

Neurobiology and Human/Animal Behaviour
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problem set #6 solutions

1. Wallerian degeneration is the deterioration and phagocytosis of the distal portion of a severed axon.
2. A growth factor is any of several trophic factors that induce, augment, or direct the growth of neurites (axons or dendrites).
3. A growth cone is a cone-shaped region at the end of a growing axon whose structure changes rapidly, sending out and retracting many short-lived processes as it advances.
4. Axons in the PNS regrow along the channel left after the Wallerian degeneration of the severed segment. In the mammalian CNS, although damaged axons develop growth cones and seem to try to regrow, as soon as they contact oligodendrocytes (the myelin-producing cells unique to the CNS) they withdraw. This inhibitory effect of contact with oligodendrocytes is mediated by damaged oligodendrocytes' expression of the inhibitory factor nogo.
5. In the goldfish, severed axons in the optic nerve regrow to re-establish contact with their targets in the goldfish's optic tectum. If the optic nerve is transected and the eyeball is surgically rotated 180°, after the optic nerve has regrown the goldfish will dart towards a startling stimulus. This work demonstrates that the assignment of retinal axons to their tectal targets does not simply arise from the geometry of the eyeball; rather, axons must be labelled for their specific tectal targets. In other, *in vitro* work, when axons from a retinal region that innervates anterior tectum are grown onto cultured strips of anterior and posterior tectum, the axons are selective for the anterior strips.
6. David Hubel and Torsten Wiesel showed that suturing one eye during a kitten's developmental critical period for ocular dominance columns diminishes the size of the columns innervated by the sutured eye. In the lateral geniculate nucleus, development of eye-specific layers depends on temporally correlated activity in retinal axons. These LGN layers can develop even in the absence of visual stimulation; even in the absence of light, interactions mediated by

amacrine cells produce waves of spontaneous activity that travel across the retina. When this activity is suppressed by tetrodotoxin, a sodium channel blocker, LGN layering is suppressed. Growth factors and labelling molecules can also affect the segregation of inputs: adding excess BDNF, NT4, or NT5 or knocking out MHC-1 genes can impair or abolish segregation.

7. Operating on the foetal hamster, remove a patch of visual cortex and a patch of, say, somatosensory cortex, and graft these into each other's places. Then sew the foetus and the dam back up. After the pup is born, see what's happened to the structure of these two cortical patches. In fact, this experiment has been done (by Barb Finlay at Cornell), and has revealed that to a large extent, the structure of cerebral cortex is determined by the signals carried by the axons that innervate it.
8. Functional imaging and event-related potentials reveal that in the congenitally blind, occipital cortex is active during speech and somatosensory processing.
9. Spina bifida is a failure of the caudal extent of the neural crest to close and to form the caudal portion of the neural tube. (Failure of the rostral neural tube to close produces anencephaly and death.)
10. The subplate guides differentiation and migration of developing neurons as they form in the ventricular zone and then migrate along radial glia to their destinations.
11. Cells in deep layers of cerebral cortex differentiate and migrate earliest, leaving cells in superficial layers to migrate *through* the already-formed deep layers.
12. Work by Max Spemann showed that explantation of mesoderm induces host ectoderm to become neuroectoderm.
13. The homeobox genes are a family of genes that code for transcription factors governing body patterning. Their fundamental structure is conserved from creatures as simple as *Drosophila* to species as complex as humans.
14. In the *Xenopus* oocyte, a high level of retinoic acid induces posterior Hox genes and represses anterior ones.
15. Transplantation of a second notochord into the *Xenopus* oocyte induces

differentiation of a second floor plate, which produces ectopic motor neurons.

16. Removal of the notochord at the time of neural tube closure abolishes the differentiation of the floor plate, but preserves differentiation of the roof plate.

17. Sonic hedgehog is expressed in the notochord and then in the floor plate. It induces dorsal differentiation.

18. BMP4 and BMP7 are expressed in the epidermis and then in the roof plate. They induce ventral differentiation.

19. *Drosophila* ommatidia have a modular, deterministic structure; each ommatidium contains the same number of cells with the same functional specialisations. This property has led to extensive study of the development of these ommatidia. Of special interest have been the mutations *sevenless*, which abolishes reception of the signal that induces differentiation of the photoreceptor R7, and *bride-of-sevenless* (a.k.a. *boss*) which abolishes the sending of this signal from the neighbouring photoreceptor R8.

20. In the video game ‘Sonic the Hedgehog’, Sonic fights to free cute, defenceless little animals from the robot monsters of Doctor Robotnick. (Beware of people called ‘Doctor’; they’re usually evil.)

21. It’s true. Sonic Hedgehog are way more nineties grunge than traditional punk.