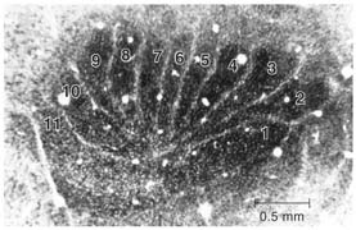
Wednesday, February 13
Life's Cognitive Edge: The Role of the Mind and What it Means to be Human
Anna Dornhaus, Assistant Professor, Ecology and Evolutionary Biology
Our human mind distinguishes us from other animal life-or does it? Recent research has revealed culture and social learning, tool use, 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} !

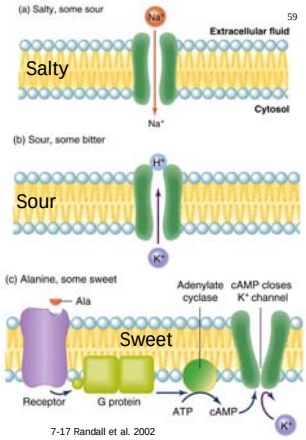
Taste Chemoreception

-Taste

Usually oral cavity
Some fish fins!

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

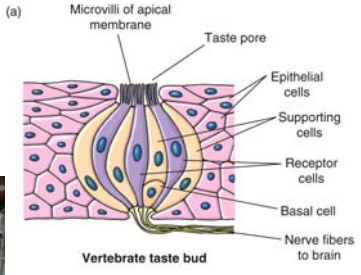
Differing Receptor Properties



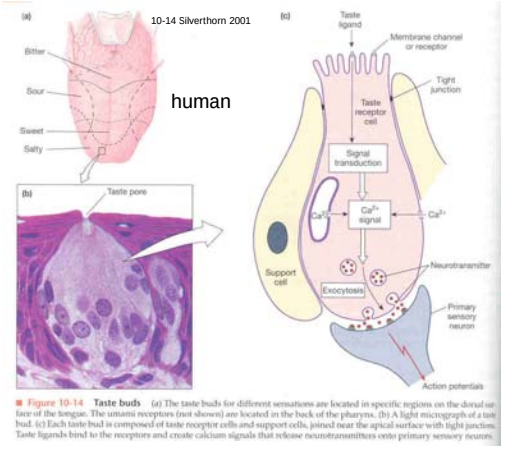
7-17 Randall et al. 2002

Taste

- microvilli
- basal cells give rise to new receptor cells every 10 days



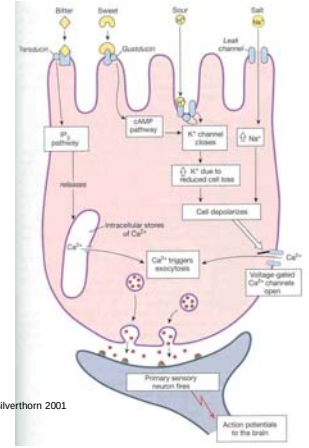
7-16 Randall et al. 2002



10-14 Silverthorn 2001

human

■ Figure 10-14 **Taste buds** (a) The taste buds for different sensations are located in specific regions on the dorsal surface of the tongue. The umami receptors (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 create calcium signals that release neurotransmitters onto primary sensory neurons.



10-15 Silverthorn 2001

■ Figure 10-15 **Taste transduction** Bitter and sweet ligand signal transduction uses G protein–coupled membrane receptors. Transducin releases Ca^{2+} from intracellular stores. Gustducin activates a cAMP second messenger pathway that closes K^+ channels. Ionic ligands alter ion channels and depolarize the taste receptor, which allows Ca^{2+} entry from the extracellular fluid. For all taste ligands, the Ca^{2+} signal triggers exocytosis of neurotransmitter.

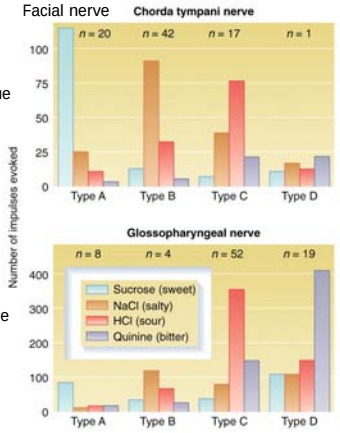
Taste

Outer tongue

-Quasi Labelled lines

- multiple receptor types/neuron

Inner tongue



Smell

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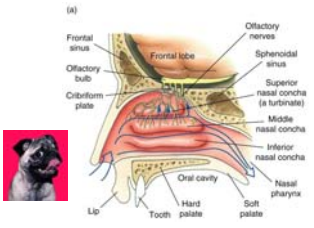
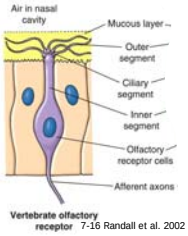
Smell/ Olfaction

-1 Nasal Cavity
-turbinates (↑s.a.)

-2 Vomeronasal organ
-usually conspecific communication



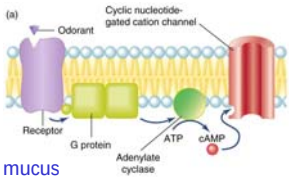
7-19 Randall et al. 2002



7-16 Randall et al. 2002

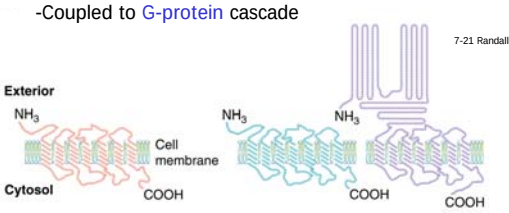
Smell/ Olfaction

-Nasal and Vomeronasal:



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

7-21 Randall et al. 2002



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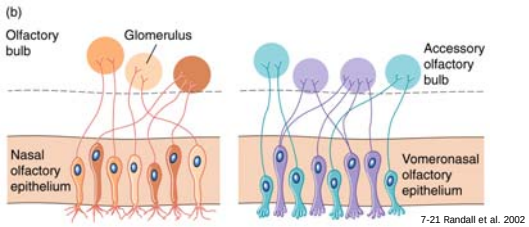
Smell/ Olfaction

- 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



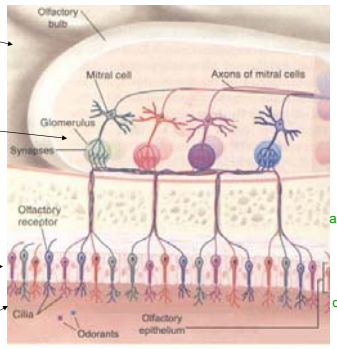
7-21 Randall et al. 2002

Olfactory bulb (info processing in brain)

Glomeruli (similar odor receptor synapses)

Sensory neurons (~ odor specific)

Mucus from epithelial glands



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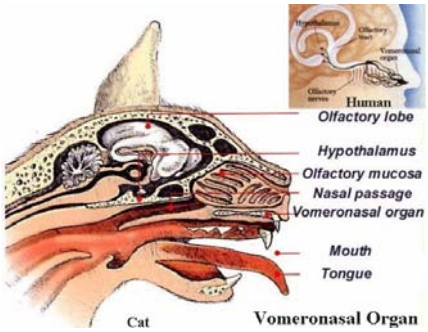

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Olfactory Neurons

In humans, 10^7 olfactory receptor neurons

In dogs, $2x10^8$

Human auditory nerve: 10^4
Human optic nerve: 10^5

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Study: Strippers Make More in Tips When Most 'Fertile'
Thursday, October 04, 2007

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.

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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

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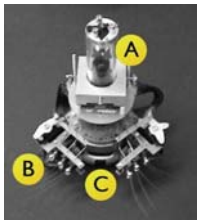

Whiskering

Are these the hair cells we are talking about?

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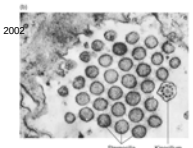
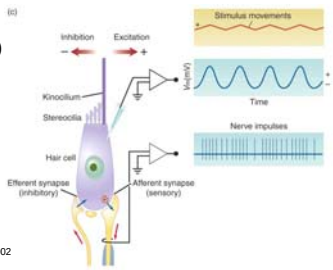
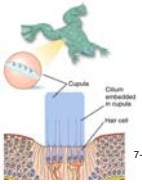
Mechanoreception

- Hair Cells in cupula
one Kinocilium (or none)
many stereocilia
e.g.,
-lateral line system in fish and amphibians (motion/electricity)
-hearing and equilibrium

7-24 Randall et al. 2002



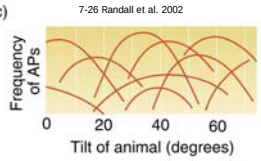




7-25 Randall et al. 2002

Hearing and Equilibrium

- Both are functions of the ear



7-26 Randall et al. 2002

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

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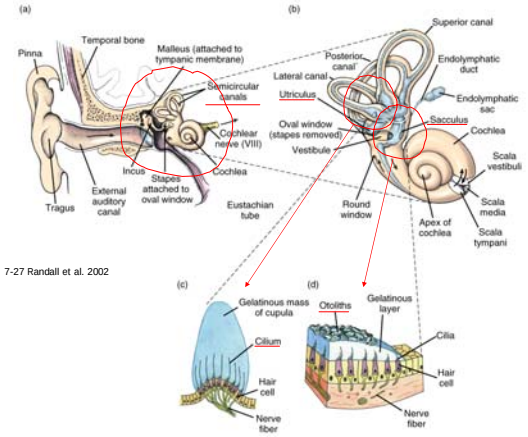

7-27 Randall et al. 2002

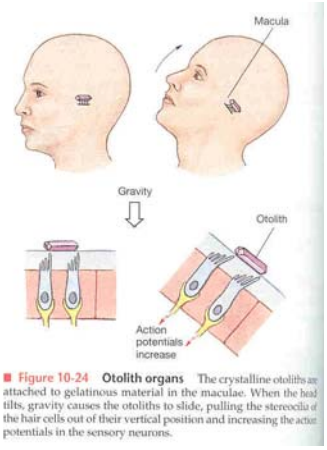

Figure 10-24 **Otolith organs** The crystalline otoliths are attached to gelatinous material in the maculae. When the head tilts, gravity causes the otoliths to slide, pulling the stereocilia of the hair cells out of their vertical position and increasing the action potentials in the sensory neurons.

10-24 Silverthorn 2001

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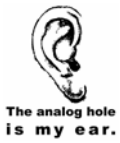
Hearing (in a nutshell...1)



- external ear funnels sound
- sound is oscillating air pressure
- funneled to tympanic membrane (eardrum)
- 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

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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

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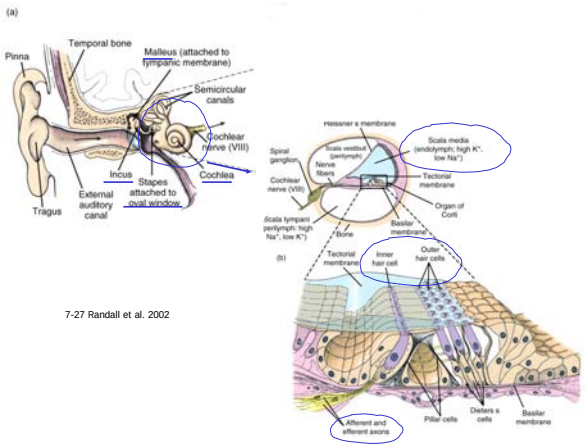
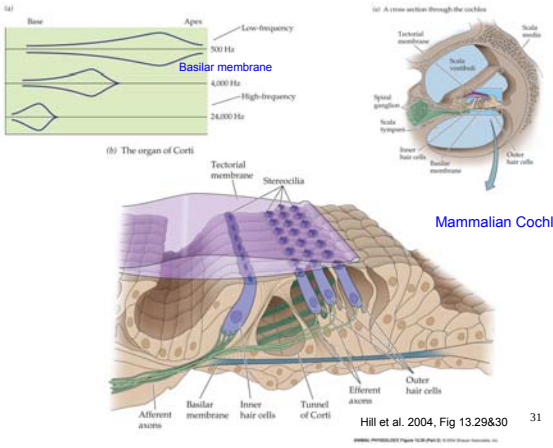


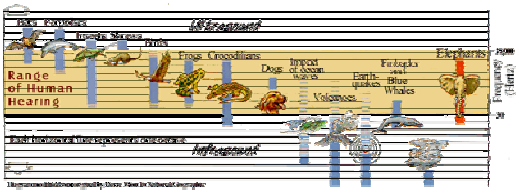
7-27 Randall et al. 2002



Basilar membrane

Mammalian Cochlea

Hill et al. 2004, Fig 13.29&30



Barn Owl

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.

Northern Saw-whet Owl

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