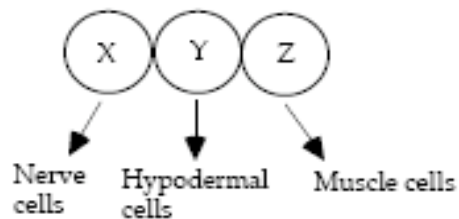


7.013 Review Session 3

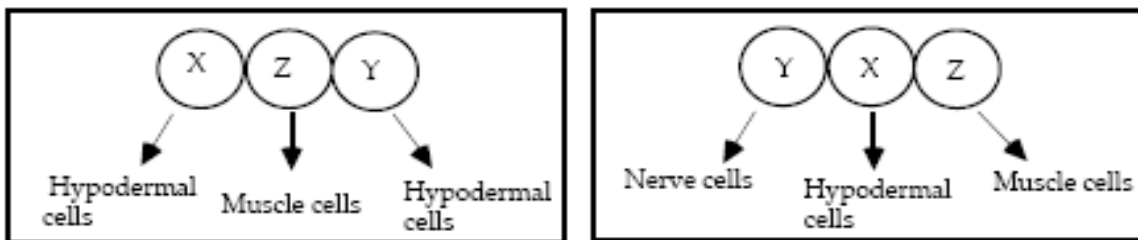
Development Review

1.

In a developing organism, three cells, X, Y, and Z, that lie adjacent to one another give rise to cells that form nerve cells, hypodermal cells and muscle cells, respectively, as shown below:



A series of transplant experiments were also done with these cells, to give the following rearrangements. The results show that the Z cell signals immediately adjacent cells to become hypodermal cells.

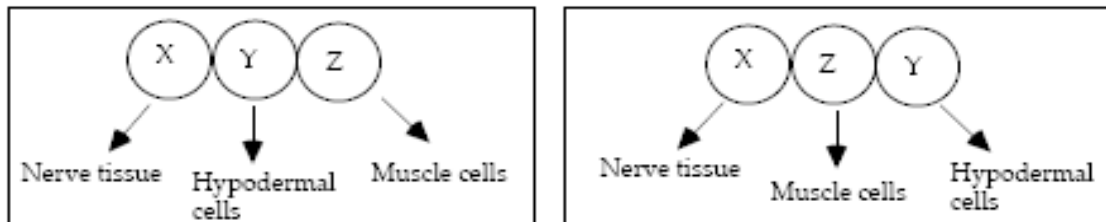


a) Based on the above information, what is the fate of cell X?

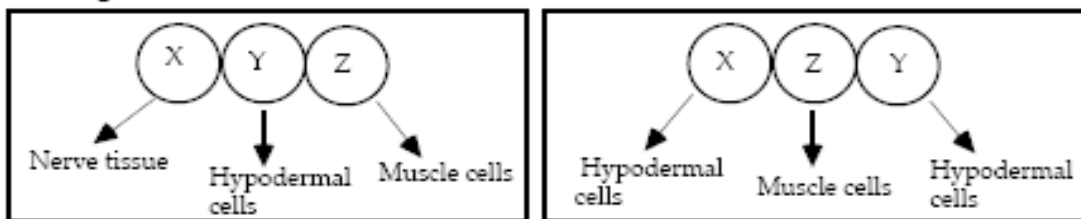
b) Based on the above information, to which cell types does cell X have the potential to give rise?

c) The same cell-surface receptor that is associated with a G protein signal transduction pathway is found on X cells and Y cells; this receptor is not present on Z cells. What is the most likely function of this receptor?

d) Briefly explain why X cells lacking the GTP-binding function of the G protein coupled to this receptor yield the following results.



e) Briefly explain why X cells lacking the GTPase activity of the G protein yield the following results.



2.

During your summer research internship in the Amazon, you stumble upon a never before seen spectacular creature (shown leaping below), which you give it the genus and species name *Nihplod reggit*.



Figure by MIT OCW.

You decide to study the early development of *Nihplod reggit* to see how if you can find similarities to known organisms. You discover that the *Nihplod reggit* has a unique organ that acts as a combination heart and lung. This organ forms from a series of primitive tubes that develop from a specific region of the mesoderm.

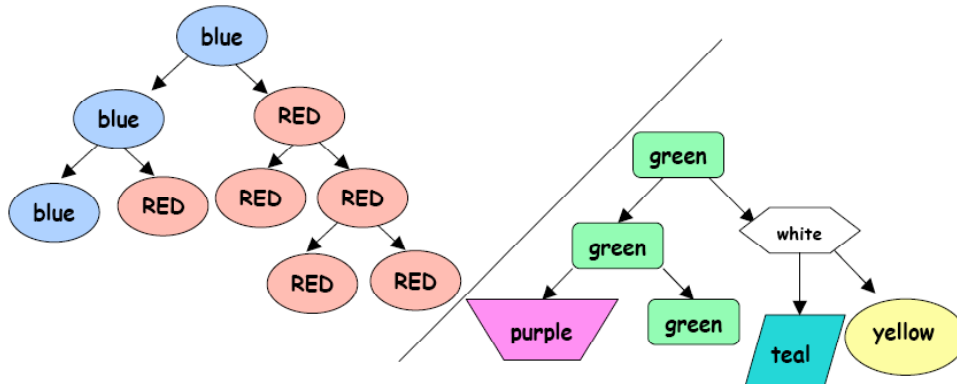
- What type of experiment could you use to determine which cells of the mesoderm give rise to this organ?
- Describe one of the 3 possible ways that these tubes can form. What type of cells are involved in this process?

Development of the mature heart lung organ requires elongation and thinning (changing layer thickness and number) of the primitive tubes.

- What types of cell movements could be leading to these changes? Are these changes likely occurring in sheets of cells or in mesenchyme?
- These shape changes are triggered by the production of heart growth factor (HGF) in neighboring cells. How could a growth factor induce changes in cell shape and movement?
- What role does actin play in cell movement?
- What effect would addition of a drug that prevented actin polymerization or depolymerization have on cell movement?

Stem Cell Review

A scientist finds a new brightly colored mammalian species, which she names *Magnificus colores*. She isolates blue and green cells from different parts of this organism, and cultures each cell individually.



- Are the blue cells stem cells? Why or why not?
- Given that the green cell is a stem cell, can you tell whether it is totipotent or pluripotent? Explain your answer.
- The scientist finds out that development in *M. colores* is similar to human development. She wants to obtain a single cell that can give rise to an individual *M. colores*. Do you have any suggestions? What is the property that this cell must possess?
- She now wants to isolate embryonic stem cells from an *M. colores* embryo. Where exactly in a developing embryo can she find such cells?
- M. colores* have coats with multi-colored spots, which are produced by the Speckle gene. One functional copy of Speckle is sufficient to give multi-colored spots. While studying different embryos, the scientist detects that one 8-cell stage embryo has both copies of Speckle mutated. Suggest a strategy using stem cells by which she could try to rescue this defective gene.
- One of the *M. colores* has a weak heart that has only 10% of the normal functioning capacity. If technology were advanced enough, how could ES cells from this animal potentially be used to save it from heart failure? Why would this be preferred over a heart transplant such as those performed today?

Cloning Review

A rare species of monkeys are close to extinction, and as a scientist you have been asked to assist with the cloning of this species in order to increase its numbers. You decide to clone the monkeys in the same manner as Dolly the sheep was cloned. One of the last healthy monkeys, KoJo, recently died in a fire and *no remains* were found. Because KoJo was an extremely healthy animal, you would ideally like to clone her instead of another monkey.

a) Is it possible to clone KoJo?

b) A few weeks later you remember that KoJo had a fraternal twin, JoKo. Could KoJo be cloned from JoKo? Why or why not?

c) KoJo's sister, Mimi, had two faulty kidneys and so KoJo, when she was alive, donated one of her kidneys to Mimi. Explain how Mimi could be useful for cloning KoJo.

d) You observe some strange symptoms in the clone of KoJo such as generalized weakness, loss of motor skills, and loss of appetite. You suspect that this is a genetic disorder, but KoJo did not display any of these symptoms during her lifetime. Given this information, why is the clone so sick?

e) It turns out that some of KoJo's oocytes were frozen back at the breeding facility. Could the nuclei in these oocytes be used to clone KoJo?

f) In case cloning with the nuclei from KoJo's oocytes doesn't work out, you decide to use the procedure involving Mimi again, but this time you want to be sure the clone doesn't exhibit the symptoms described above. Given all the available information, how might you proceed with the cloning experiment?

g) Will these clones produced in (f) have the same temperament, IQ, or eating habits as KoJo?

Neurology Review

1. Acetylcholine (ACH) is a neurotransmitter used at all vertebrate neuromuscular junctions.

At each axon terminal, ACH is released from the pre-synaptic cell when vesicles fuse to the plasma membrane and release ACH into the synaptic space. ACH then binds to acetylcholine receptors that act as sodium channels. Thus when ACH binds to receptors on the post-synaptic muscle cell, sodium enters and depolarizes the muscle cell causing a muscle contraction.

a. What would be the effect on an organism that had a mutated ACH receptor, and thus could not bind ACH as well as wild type? Would increasing the amount of ACH released by the pre-synaptic cell help restore wild type activity? Explain.

b. The drug Prozac acts at synapses controlled by the neurotransmitter, serotonin. Serotonin acts at central nervous system synapses and plays a role in pain control and mood elevation. Serotonin is not broken down by a specific enzyme, but is instead removed from the synaptic cleft by active transport back into the pre-synaptic cell. Give one possible mechanism for how Prozac might work to elevate mood.

2. You have some drugs that affect neurotransmission, and you wish to determine how they affect signal transmission.

In a Petri dish culture of neurons, you depolarize a pre-synaptic cell with an electrode and observe a resulting action potential in that pre-synaptic cell. This step is the same regardless of whether the drugs are present. However, the effect on the post-synaptic cell varies.

In the **post-synaptic cell with no drug**, you see a slight depolarization followed by no action potential.

In the **post-synaptic cell with Drug 1**, you see a large depolarization followed by an action potential

In the **post-synaptic cell with Drug 2**, you see no depolarization and no action potential.

a. What are possible targets of **Drug 1**?

b. What are possible targets of **Drug 2**?

3.

The receptors Robo and DCC are important for axon's ability to responding to guidance cues from Netrin and Slit proteins expressed near the brain midline. The mammalian model is summarized below.

- Netrin is secreted from the midline and bound by DCC on the neuron. This attracts the neuron toward the midline.
- Robo is expressed on neurons once they have crossed the midline.
- Slit is secreted from the midline and bound by Robo on the neuron. This repulses the neuron from the midline.
- DCC receptors on the neurons expressing Robo become non-responsive to Netrin binding.

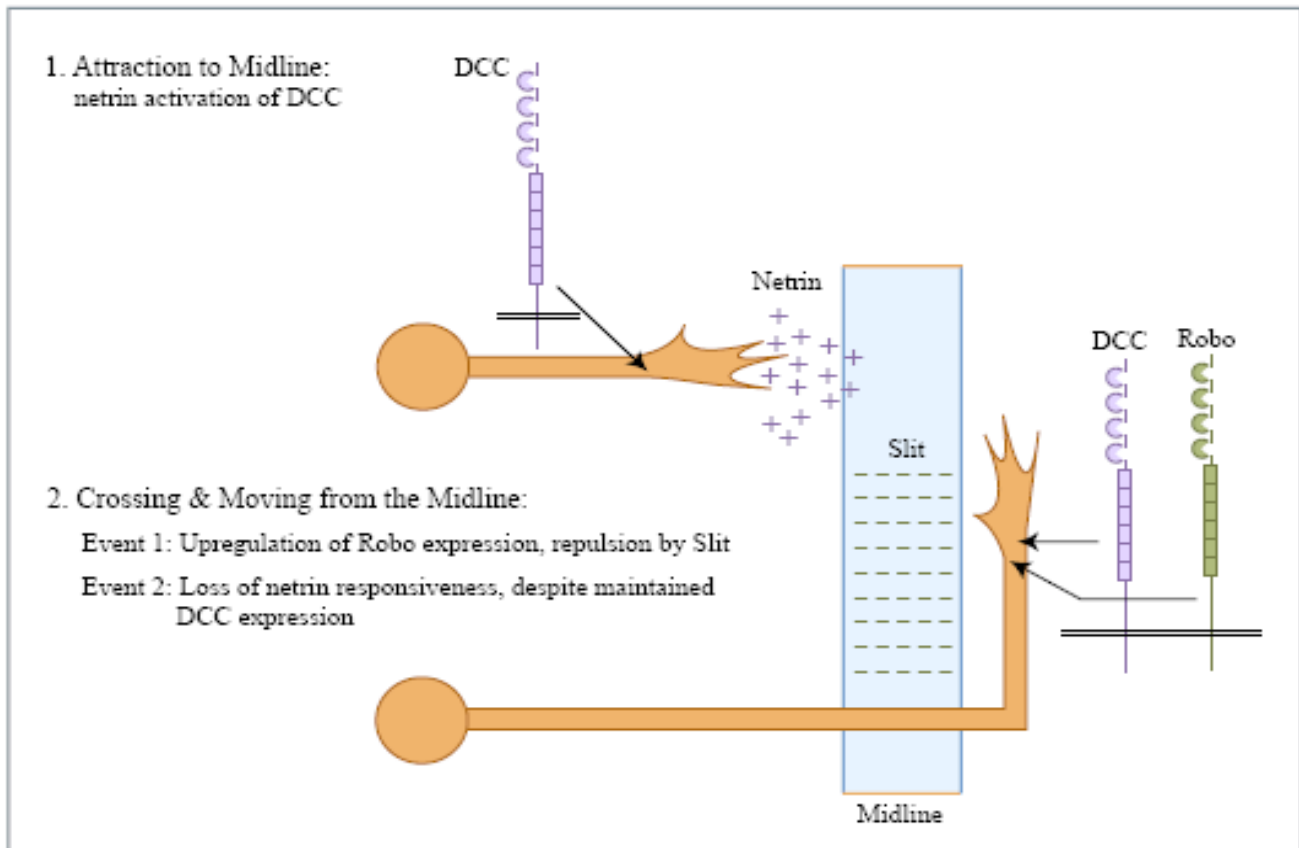
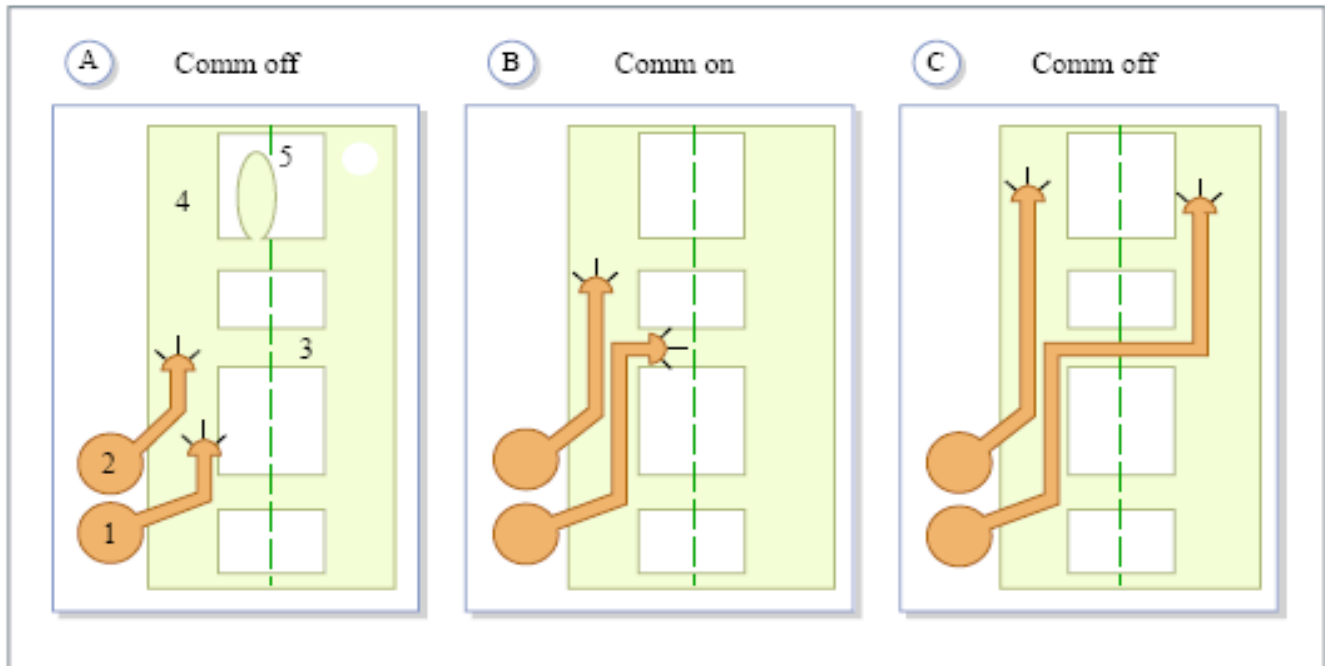


Figure by MIT OCW.

a) In this model of axon guidance it is important that Netrin is...

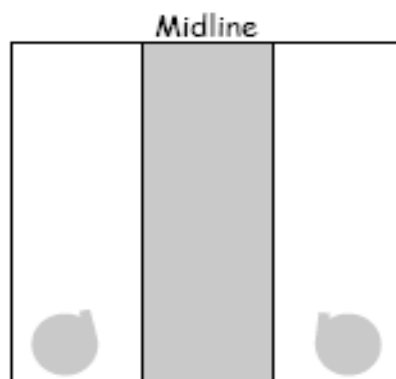
a (short/long) range **attractant** and a (short/long) range **repellant**

- b) In fruit flies there is another intracellular protein, called *Commissureless* (*Comm*), that must be expressed for these neurons to cross the midline. The figure below shows different time points from early (A), to later (B), to even later (C). In figure B, only neuron 1 is expressing the *comm* gene, transiently.



Figures by MIT OCW.

What would an animal with a deletion of both *comm* genes look like? Draw your answer in the box below elongating the axons of the neurons on either side of the midline. (Assume Netrin, DCC, Robo and Slit still expressed normally.) Axon growth cones never enter midline.



- d) *Comm* is a (Negative/Positive) regulator of the Robo receptor.
 e) Give one example of how intracellular *Comm* may act on the receptor Robo.