

## 7.391 Concept-Centered Teaching Semester I

### 7.01x Misconceptions List

#### General Problems Students Face while Taking Introductory Biology

1. Students have difficulty visualizing biological molecules in 3D and understanding that these molecules interact because they can via a series of dynamic interactions.
2. Students rarely see the connection between what they are learning in class and everyday biological processes like diseases or eating.
3. Students do not see the connections between different aspects of biology, like biochemistry and genetics. They see biology as a series of separate topics.
4. Students do not understand how a genetic change can result in a phenotypic change at the protein level.
5. Students rarely understand the importance and prevalence of proteins in cells.
6. Students are unable to see the important concept(s) in historical experiments. They think they need to memorize the experiment and who performed it, and do not grasp the importance of the process.

#### Biochemistry

- Are Van der Waals interactions the only dynamic force?
- What is the role of the hydrophobic effect in energy minimization?
- How is a disulfide bond made?
- Is a disulfide bond different from a covalent bond?
- What is the role of a disulfide bond?
- What is the role of hydrogen bonds in maintaining secondary structure?
- Where are the R-groups found in an  $\alpha$ -helix?
- Is there a “hole” in the middle of an  $\alpha$ -helix?
- How flexible is an  $\alpha$ -helix?
- What is polarity? How is it related to shape and charge?
- What is ATP? Where is the energy stored?

#### Genetics

- What are a gene, allele, chromosome, DNA, and nucleic acids and how are they related?
- What is a double helix? What is its relationship to an  $\alpha$ -helix?
- What is the relationship of a gene to a protein and to a phenotype?
- How can a change in a gene cause a change in a protein?
- What does it mean to be dominant? Recessive?
- Is it easier to lose function or gain function in a protein? Why?
- Is it easier to get a dominant or recessive mutation? Why?
- What is a complementation test? A recessivity test?
- What is an epistasis test? How are the genetic changes related to the phenotypic changes?

- What do chromosomes look like? Are they really X and Y shaped?
- When and where does recombination occur? How is this related to recombinant DNA technology?

### Molecular Biology

- How does gel electrophoresis separate proteins?
- How and where is DNA replicated in the Messelsohn-Stahl experiments?
- What is the difference between semi-conservative, conservative and dispersive DNA replication?
- How can DNA be labeled with P<sup>32</sup>?
- What does DNA look like? Is it 2D or 3D?
- Why is DNA held together by hydrogen bonds instead of something more permanent?
- How and why is DNA replication bidirectional?
- Where are the phosphates found in DNA replication?
- How are RNA primers for DNA replication made?
- What is the role of RNA primers?
- What is a telomere and what is its role in DNA replication?
- What is a codon?
- What is the codon-anticodon, mRNA-tRNA connection?

### Gene Regulation

- What is the molecular difference between different cell types in the human body?
- Where does an amino acid bind the DNA?
- What types of interactions do proteins use to bind DNA?
- Where and what are the promoter, operator and enhancer?
- What is the role of a repressor and what is it?
- What are the roles of the regulatory elements in gene regulation?
- How do changes in protein shape affect gene regulation?
- How does a protein “know” where and how to bind DNA?

### Immunology and HIV

- How do viruses replicate themselves? Whose machinery do they use?
- What are the components of a virus? Why does it need a cell to propagate?
- What is the difference between an extracellular and intracellular response?
- What does a B Cell do? T cell?
- What is the role of a MHC I? MHC II?
- Why does an antigen presenting cell have both MHC I and MHC II molecules?
- Where does VDJ recombination occur, in DNA or RNA?
- What is an antigen versus a pathogen?
- Can a cell make multiple versions of the same antibody? TCR?
- From where do antigens come?
- How does HIV kill cells and eventually “kill” people?

### Recombinant DNA Technology

- What does cloning mean in biology?
- Are there eukaryotic types of bacteria?
- What do restriction enzymes do? Do they cut at random?
- How and where do small fragments ligate?
- How is it possible for fragments to ligate in both directions?
- What the difference between an origin and a promoter?
- How are the plasmids replicated? Are they autonomous or do they require an organism?
- How efficient is ligation?
- How efficient is transformation?
- Do antibiotics affect the plasmid or the organism? How does this assist cloning?

### 7.012 Specific

#### Organismal Cloning

- Why is it not necessary to fertilize an egg to make an oocyte divide?
- Would you want a nucleus from a meiotic or mitotic cell to clone?
- Why can't you place a nucleus from one organism into an oocyte of another?
- How does the environment of the developing fetus affect the cloned organism's trait?
- How many chromosomes does a somatic cell have? A germ cell?
- Do eggs and sperm undergo meiosis? Why or why not?
- Why do you need to arrest cells in G1 to transplant nuclei?

#### Cancer, Cell Cycle, and Signal Transduction

- What is the cell cycle?
- What is signal transduction?
- What are cyclins and CDK's and how do they work?
- Do cyclins and CDK's act together or separately?
- What are the traits of a cancerous cell?
- How is signal transduction related to cell growth and control of the cell cycle?
- How do mutations in signal transduction pathways connect with loss of need of growth factors in cancer?
- What are cAMP and ATP?