AP Bio FRQ Fridays

2014 #2
Phylogenetic Tree & Immune System

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Mammalian milk contains antibodies that are produced by the mother's immune system and passed to offspring during feeding. Mammalian milk also contains a sugar (lactose) and may contain proteins (protein A, protein B, and casein), as indicated in the table.

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

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(a) Using the data in the table, **construct** a cladogram on the template provided to indicate the most likely evolutionary relationships among the different mammals. **Indicate** on the cladogram where each of the characters most likely arose in the evolutionary process, and **justify** the placement of the characters on the cladogram.

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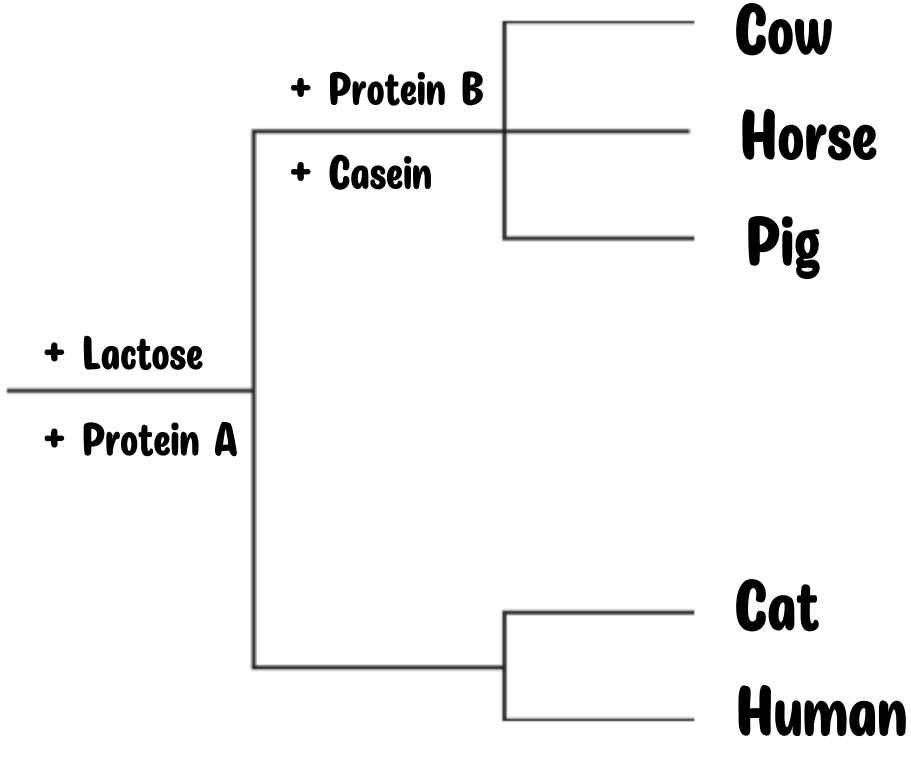

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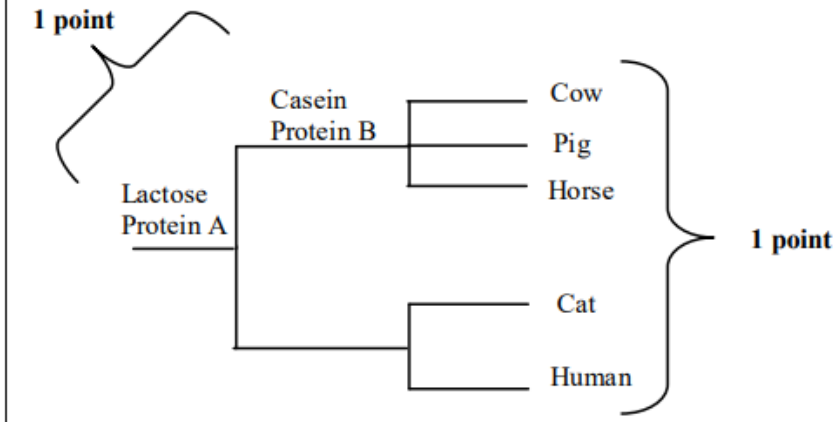

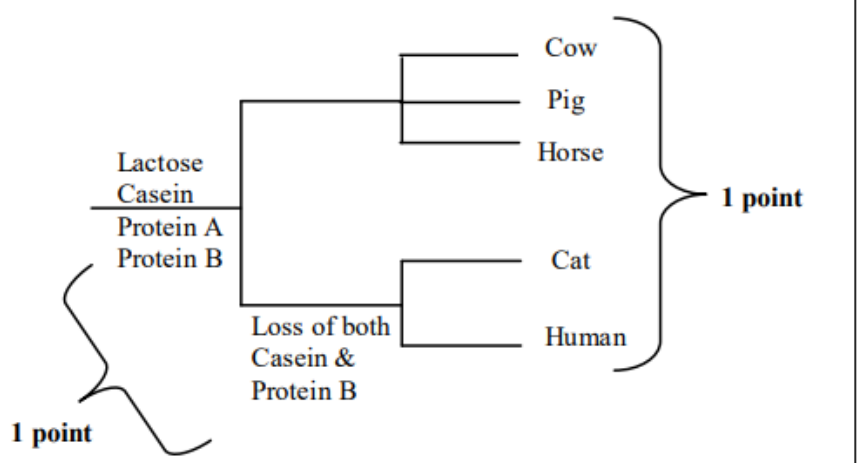

Justification (**1 point**)	Justification (**1 point**)
Lactose and Protein A arose in a common ancestor to all 5 animals. Protein B and Casein arose only in the common ancestor to the pig/cow/horse clade/branch.	Lactose, Casein, Protein A, and Protein B arose in a common ancestor to all 5 animals. Protein B and Casein were lost in the common ancestor to the cat/human clade/branch.

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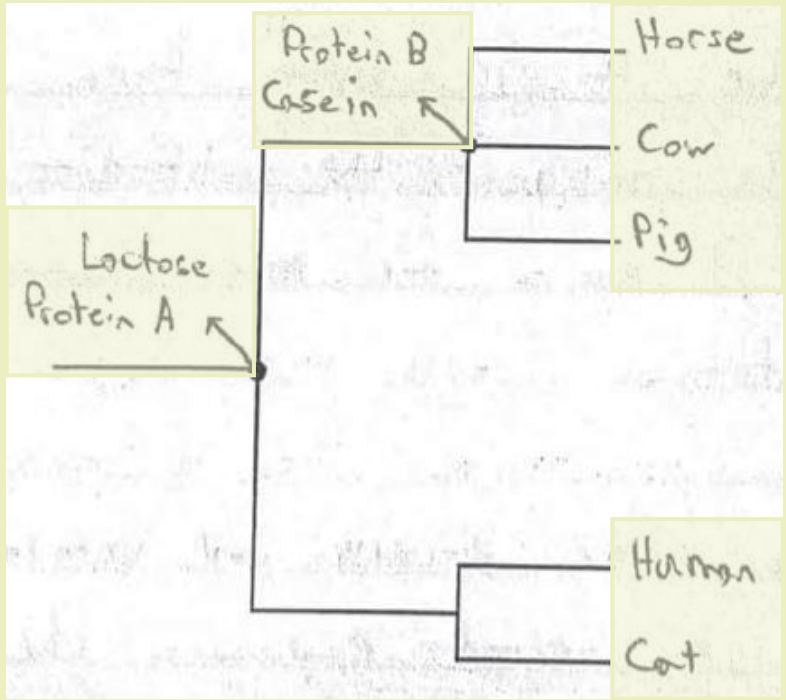

a.) Both Humans and cats lack Protein B and casein so they would be grouped together and they would have a common ancestor. Furthermore, Horses, Pigs and Cows all possess every trait so they would be grouped together. Since all the species posses Lactose and Protein A it would have to arise in a common ancestor for all the species. Therefore, Protein B and Casein would have to arise in the common ancestor of Horses, Cows and pigs.

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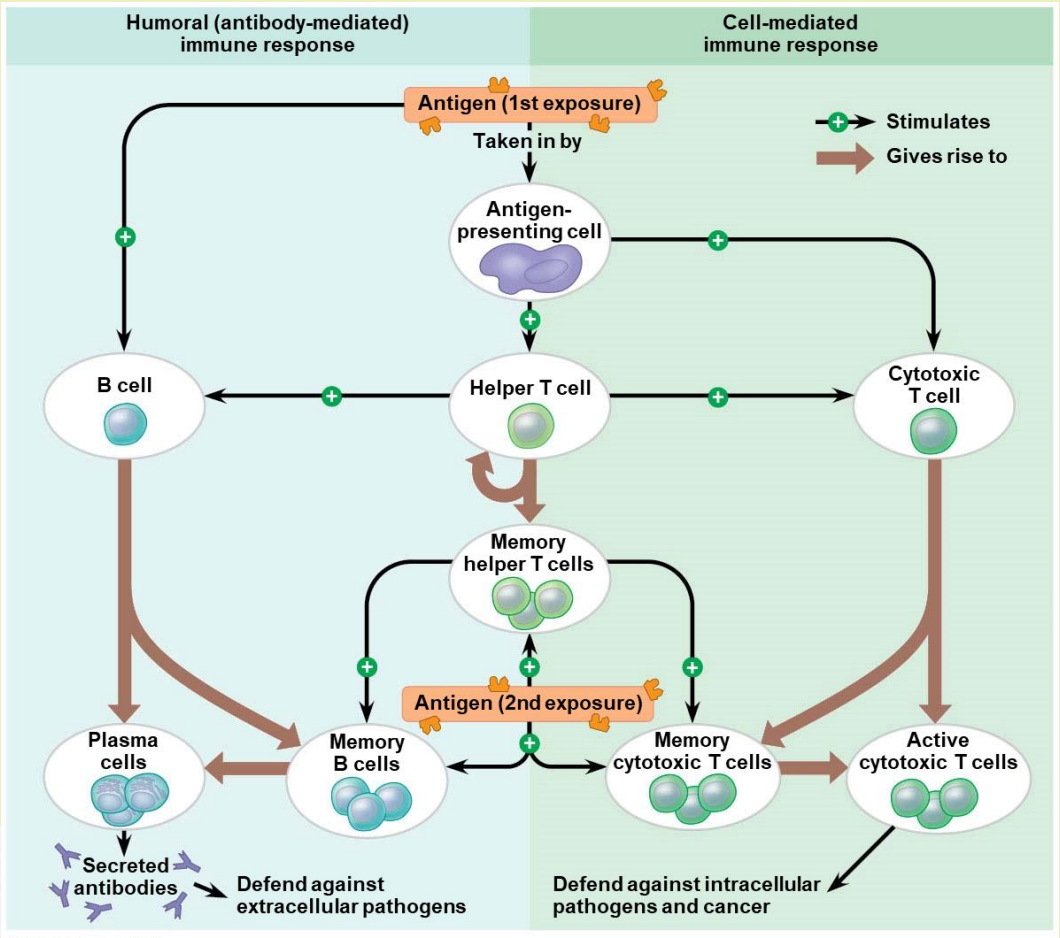
(b) **Describe** FOUR steps in the activation of the mother's specific immune response following exposure to a bacterial pathogen. **Predict** how the mother's immune response would differ upon a second exposure to the same bacterial pathogen a year later.



Description (**1 point each; 4 points maximum**)

- Endocytosis of antigen by dendritic cell/macrophage/B-cell
- Degradation of antigen
- Antigen complexed with MHC molecule
- Presentation of antigen on surface of cell
- Recognition of antigen on surface of antigen presenting cell by (helper) T-cell
- Activation of signal transduction mechanism in T-cell
- Activation of (helper) T-cell
- (Helper) T-cells release chemicals that recruit/activate B-cells
- Antigen recognition by B-cell
- Activation of signal transduction mechanism in B-cell
- Activated B-cell or T-cell will clone itself
- Plasma cells/B-cells produce antibodies
- Antibodies recognize antigen
- Antibody binding to antigen is specific
- Memory B cells/memory helper T cells are produced

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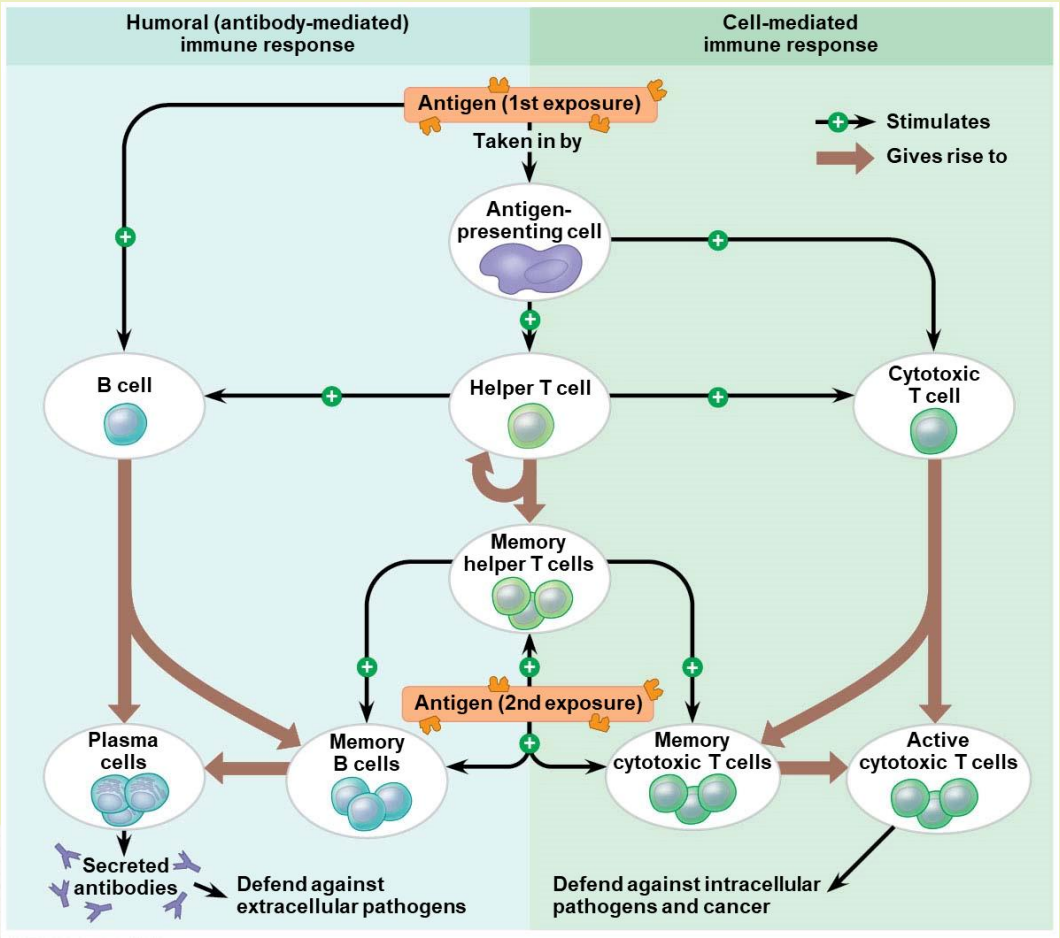

Prediction (**1 point**)

- Results in more rapid immune response
- Presence of memory cells
- Greater production of antibodies
- Antibodies circulate longer
- Antibodies have a greater affinity for the antigen

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(b) **Describe** FOUR steps in the activation of the mother's specific immune response following exposure to a bacterial pathogen. **Predict** how the mother's immune response would differ upon a second exposure to the same bacterial pathogen a year later.

b.) A macrophage will phagocytose the pathogen. It will then present the antigen to a helper T-cell. The macrophage will be known as an antigen presenting cell. The antigen will bind to receptors on the helper T-cell. Afterwards the helper T-cell will release cytokines that will signal B-cells and Cytotoxic T-cells. This known as the humoral response (B-cells) and cell mediated response (cytotoxic T-cells)

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respectively. The B-cells will then produce antibodies to combat the antigens. The antibodies will then clump antigens making it easier for macrophages to phagocytose them. The cytotoxic T-cells will recognize and destroy cells that have been infected by the antigen. After the antigen is dealt with some B-cells and cytotoxic T-cells will remain. During a second exposure the response would be way quicker, ~~once the antigen~~ due to left over B-cells and cytotoxic T-cells that are specific to that antigen. So these cells will instantly produce antibodies and attack infected cells. The second response would be much quicker and more organized.

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(c) **Predict** the most likely consequence for a nursing infant who is exposed to an intestinal bacterial pathogen (e.g., *Salmonella*) to which the mother was exposed three months earlier. **Justify** your prediction.

Prediction (**1 point**)	Justification (**1 point**)
Infant will be protected/not get sick	Antibodies are passed to infant *in utero*/via breast milk/infant receives B-cells in breast milk
Infant will become sick/die	Insufficient antibodies were transferred to the offspring/infant exposed to high infecting dose of the pathogen

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C.) The infant would already have antibodies that were given to it by its mother via possive immunity. Then the antibodies would make it significantly easier for the non-specific immune system of the infant to get rid of the antigens. Furthermore the infant could also have inherited cytotoxic T-cells from its mother that will help destroy cells infected by the antigen. The infant would most likely survive due to possive immunity.