MIT Department of Biology
7.013: Introductory Biology - Spring 2005
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7.013 Spring 2005 Problem Set 7

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Question 1

Bovine spongiform encephalopathy (BSE, also called mad cow disease) and other similar diseases are caused by infectious particles called prions.

a) Prions are made of (circle one.)

Viruses bacteria DNA RNA **protein** lipid carbohydrate

b) True or false, if false correct the sentence:

T **F**	Several new mutations arise in the brains of cows that become affected by BSE. **Affected and unaffected cells are genetically identical.**
T **F**	In BSE, viral factors convert proteins in the brain from one form to another. **Protein conformational changes occur without contribution from an external pathogen.**
T **F**	BSE cannot be transmitted from one cow to another. **BSE can be transmitted between cows by injection or ingestion of affected CNS material.**
T **F**	Spongiform encephalopathies cannot be transmitted from one species to another. **These diseases are not spread as easily between species as among animals of the same species, but at low frequency they can jump the species barrier.**

In yeast, there have been found prions that behave similarly to those that cause BSE. In the case of one yeast prion, one protein conformation causes the cells to be white and another conformation causes them to be red. This confers to colonies being red or white. Assume that the protein state analogous to the infectious form of BSE causes the yeast to be red.

You grow these yeast and you notice that individual colonies are mostly of a single color, but small white sectors arise within red colonies, and small red sectors arise within white colonies.

c) What causes red sectors to arise within white colonies?

Some protein spontaneously converts to the prion form.

d) If you took yeast from a red sector and replated them what color colonies would form and why?

Red. Once some of the prion form has been generated, it will mostly be stably maintained in the population. So there will be red colonies with some occasional white sectors.

e) What causes white sectors to arise within red colonies?

Some cell division events result in cells that did not inherit any of the prion form of the protein. . The prion is inherited as a cytoplasmic factor.

f) If you took yeast cells from a white sector and replated them, what color colonies would form and why?

White. Once the prion form is gone, it will only be spontaneously regenerated at very low frequency. This will cause occasional red sectors in white colonies.

g) Heat shock proteins help prevent the proteins present in cells from becoming aggregated and then degraded when cells are exposed to high temperature. They do this by unfolding and then refolding these proteins.
You find that when you express high levels of these heat shock proteins in red yeast cells (from above) and replate the yeast, now they grow into white colonies. Provide a possible explanation for this.

These heat shock proteins unfold and refold the prion proteins, when they refold they do not take on the prion conformation so the colonies are white.

Question 2

AIDS is an immunodeficiency disease caused by infection by a retrovirus called HIV.

a) What is the central dogma?

DNA to RNA to protein

b) How do retroviruses violate this principle?

RNA genome, reverse transcribed into DNA

Viruses require host cells for propagation. Each virus has a specific host cell type that it infects.

c) How are viruses able to specifically infect only one cell type?

General, proteins on virus capsid recognize and bind to specific receptors on host cell. Specifically for Aids, proteins on the virus bind to the CD4protein on the cell membrane

d) What is the role of helper T_H cells in the immune system?

Control B cells, regulate clonal expansion and antibody production

e) What is the effect of loss of helper T_H cells?

Weakens immune response, leads to susceptibility to all viruses