MIDTERM 2
MCB 160, SPRING 2005
100 points
5 questions
5 pages

BE SURE TO PUT YOUR NAME AT THE TOP OF EVERY PAGE!!!!!!!!!!
CHECK THAT YOU HAVE FIVE QUESTIONS!!!
WRITE IN INK!!!

Name

SID #

GOOD LUCK!!!
Do not write below this line (for grading purposes only).

1. /18
2. /22
3. /20
4. /20
5. /20

Total
1. (21 pts total) Define the following developmental hypotheses (1-4 sentences each). For each hypothesis, name a secreted molecule that supports it, as discussed in class.

A. Chemoaffinity hypothesis (5 pts)

Specificity of wiring is based on chemical tags (2). Different neurons express different tags (2). Matching of tags on pre- and postsynaptic neurons allows proper connections (1).

Secreted molecule that supports chemoaffinity hypothesis (1 pt): ________________
Either netrin, slit or semaphorin

B. Neurotrophin Hypothesis (5 pts)

- The target cells release a factor that promotes cell survival (2)
- This factor is found in limiting quantities (1)
- Cells compete to get enough factor to survive (2)

Secreted molecule supporting neurotrophin hypothesis (1 pt): ________________
NGF, BDNF

C. Morphogen hypothesis (5 pts)

Morphogens are secreted molecules that diffuse from a point source. (2) A morphogen determines cell fate based on its concentration. (2) Different concentrations of a morphogen may turn on/off the expression of different target genes. (1)

Secreted molecule supporting morphogen hypothesis (1 pt): ________________
SHH, BMP or bicoid
2. (22 pts total)
   A. Sonic Hedgehog is important for patterning the ventral spinal cord. What molecule is important for patterning the dorsal spinal cord (2 points)?

   **BMP**

   B. Name two experiments that would show this (based on the work with SHH) (5 points). (2-4 sentences)
   
   2.5 pts/expt, 2 expts
   
   1. Add different concentrations of BMP to a spinal cord extract and show different fates
   
   2. Loss of BMP leads to loss of dorsal fates
   
   3. Ectopic expression of BMP leads to dorsal fates in inappropriate regions

   C. What would happen if you expressed Noggin in the roofplate? Why? (5 points) (1-2 sentences)

   Noggin is a BMP inhibitor and would bind BMP (2.5). There would be loss of dorsal cell fates (2.5).

   D. Ventral neurons and dorsal neurons do not mix in the spinal cord, even at the midline. Name two possible reasons. (5 points) (two sentences)

   2.5 pts each, need 2 of 3
   
   1. Cell fate A turns off cell fate B, and cell fate B turns off cell fate A. Feedback inhibition
   
   2. Like attracts like
   
   3. opposites repel

   E. There is a complex mouse mutant in which the entire spinal cord is composed only of ventral motor neurons. Explain how defects in dorsal and ventral patterning molecules could produce this. (5 points) (two sentences)

   **Model 1:** No BMP (2.5), uniform high level of SHH throughout spinal cord (2.5)
   
   **Model 2:** No BMP receptor (2.5), uniform level of SHH throughout spinal cord (2.5)
3. (20 points total). A series of very short answer questions on the different sensory modalities.

One point per blank:

A. Number of opsin receptors________5 (1/2 pt for 4)___________________________
B. Number of T1R taste receptors_________________3_______________________
C. Number of T2R taste receptors_________________~30_________________________
D. Number of mouse olfactory receptors___________~1000_____________________
E. Number of olfactory receptors in one olfactory neuron_______1______________
F. Number of T1Rs in a sweet taste cell____________________2________________

G. Mice without rods and cones still have circadian rhythms. This is because they have the ____melanopsin_______ receptor in ____retinal ganglion______cells.

H. Male mice without the TRP ion channel in the VNO show altered sexual behavior. What is the behavior?_______attempt to mate females and males equally

I. Mice with the taste-specific PLC only in T2R taste cells taste__bitter________ and __salt___________ and __sour___________ compounds.

2 points per blank

On each line, list which sensory systems -- visual (V), auditory (A), olfactory (O), gustatory (G), or vomeronasal (VN) – are accurately described by the statement.

A. Requires a GPCR__V O G VN____(0.5 pt each)____________
B. Cyclic nucleotide-gated channels__V O______(1 pt each)____________
C. Ligand covalently binds receptor__V or_V A_ (2 pt either way)____
D. Receptors bind more than one ligand______O G VN________
4. (20 points total) Mammalian taste cells are not neurons. Instead, neurons send dendrites to the taste cells and their axons go to the first gustatory relay in the brain. Imagine that you are a graduate student interested in understanding axon guidance of neurons from the tongue to the gustatory center in the brain. You look to see if any of the known axon guidance receptors are expressed in these neurons.

   A. Name four guidance receptors that you would look for (4 points.)

   **Four of these: Ephrin receptor, Robo, Plexin, Neuropilin, Dcc, Unc-5**

None of the known axon guidance receptors is expressed in these neurons. After a lot of work and some good luck, you identify a receptor tyrosine kinase YUM that is expressed in neurons that contact sweet taste cells on the tongue and a ligand Y in the gustatory center. You suspect that YUM is an axon guidance receptor that recognizes Y in the gustatory center. You also believe that the taste system uses labeled lines to code taste information.

   B. What is the labeled line model of taste coding? (6 points)

   **Different taste modalities are recognized by different taste cells. Taste information is segregated.**

   C. What would happen to the axons and to the mouse if you knock out Y (5 points)?

   **Axons do not target properly (2.5), mouse can’t taste sweet substances (2.5)**

   D. What would happen to the axons and mouse if you put YUM in neurons that contact cells expressing T1R3 (5 points)?

   **Axons target like those from sweet cells (2.5), the mouse would like sweet and umami substances (2.5)**
5. Hearing and vision both use very different signaling mechanisms to change the electrical activity of the sensory cells.

   A. Hair cells activate a potassium channel, causing a depolarization. Photoreceptors use a cation channel but light causes hyperpolarization. Explain how potassium channels depolarize hair cells and cation channels hyperpolarize photoreceptors. (7 pts) (2-4 sentences)

   Hair cells have high K outside, so the opening of K channels causes K to enter the cell and depolarize it (3.5).

   Light causes a decrease in cGMP and the closing of cGMP-gated ion channels, causing hyperpolarization (3.5).

   B. How does calcium affect phototransduction? Name two molecules that are regulated by calcium and their mechanism of action. (6 pts) (2 sentences)

   Decrease in calcium causes adaptation (2).
   Two of the three:
   Decrease in Ca activates rhodopsin kinase to deactivate receptors (2)
   activates Guanylate cyclase to produce cGMP to open channels (2)
   calmodulin doesn't bind ca, opens channels (2)

   C. Draw the voltage change due a light stimulus in photoreceptors and a mechanosensory stimulus in hair cells. Be sure to show differences in the responses due to activation, adaptation and deactivation. (7 pts)