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

Total
1) During development, gradients of chemical cues are used to set up the final body plan. (22 points total)

A) Describe how a spatial gradient is formed and how it sets up different cell fates. Name one biological example discussed in class (7 points).

B) Describe how a temporal gradient is formed and how it sets up different cell fates over time (7 points).

C) The same chemical cue can set up different cell fates at different developmental times. BMP is involved in early neurulation as well as in later spinal cord development. In what tissue is BMP expressed in early, and what cell fate does it induce? In what tissue is it expressed later and what cell fate does it induce (8 points)?
2). In Roger Sperry's classic experiment, he rotated the frog eye and examined retinal projections to the optic tectum. (20 points total)

A) Why does this experiment support the chemoaffinity hypothesis (6 points)?

B) The receptors and ligands that set up the topographic map from the retina to the tectum have now been identified. Name the receptor and ligand (2 points).

C) Draw a schematic of the retina and tectum showing the gradients of receptor and ligand. Label the anterior and posterior retina and tectum and the low and high concentrations of receptor and ligand. Draw the projections from the anterior and posterior retina to the tectum (6 points).

D) What would happen to retinal projections if the amount of receptor was decreased by 50% in each retinal ganglion cell? Draw the projections from the anterior and posterior retina to the tectum. Provide a brief explanation. (6 points)
3) The sense of taste in mammals is composed of five taste modalities: sweet, bitter, sour, salty and umami (the taste of MSG). (20 points total)

A) What taste receptors recognize sugars? Bitter compounds? Umami? (6 points)

B) The molecules that detect sour have not been identified. Would an electrophysiology experiment that monitors taste cell depolarization to sour compounds distinguish whether a GPCR, an RTK or an ion channel detects sour taste? Why or why not? (4 points)

C) If you could add a drug during the electrophysiology experiment to inhibit the action of one protein, what protein would you inhibit to distinguish whether a GPCR, an RTK or an ion channel detects sour? (4 points)

D) If sour taste were mediated by RTK signaling, then blocking RTK signaling should block sour taste (turn lemons into lemonade). Name two ways in which a pharmaceutical company might try to block sour taste. (6 points)
4) The growth cone of an axon contains the axon guidance receptors robo, DCC and Unc5. It takes a route from the dorsal root ganglion in the spinal cord to peripheral skin tissue. On its way, it first travels toward muscle A. Once it reaches muscle A, it rapidly moves away from it to synapse onto muscle B. (20 points total)

A) What axon guidance molecule would muscle A contain to attract the axon to it? (3 points)

B) What axon guidance molecule would muscle A contain to repel the axon? (3 points)

C) How could the axon first be attracted and then be repelled? (6 points)

D) The axon reaches its final destination in the spinal cord. It dies by programmed cell death. Adding snake venom would have prevented death. Why? What is the signaling cascade that leads to cell death? (Name the proteins for either the worm or mammalian pathway, and draw regulatory arrows between the proteins to show whether they activate or inhibit the next protein.) (8 points)
5) The senses of smell, taste, hearing and vision all use very different strategies to collect information about the outside world and relay it to the brain. (18 point total)

A) Name three strategies that rods in the eye use that allow them to produce measurable responses to single photons of light. (6 points)

B) What strategies does the auditory system use to adjust the hair cell's response to sound? Name one transduction mechanism used by inner hair cells and one mechanism used by outer hair cells. (6 points)

C) How are 50,000 different smells detected by the olfactory system when there are only 1000 types of olfactory receptors? (6 points)