Physiology 6

- send answer to iClicker Question 26A now.

Sensory Input: ex. smell

- nose & brain anatomy
- olfactory sensory neuron
  - mechanism

Nicole E. - see me

- iClicker Question 26B

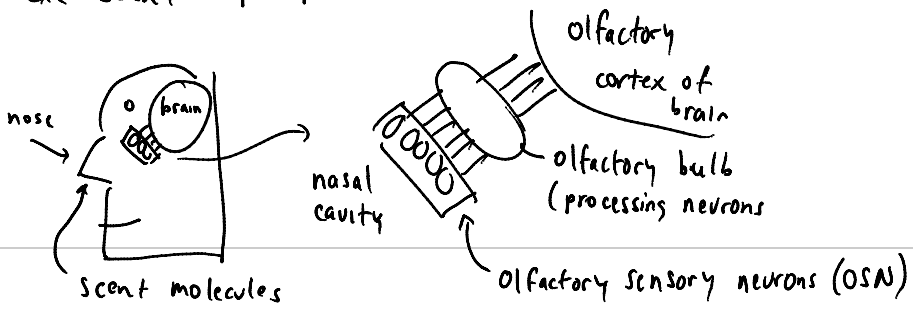
Nothing due in lab **this** week: nothing

Exam 3 Monday 4/26 - details in Ecology I handout

- Last names A - G in McCormack Cafe
- Last names H - Z here (1 bonus point for going to correct place!)

Sensory input ⇒ nervous system

ex. scent - perception of volatile molecules via nose



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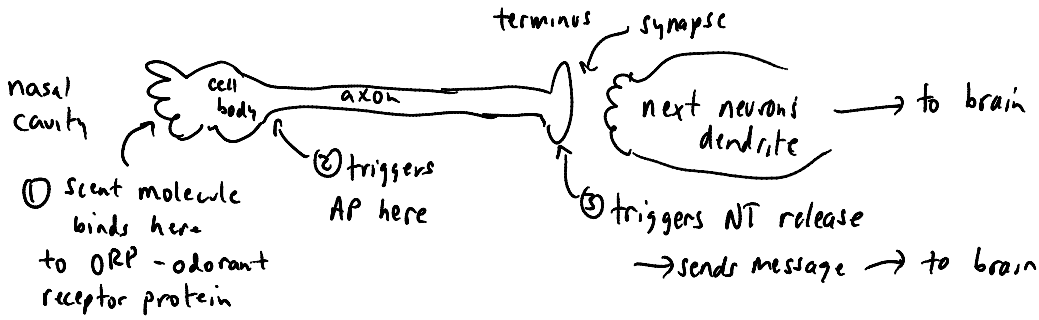
each OSN responds to a specific scent molecule:



Q: how to go from scent molecule binding to ORP to action potential?

A: could have ORP be a scent-molecule gated Na^+ channel

scent molec binds ⇒ opens Na^+ channel ⇒ Na^+ go in

$\Rightarrow V_m \Theta \Rightarrow$ A.P.

BUT not very sensitive - one scent molecule opens one channel only

∴ need many open Nat channels to get AP

∴ not sensitive enough

- need "molecular amplifier"
  - "G-protein signal transduction cascade"

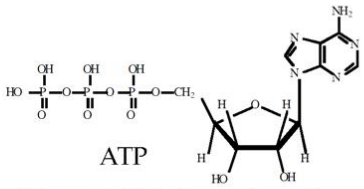
goal: 1 scent molecule binds ⇒ many Nat channels open ⇒ AP fires

Bio 112 Smells

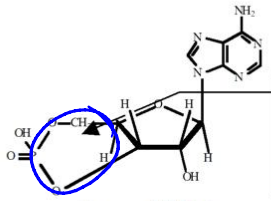
Key players:

These are all described in Campbell pages 206-217.

1. Scent Molecule a small molecule (see below) that has a scent (a.k.a. an "odorant"). Roughly equivalent to the "growth factor" in the Cancer section of Bio 111.
2. Odorant Receptor Protein (ORP) a protein that is embedded in the membrane. The outside-the -cell part of the receptor binds the scent molecule - receptors bind only one kind of scent molecule (or a closely-related family of molecules). Once the scent molecule is bound, the inside-the-cell portion of the receptor becomes active and activates G-proteins. Roughly equivalent to the "receptor" in the Cancer section of Bio 111.
3. G-protein a protein that is activated by an active receptor; it has a time-delayed deactivation mechanism. Active G-protein activates ATCase. Roughly equivalent to the "ras protein" in the Cancer section of Bio 111. See Campbell fig. 11.7
4. Adenylyl cyclase (ATCase) a protein which, when activated by active G-protein converts the small molecule ATP to the small signaling molecule cAMP. See Campbell fig. 11.9 and 11.10
5. ATP the same ATP from glycolysis, etc. See figure 11.9.
6. cAMP (cyclic AMP) a modified form of ATP that is used as a signal inside some cells (see below). See figure 11.9



ATP

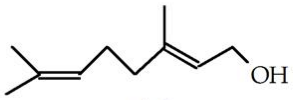


cAMP

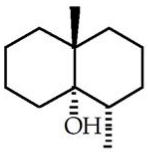
Notice the ring - that's why it's "cyclic".

7. cAMP-gated Na^+ channels sodium channels that open when cAMP is present.

Some scented molecules:

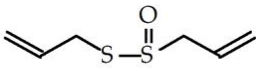


geraniol
(rose scent)

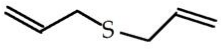


geosmin
(beets & earthy smell)

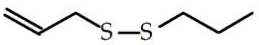
similar structures have similar shapes



allicin
(garlic scent in actual garlic)



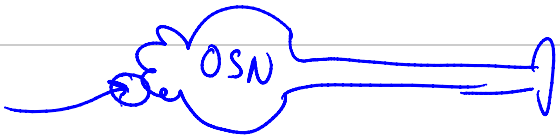
di-allyl sulfide
(smells like garlic)



allyl-propyl disulfide
(onion smell in onions)

in dendrite of OSN

⇒ here

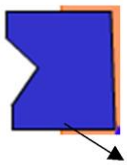


Bio 112 Scent Transduction

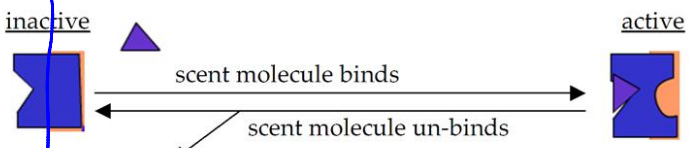
Cast of Characters Note that each has a turn-on and a turn-off mechanism.

1) **Scent Molecule**: one of millions of molecules that we can smell.

several thousand different ones



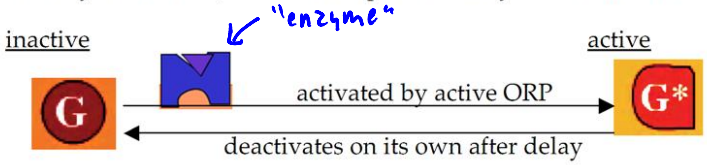
2) **ORP** (odorant receptor protein). Specialized to ~~bind one~~ scent molecule or a set of related scent molecules. It has two forms:



nasal cavity

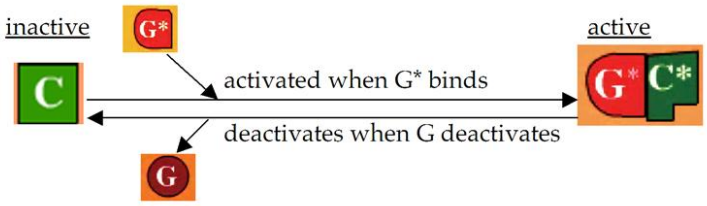
inside OSN's dendrite membrane

3) **G-protein**. A signal transduction protein used in many systems. **Catalytically** activated by active ORP; deactivates spontaneously after a short time.



all inside OSN

4) **ATCase** (adenylate cyclase). Another signal transduction protein used in many systems. **Individually** and reversibly activated by active G-proteins. When active, it converts ATP to cAMP (cyclic AMP).

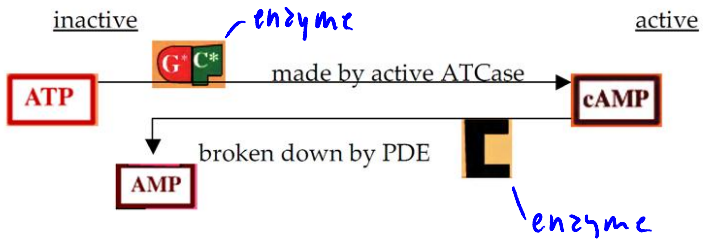


inside OSN

Physiology 6 - 3

cAMP

5) **cAMP** (cyclic AMP). A signaling molecule used in many systems. **Catalytically** synthesized from ATP by ATCase; broken down by PDE (phosphodiesterase) to AMP.

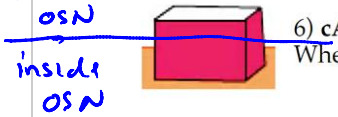


in OSN

hi Na^+

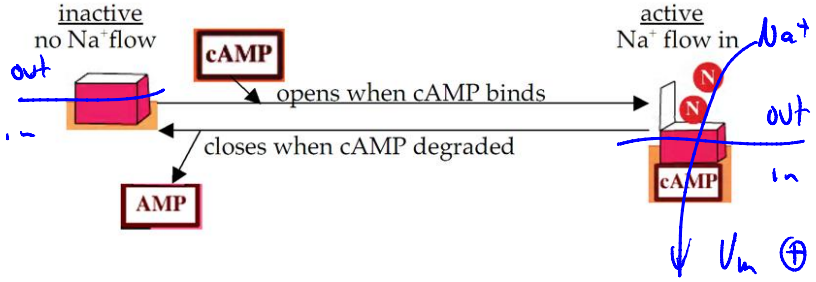
outside OSN

inside OSN



6) **cAMP-gated Na^+ channel**. A Na^+ channel that is **individually** gated by cAMP. When cAMP binds, it opens; when cAMP is absent, it closes.

lo Na^+ V_m ⊖



V_m ⊕ ⇒ AP

Very rough #s (steps)

① 1 scent molecule binds ORP ⟶ 1 active ORP

② 1 active ORP ⟶ 1000 active G proteins

③ 1000 active G ⟶ 1000 active ATcase

④ 1000 active ATCase ⟶ 1,000,000 cAMP

⑤ 1,000,000 cAMP ⟶ 1,000,000 open Nat channels

⑥ ⟶ AP

takes ~ 140 msec

= "a molecular amplifier"

also used in vision (1 photon ⇒ NT release) * need to know for exam 3

& also many other sensory mechanisms

= different receptors, similar amplifier

Turnoff ① scent molecule unbinds from ORP

② ORP deactivates

③ G's deactivate spontaneously

④ without G^*, ATCase deactivates

⑤ enzyme destroys cAMP

⑥ channels close (Na^+)

⑦ K^+ goes out

⑧ $V_m \rightarrow \ominus$

& cell is ready again