

Name

BENG 100b: Frontiers in Biomedical Engineering

Midterm Examination

28 February 2006

There are 100 possible points on this exam. THIS EXAM IS CLOSED BOOK.

SHORT ANSWER (Total=70 points)

Read the questions carefully. For short answer questions, keep your response in the space provided, but give the most complete answer that you can.

1. (6 points) Distinguish between the innate and adaptive immune responses:

Innate immunity is present from birth and is achieved primarily via barriers, e.g. skin, mucous, temperature, pH. Innate immunity is non-specific and, therefore, responds equally to all assaults. Adaptive immunity, however, is specific and has memory. Those characteristics give it diversity and allow it to distinguish self from non-self. Adaptive immunity develops over time and uses B and T cells as well as antibodies to launch an immune response.

Innate immunity does not require stimulation by a specific antigen. It is non-specific, has no memory. Innate immunity involves macrophages, neutrophils, but not B cells and T cells (+3).

Adaptive immunity is specific, has memory (higher 2nd response) and involves T and memory B cells (+3)

2. (6 points) What is an antigen?

An antigen is a foreign molecule or particle that is recognized by the immune system.

An epitope refers to a small segment of an antigen that is recognized by an antibody, T cell receptor or other recognition element of the immune system.

+2 For an antigen is an foreign molecule or particle that is recognized

+2 For recognition by the immune system.

+2 For discussing how an antigen elicits an immune response

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3. (6 points) What is phagocytosis? Is phagocytosis by macrophages important in innate immunity, or in adaptive immunity, or in both? Explain.

cell-eating. is important to engulf/digest/destroy antigens in both types of immunity

4. (6 points) What is cDNA, and how would you produce cDNA from cultured cells?

Genomic DNA contains an organism's entire genome whereas cDNA only contains transcribed portions of the genome. As a result, genomic DNA has exons and introns and cDNA contains only the exons, i.e. the coding regions. Genomic DNA is identical for all cells in an organism, but cDNA differs from cell to cell, based on what is expressed, i.e. transcribed and translated, as determined by cell function, environment, etc. Genomic DNA is produced in the nucleus and cDNA is produced from mRNA in the cytoplasm. To produce cDNA, you would isolate the mRNA from a cell on interest and use reverse transcriptase to convert that mRNA into DNA.

+3 For cDNA is a complementary strand of DNA produced from mRNA. Because it contains only transcribed portions of the genome cDNA contains only the exons, i.e. the coding regions. Genomic DNA is identical for all cells in an organism, but cDNA differs from cell to cell, based on what is expressed, i.e. transcribed and translated, as determined by cell function, environment, etc. Genomic DNA is produced in the nucleus and cDNA is produced from mRNA in the cytoplasm.

+3 For To produce cDNA, you would isolate the mRNA from a cell on interest and use reverse transcriptase to convert that mRNA into DNA.

5. Insulin is a protein hormone and estrogen is a steroid hormone.

- a. (6 points) Describe in general terms the differences between their modes of action.

Protein hormones are proteins and are thus unable to cross the cell membrane. As such, their action arises from the interactions with specific protein hormone receptors which are mostly transmembrane proteins. The hormone binds the extracellular portion of the hormone receptor, causing a change in the conformation of the receptor and the activation of downstream effectors.

Steroid hormones are lipid soluble molecules which cross the cell membrane, and enter the cytoplasm. They interact with steroid hormone receptors, which are proteins located in the cytoplasm or the nucleus to activate signaling cascades. Most signaling by steroid hormones results in activation of transcription factors.

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+3 For proteins are water soluble and cannot pass through cell membranes, therefore it must bind to extracellular receptors. Steroids can pass through the cell membrane and interact with intracellular receptors

b. (4 points) Which of these two molecules is the most challenging to make into a drug? Why?

Insulin, i.e. proteins in general are more challenging.

They are large, complex molecules that often exist in tertiary conformations. They cannot be delivered orally because the digestive system is designed to break down proteins (enzymes). They also cannot be easily transported through membranes. They often have short half-lives in the bloodstream requiring repeated injections.

+1 For insulin/proteins are more challenging

+2 For proteins are large, complex molecules that often exist in tertiary conformations. They cannot be delivered orally bc your digestive system is designed to break down proteins (enzymes). They cannot be easily transported through membranes. They often have short half-lives in the bloodstream requiring repeated injections.

6. a. (4 points) Explain why this statement is false: The left ventricle is a stronger pump than the right ventricle because more blood is needed to supply the body tissues than to supply the lungs.

because pressure is proportional to flow and resistance. lungs has less resistance, so less pressure is needed to produce the same flow.

+2 for equation / relationship

+2 for identifying resistance of lunggs

b. (4 points) What is wrong with this statement? Repeated contraction and relaxation of the heart muscle leads to (**net**) flow of blood through the circulatory system.

Pressure difference drives flow

7. (6 points) Phospholipids can assemble into stable structures, such as bilayer membranes. Explain why these structures are stable, and what chemical features of phospholipids are important in this behavior.

Phospholipids are amphiphilic, meaning that they have both hydrophilic and hydrophobic groups. The head groups are polar/hydrophilic and the tails are hydrophobic. This allows for self-assembly into complex structures such as the cell membrane, because the hydrophilic heads orient towards the outside aqueous environment, while the hydrophobic tails associate with each other towards the inside and away from the water.

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+2 For discussing how phospholipids are amphiphilic meaning that they have both hydrophilic and hydrophobic groups.

+2 For discussing that the head groups is polar/hydrophilic and the tails are hydrophobic allowing for self-assembly into complex structures such as the cell membrane

8. (6 points) You swallow a smart pill, that remains within the lumen of your intestines, and transmits information as it passed through your intestinal tract. During transit, is that pill inside or outside of your body? Justify your answer.

+3 outside

+3 for epithelial cell, tight junctions, etc

9. (6 points) Define the concept of “selection” in cell culture. How can the plastic surface of a Petri dish be used to “select” for cells of interest?

Selection refers to the use of cell culture conditions to encourage growth or survival of a subpopulation of cells of interest. By picking the conditions of cell culture, you favor the growth and survival of cells that are best adapted to those conditions. In the case of plastic dishes, some cells will attach to a properly modified plastic surface while others will not. The surface can, therefore, be used to select for cells that adhere.

+3 for appropriate definition

+3 for explanation relating to plastic surface selection

10. a. (4 points) What is hybridization of a nucleic acid? What chemical forces are responsible?

Hybridization of a nucleic acid is the binding/association of single-stranded into double stranded nucleic acid molecule with base-pair alignment. Hydrogen bonding of base pairs is responsible for this specific interaction.

+2 binding/association of single-stranded into double stranded with base-pair alignment

+2 H-bonding of base pairs

b. (2 points) Describe one practical application of nucleic acid hybridization.

E.g., DNA fingerprinting or cloning.

+2 DNA fingerprinting, cloning, etc

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MULTIPLE CHOICE (3 points each, Total=30 points)

Read the questions carefully.

CIRCLE ALL OF THE CORRECT ANSWERS.

Write “NONE” if appropriate.

If you are unsure, use the area at the right of each question to explain your answer.

1. The production of an mRNA polymer from a DNA template is:

A. an essential step in the synthesis of a gene product.

B. called translation.

C. called transcription.

2. Osmosis is

A. the movement of ions

B. the movement of proteins

C. the movement of water

D. essential for proper function of the circulatory system

3. Cell culture

A. was first reported in 1950

B. can be initiated from human biopsy samples

C. are often created from rodent cells

D. are always immortal

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E. are one of the most important tools of medical research

4. The plasma membrane

A. includes lipids and proteins

B. is deformable

C. permits selective transport of ions

5. An organelle is

A. a membrane-bound structure found in the cytoplasm of eukaryotic cells

B. a collection of cells with a common function

C. an explant culture of cells

6. Attenuated viruses:

A. sometimes occur naturally

(variola --> vaccinia)

B. sometimes can be produced in the laboratory

C. cause immune responses but not disease

D. have never been used in humans

(the Sabine vaccine is an attenuated polio virus)

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7. A secondary antibody response (i.e. the response to a second exposure to antigen)

A. has higher antibody production when compared to the primary response

B. has a short lag period before antibody production begins

C. is exploited in immunization by “booster” shots

8. Pluripotent

A. refers to the use of more than one vaccine to activate the immune system

B. indicates the variety of mechanisms the kidney uses to concentrate urine

C. refers to a stem cell's ability to differentiate down multiple paths, resulting in different cell phenotypes

9. Metaphase

A. the resting period between mitotic events

B. describes the gap junctions between cells

C. used to describe the extracellular matrix

NONE

10. Biomedical engineering is

A. the development of technologies to improve human health

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**B. the use of engineering analysis
and methods to understand human
biology**

**C. the development of technology
for examining human function**

12. (4 points) Describe one element of biomedical engineering that you expected to hear about in this course, but has not appeared on the syllabus or been discussed in class.