Biology 1305  
**Modern Concepts in Bioscience (ICB Textbook)**  
Week of December 6, 2021

Hi everyone! This week, we are going to review some of the most important concepts and figures that we have covered this semester in preparation for the final. In order to be successful on the final, make sure you start studying early, and remember to pace yourself! As always, we are going to focus on the big concepts which are emphasized by the ICB text.

In order to access all past resources from this semester, please go to the following page:  

Our last Group Tutoring Session will be from 5:15 PM to 6:15 PM in room 74 of the Sid Richardson building basement this Tuesday. Please see [Tutoring | Center for Academic Success and Engagement](https://www.baylor.edu/case/index.php?id=978656) for more information on how to sign up for sessions and how to access the many other resources that the Baylor Tutoring Center provides. You can always feel free to contact me at Mahita.Maddukuri1@baylor.edu if you would like to reach out with questions or feedback!

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**Final Review**

Recall that the structure of the ICB text is based on five big ideas:

1. Living systems have multiple mechanisms to store, retrieve, and transmit *information*.

2. The diversity and unity of life can be explained by the process of *evolution*.

3. *Cells* are a fundamental structural and functional unit of life.

4. Interdependent relationships characterize biological systems, and these interactions give rise to *emergent properties*.

5. Biological systems maintain *homeostasis*.

A great way to prepare for the final is to divide all of the concepts and figures we have covered this semester into these five big ideas. Because we can’t cover everything in this one resource, it’s important for you to go back and review all of the figures from previous chapters. Now, let’s look at some of the important concepts that we have covered over the past few months!
**Key Concepts:** Information is stored and passed on from generation to generation in the form of DNA. The information in DNA is ultimately used to make proteins and carry out many important cellular functions that are important for a living organism.

The fourth experiment led Griffith to hypothesize that there was a component of the S cells which was somehow communicated to the R cells, and that this component, which he called the “S factor,” was the “heritable material for all of life.”

Hershey and Chase’s results showed that about 80% of the radioactive phage protein was still in the media, which meant that it did not enter the bacteria. On the other hand, 70% of the phage DNA was found in the bacteria, and only 30% was found in the extracellular media. This meant that it was extremely unlikely that protein was the transforming factor, since the majority of it did not enter the cell.

The radioactive uracil is only found in newly transcribed RNA. The two large blue peaks are ribosomes. There are many small radioactive RNA molecules which vary in size, and which associate with the ribosomes in the cell, but not with individual rRNA molecules. This data showed that an RNA intermediate was being used to encode viral protein production. This was called messenger RNA.
When we breed a homozygous dominant parent with a homozygous recessive parent, all of the offspring will have the phenotype of the dominant parent and the heterozygous genotype. Therefore, the entire F1 generation is heterozygous.

Of the TOTAL F2 offspring, \( \frac{1}{4} \) of the peas were YY (homozygous dominant), \( \frac{1}{4} \) were yy (recessive), and \( \frac{1}{2} \) were Yy (heterozygous). Based on this, we can say that the genotypic ratio for this generation is 1:2:1, and the phenotypic ratio is 3:1.

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HIGHLIGHT #2: Evolution (Weeks 7-8)

Miller’s experiment demonstrated that amino acids could be synthesized in the conditions of the prehistoric earth, before life existed on our planet. His experimental design and results encouraged many new ways of visualizing and simulating abiotic formation of biological molecules.

**Evolution:** The change in the allele frequency of a population over time. The mechanisms of evolution are:

1) **Mutation:** a change in DNA sequence; can happen with erroneous replication of DNA by DNA polymerase
2) **Gene flow:** an individual from one population transmits a new allele to one or more individuals in another population.
3) **Genetic Drift:** allele frequency in a population changes due to random events; these random events can be environmental or due to overrepresentation or underrepresentation of an allele when gametes are produced during meiosis.

4) **Natural Selection:** which organisms which are better adapted for their environment have a higher chance of surviving in that environment, reproducing, and passing on their traits to their offspring.

This diagram illustrates how a primitive species could diverge into two branches, which later merged genomes to produce a third branch. Humans and all eukaryotes contain genes from both eubacteria and archaea which both diverged from a common ancestor, *species α*, long ago. This model explains why some human proteins are more closely related to eubacterial proteins, while others are more closely related to archaeal proteins.

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**HIGHLIGHT #3: Cells (Week 9)**

Scientists compared growth rates of different species of related green algae as a function of nutrient enrichment.

We can see from the above figure that *V. carteri* grew the fastest of the four species tested, suggesting that multicellularity with division of labor is better adapted to growth in a rich environment.
Biochemists used centrifugation to isolate chromatin fragments of DNA and histones in units of 1, 2, 3, or 4 beads. Remember that centrifugation is a technique that separates different components of a heterogenous mixture by size, shape, or density.

As we can see from the four peaks in this image, the chromatin separated into four distinct sized fragments. This helped to confirm that DNA was uniformly organized around distinct histone proteins.

### Protein Structure and Function

All proteins have at least three layers of structural information that allow them to fold and function correctly.

**Primary Structure**: the amino acid sequence of a protein; The primary structure of a protein contains all the information that is needed for the protein to form its final 3D structure.

**Secondary Structure**: describes local structures such as alpha helices and beta strands which are part of the overall folded protein.

**Tertiary Structure**: the overall 3D shape of the entire protein.

Some proteins also have quaternary structure, which occurs when multiple protein subunits assemble to form a larger multi-unit structure.

**Remember**: STRUCTURE DETERMINES FUNCTION
Epinephrine is a hormone which is secreted by your adrenal glands as part of your body’s fear response. The end result of this pathway is that your liver cells will be stimulated to release glucose.

- **Epinephrine** binds to the receptor
- The receptor changes shape and interacts with the G-protein
  - The G protein subunit dissociates and interacts with adenyl cyclase
    - Adenylyl cyclase converts ATP into cyclic AMP
    - cAMP diffuses throughout the cytoplasm until it binds and allosterically activates protein kinase A
  - pKA activates phosphorylase kinase and inactivates glycogen synthase through phosphorylation
  - Phosphorylase kinase activates glycogen phosphorylase, which removes one glucose from glycogen and adds a phosphate on carbon #1 of glucose to produce a monomer of glucose-1-phosphate
  - Inactivating glycogen synthase prevents it from synthesizing glycogen from glucose monomers (remember that we’re trying to release glucose, so we don’t want glucose to be stored as glycogen!)

This figure shows us that in glycolysis, a 6 carbon glucose molecule is oxidized into two 3 carbon molecules called pyruvates. It isn’t necessary to memorize every step, but notice that ATP is consumed during the first half of this process and is then produced in the second half. In addition to the pyruvate molecules, the net products of glycolysis are NADH and ATP. Additionally, after glycolysis, the resulting pyruvate molecules are further oxidized into CO2 plus an acetyl group, which is covalently attached to CoA. Acetyl-CoA is the common intermediate product which is formed in carbohydrate metabolism, lipid metabolism, and protein metabolism.
Joseph Priestly was trying to understand what was in the composition of air which allowed the flame of a candle to burn. The results of this experiment showed that in order for a flame to burn, both sunlight and the mint leaves were needed. If either of these two things were missing, the burning of the flame was not supported. Today, we know that the mint plant was releasing oxygen, which is needed for a fire to burn. In order for this to happen, sunlight was required.

HIGHLIGHT #5: Emergent Properties (Week 15)

This sigmoidal (S-shaped) solubility curve of Hemoglobin demonstrates that the amount of oxygen dissolved in a hemoglobin solution increases very rapidly with very little increase in oxygen concentration. This sigmoid-shaped oxygen solubility curve allows hemoglobin to move oxygen from high to low concentration in your body.
Hemoglobin has both low and high affinity (molecular attraction) for oxygen. This graph depicts oxygen saturation curves for three different molecules. The first molecule binds to oxygen with high affinity, the second molecule binds to oxygen with hybrid affinity, and the third molecule binds to oxygen with low affinity. Hemoglobin can bind to oxygen in the lungs (where the oxygen concentration is high) and release oxygen in the muscles (where the oxygen concentration is lower) because of its hybrid affinity binding.

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**CHECK YOUR LEARNING**

*(Answers below)*

1) Why was the phage system chosen by Hershey and Chase so effective for their experiment?
2) Where does transcription take place in the cell? What about translation?
3) What is the difference between two events being independent and mutually exclusive? Can two events be BOTH independent and mutually exclusive?
4) What is the probability of producing an F2 pea plant which is heterozygous (Yy)?
5) What was Stanley Miller trying to test? Why did he use ammonium, methane, and hydrogen gases for the “atmosphere” in his experiment?
6) Why do you think *volvox* thrive in nutrient rich environments but not in nutrient poor environments compared to other smaller species of algae?
7) Why does inactivating glycogen synthase play a role in increasing the release of glucose?
8) How many molecules of Acetyl-CoA can be produced if one molecule of glucose undergoes glycolysis?

ANSWERS

1) The phage had a fast generation time and only contained DNA and protein, which were the two molecules they were studying.

2) Transcription takes place in the nucleus. Translation takes place in the cytoplasm.

3) Independent events mean that one event does not affect the probability of the other event; the two probabilities of each event occurring are completely independent. Mutually exclusive events cannot both occur together; if one happens, then the other cannot happen. Therefore, we know that mutually exclusive events are NOT independent! The occurrence of one event prevents the other one from happening, which means it is definitely affecting the probability of it occurring, and the two events can never be independent.

4) The probability of getting a Yy plant is the probability of getting a Y allele from the female parent and a y allele from the male parent, OR vice versa. Remember that all of the F1 parents are heterozygous. Therefore, the probability is: $\frac{1}{4} + \frac{1}{4} = \frac{1}{2}$ (We have to first use the multiplication rule and then the addition rule).

5) Miller wanted to see if amino acids and other biologically important molecules could be formed in the abiotic conditions of the early earth. He used these gases because that is what the atmosphere of the early earth was composed of.

6) Maintaining larger colonies requires much more energy, so in nutrient poor environments where it is difficult to access the required nutrients, volvox expend more energy than other smaller species but cannot benefit from their colony structure. However, in nutrient rich environments, volvox’s colonies and division of labor give them an advantage.

7) Inactivating glycogen synthase stops it from forming glycogen. When the cell is trying to release glucose, formation of glycogen from glucose monomers opposes this goal. Instead, the cell wants to break down glycogen to release glucose.

8) 2 molecules (one from each of the two pyruvate molecule)

That’s it for this week! Please feel free to reach out with questions or check out Baylor Tutoring Center’s website for more resources. Good luck with your final exams!