Life in Its Biological Environment

Life in Its Biological Environment

FLORIDA STATE COLLEGE AT JACKSONVILLE

Contents

PART I

FACULTY RESOURCES

1. I Need Help

Need more information about this course? Have questions about faculty resources? Can't find what you're looking for? Experiencing technical difficulties?

We're here to help! Take advantage of the following Lumen customer-support resources:

- Check out one of Lumen's Faculty User Guides here.
- Submit a support ticket here and tell us what you need.
- Talk and screen-share with a live human during Lumen's OER office hours. See available times here.

PART II

MODULE 1: THE BUILDING BLOCKS OF LIFE

2. Introduction

Module 1 – The Building Blocks of Life

Introduction

Biology is the study of life and, in this course, we begin our journey toward understanding some of the basic concepts within the study of life. Cells are the basic unit of life and we will explore the cell in full in a few weeks, but to understand the life of the cell, we must begin by taking a close look at the basic building blocks of matter. Most of you are probably familiar with the term *matter* , which is defined as anything that has mass and takes up space. It is easy to memorize definitions like matter, elements, atoms, etc., but you want to really dissect the terms and think about how atoms which are the building blocks of matter come together to form important molecules within the cell like water, lipids, carbohydrates, and proteins (terms that you are probably more comfortable with than matter, elements, and subatomic particles).

For many of you, this module may be the hardest, but think of this as the "chemistry of life." It is important that you understand the chemical nature of the important molecules that make up the cell, the basic unit of life, to really understand the inner-workings of the cell. To that end, we begin this module by looking at the chemical nature of atoms, molecules, and matter and take a closer look at the chemical nature of these molecules that make up the air you breathe, the water you drink, as well as the important organic and inorganic molecules that make up your cells. One important concept to take away from this chapter is the chemical nature of the water molecule, which makes up 60-70% of the cell and has

some rather unique properties that allow for it's role in the cell and environment on the whole.

Please consider this a building course – each module introduces new concepts that build on the previous one. We will move at a fast pace and it is important that you have a strong understanding of the content covered in each module before you move on to the next. Be sure to give each of these modules the time they deserve as each one covers quite a bit of information. [1]

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom. [1]

Module Objectives

Upon completion of this module, the student will be able to:

- Define the following terms: *matter* , *element* , *atoms* , *atomic number* , *atomic mass* , *subatomic particles* , *protons* , *neutrons* ,*electrons* , *isotopes* , *valence shells* , *valence electrons* , *inert* , *polar* , *nonpolar* , *hydrophilic* , and *hydrophobic*

- Describe the properties of the subatomic particles and state the way in which electrons are organized in energy levels around the nucleus of an atom
- Use the atomic mass and atomic number from the periodic table of elements to determine the number of protons, neutrons, and electrons an element will have when electrically neutral.
- State the 4 elements that make up 96% of human body weight
- Discuss examples of elements that are essential for body function but required in smaller amounts
- State some uses of isotopes in science
- Describe the properties of covalent, ionic, and hydrogen bonds and review the examples in the text for each type of chemical bond covered in this module, .
- Describe the chemical properties of water
    - Name the type of chemical bond found within one water molecule between the oxygen and each hydrogen atom.
    - Name the type of chemical bond found between two adjacent water molecules.
- Define pH, be familiar with the terms: acid, base, and neutral solution and review the examples within the text. [1]

3. Readings and Resources

Readings and Resources

Read the attached document, *Module 1 Readings* (Module_01_Readings.pdf).

You will need Adobe Acrobat Reader to access this file. [2]

PART III

MODULE 2: LIFE'S COMPONENTS: BIOLOGICAL MACROMOLECULES

4. Introduction

Module 2 – Life's Components: Biological Macromolecules

Introduction

Your work in this module will be dedicated to exploring 4 important organic macromolecules. These 4 macromolecules (proteins, lipids, carbohydrates, and nucleic acids) make up 96% of your body mass. At the cellular level, these molecules play critical roles in the structure and the overall function of the cell. As mentioned in Module 1, this is a building course, so you want to bring what you learned in Module 2 (the chemistry of life) to your work on this module. Understanding the chemical nature of the subunits, or monomers, that make up these polymers, is essential to understanding their "work" at the cellular level.

A central theme in biology, and science in general, is "structure equals function". In other words, organisms, environments, and molecules work the way they do (function) because of how they are built (their structure/ their chemical make-up). This module is an excellent example of this concept in that many of the large, organic molecules we will discuss; carbohydrates, lipids, proteins, and nucleic acids, are all critical to the general function of your body and what allows for their respective functions is 100% a result of their structure. Please review the examples of large, organic molecules discussed in the text. [1]

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom. [1]

Module Objectives

Upon completion of this module, the student will be able to:

- State the definitions of polymers and monomers and describe the general way in which they are synthesized and broken down.
- For each of the large, organic molecules covered in this module (carbohydrates, proteins, nucleic acids, and lipids (for which you will further break down into fats and oils, phospholipids, and steroids)), describe the following:
    - the general chemical make-up of each
    - the monomers or repeating units of which they are composed
    - the functions of each
    - give examples of each [1]

5. Readings and Resources

Readings and Resources

Read the attached document, *Module 2 Readings* (Module_02_Readings.pdf).

You will need Adobe Acrobat Reader to access this file. [2]

PART IV

MODULE 3: THE CELL

6. Introduction

Module 3 – The Cell

Introduction

We have reached our discussion on the smallest unit of life, the cell. For many students, this module is one of their favorites. In Module 1, you worked to gain a general understanding of the chemistry of life, and then put those concepts together to think about how and why certain atoms interact to form important organic molecules of the cell. You took a closer look at these individual molecules, their structure, and their general functions and in this module you will put all of these concepts together to gain an understanding of how they work together to promote the life of the cell, the basic unit of life.

In addition to defining the function of the individual structures within the cell, be aware that there is communication among the structures within the cell. An example is the act of producing a lysosome. The digestive enzymes found in the final product (lysosomes) are produced in the rough endoplasmic reticulum. A vesicle buds off of the rough endoplasmic reticulum and carries the digestive enzymes to the golgi apparatus, where the vesicle will dock and fuse. The membrane of the vesicle becomes a part of the golgi apparatus and "dumps" the digestive enzymes into the golgi. Once the final vesicle buds off of the golgi apparatus carrying the digestive enzymes within, this is called the lysosome, and is an example of two compartments/ organelles acting together within the cell.

In this module, think about the "cell theory", compare eukaryotes

and prokaryotes, and then take a close look at the structures within the cell and the functions they provide to the cell on the whole. When you are reviewing the structures within the cell, also keep in mind the size of the cell (small; how small?) and the idea that the structures within the cell have their individual functions, but also interact with each other to promote the overall functioning of the cell.

Another important concept to consider in this module is that as cells specialize, they develop more or less of the organelles listed above. For example, red blood cells (RBCs) in the body will actually squeeze the nucleus out of the cell during development. Why? The nucleus is often thought of as the "brain of the cell", since this is where your genetic information, DNA, is stored. Consider the theme "structure equals function" from Module 2 and apply it to the function of the red blood cell. This particular cell's main function is carrying oxygen to nourish the cells of the body. To this end, RBCs are packed full of hemoglobin and squeezing the nucleus out of the cell can be seen as a way to pack in more hemoglobin molecules and allow for more oxygen to be carried. You will explore cell specialization in the discussion board for this module [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom. [1]

Module Objectives

Upon completion of this module, the student will be able to:

- State the cell theory
- Compare eukaryotes and prokaryotes and give examples of each
- Compare plant and animal cells and name cellular structures discussed within the chapter that they have in common and also those that are unique to each organism
- Define organelle.
- Describe the function of the cellular structures covered within this module including the following:
    - plasma membrane
    - nucleus
    - cell wall
    - cytosol and cytoplasm
    - rough and smooth endoplasmic reticulum
    - ribosome
    - chloroplasts
    - mitochondria
    - large central vacuole (name at least three functions within the plant cell)
    - vesicles
    - golgi apparatus
    - lysosomes
    - peroxisomes
    - glyoxysomes
    - cytoskeleton (name at least three functions within the cell)
- Describe how lysosomes break down old organelles and foreign material within the cell.
- Consider how the individual structures within the cell work together for the overall function of the cell [1]

7. Readings and Resources

Readings and Resources

Read the attached document, *Module 3 Readings* (Module_03_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2].

PART V

MODULE 4: THE PLASMA MEMBRANE

8. Introduction

Module 4 – The Plasma Membrane

Introduction

You learned in the last module that cells are the basic unit of life. We explored some of their internal structures and how those internal structures facilitate the life of the cell. One of the most important features of the cell is the external barrier of the cell, the plasma membrane. All cells have a plasma membrane. As you know from your work in the last module, the plasma membrane is made of a phospholipid bilayer with proteins, and other molecules, embedded and provides the cell will some measure of control over what is entering/ exiting the cell (selective permeability).

Why is this important? Every cell, whether it represents a unicellular organism or one cell of a multicellular organism, interacts with it's environment. Each cell will in the least require nutrients (entering) and make waste (exiting) the cell.

In this module, we will review the composition of the plasma membrane in more detail and then discover several ways in which molecules enter/ exit the cell through the plasma membrane. In addition to phospholipids, you will explore roles of proteins embedded in the plasma membrane. Also, it is important to note that the membranes of the endomembrane system (please define) are also composed primarily of phospholipids and proteins.

Once you have a strong understanding of the general composition of the plasma membrane in general, investigate passive and active movement across the membrane. You should be able to describe the examples discussed within the text (simple diffusion, osmosis,

facilitated diffusion, active transport, and bulk transport: exocytosis and endocytosis).

While you work on understanding these concepts, it is also important to consider that while all cells have a plasma membrane only some additionally have a cell wall. Consider the plant cell wall and how this structure will influence the response of the plant cell to different tonicities. Figures 3.22 and 3.23 in your readings provide an overview of animal and plant cells exposed to isotonic, hypotonic, and hypertonic environments. [1]

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Review the composition of the plasma membrane.
- Review the composition of the plant cell wall (NOTE: other organisms have cell walls that may differ in composition, but have some similar functions).

- State which types of molecules freely pass the plasma membrane.
- Define the Fluid-Mosaic Membrane model as it relates to the plasma membrane.
- Describe the concepts of passive and active transport and for each of the examples covered in this module define: (simple diffusion, osmosis, facilitated diffusion, active transport).
- Describe the general idea of tonicity – see Figures 3.22 and 3.23 in the readings.
- Define isotonic, hypotonic, hypertonic solutions and state how they influence the cell in general.
- Define bulk transport: endocytosis and exocytosis [1].

9. Readings and Resources

Readings and Resources

Read the attached document, *Module 4 Readings* (Module_04_Readings.pdf).

You will need Adobe Acrobat Reader to access this file. [2]

PART VI

MODULE 5: ENERGY AND CELLULAR RESPIRATION

10. Introduction

Module 5 – Energy and Cellular Respiration

Introduction

What do the hairs on your arm "standing" upright, movement of nutrients into the cell, and production of food by photosynthesis all have in common? These are processes that require energy input at the cellular level. When you think of where you obtain cellular energy, you may say from eating nutritious food. You would not be wrong in that answer, but in the next few chapters we will peel back the layers to understanding metabolism basics at the cellular level and on the organism level. We will explore the energy currency of the cell, the process from which cells are able to produce energy which is used to power the above-mentioned processes and many others, and discuss how you are able to use nutrients within food to produce energy at the cellular energy through a process called cellular respiration.

Cells are miniature factories inside of which many reactions take place every second. The collection of all these reactions is referred to as *cellular metabolism*. Two examples of reactions taking place within the cell are reactions that break large organic molecules into smaller subunits and those that build large organic molecules from their subunits. Think about some of the important organic macromolecules that we discussed in Module 2 (carbohydrates, lipids, proteins, and nucleic acids). Can you name the repeating units, or monomers, that compose these macromolecules? In this module, we will explore how the single units, monomers, are combined to produce the polymers mentioned above, and how

macromolecules can then be broken down. Why is this important for the overall functioning of the cell/ organism? We will add to the "why" in the next as we will look specifically at the break down of the sugar molecule (the monomer of carbohydrates) and how this monomer can be broken down to release energy.

We will also explore enzymes: molecules that catalyze reactions within the cell. We will examine how enzymes are able to speed reactions within the cell, factors that influence enzyme function in the cell, and how enzymes are regulated. By the end of this module, you should have an understanding of the laws of thermodynamics, the idea of spontaneous and non-spontaneous reactions and how to determine the nature of a reaction within the cell. In addition, you should understand the energy currency of the cell. Here we will focus on ATP.

Next, we will look the process of energy production at the cellular level or *cellular respiration* .

Previously, you learned about an organelle called the *mitochondria* . This organelle is often called the "powerhouse" of the cell. Why? The mitochondria is where most of the energy (ATP) is produced in the cell. Since this is a building course, think about what you can bring to the discussion in this module from your previous work. In Module 3, The Cell, you were introduced to the mitochondria and the cell types where you would expect to see more or less of these organelles. What were they? You know that eukaryotes have membrane-bound organelles, under which the mitochondria falls. Some examples of organisms that have mitochondria, are plants and animals.

What about bacteria? Bacteria fall under the prokaryote classification. We know from Module 2 that these organisms do not contain membrane-bound organelles, but some bacteria do have the ability to undergo cellular respiration (the process that produces energy/ ATP). In fact the mitochondria is thought to have originated through an endosymbiosis event where a eukaryotic cell engulfed (the "endo" part of endosymbiosis) a bacteria that had the ability to produce energy and that bacteria was incorporated (the "symbiosis"

part of endosymbiosis) into the overall functioning of the eukaryotic cell rather than being digested and broken down. This is called the*Theory of Endosymbiosis* and is a topic for a discussion board this module.

In this module, you will also focus on understanding the processes of cellular respiration and fermentation. Here, you will research how ATP is made. We will take each of the three steps that make up cellular respiration and break them down for a better understanding of the process on the whole. For each step, compare the specific way in which the ATP is produced. It is important that for each of the following steps: Glycolysis, the Citric Acid Cycle (or Kreb's Cycle), and the Electron Transport Chain, you understand:

1. where in the cell each takes place
2. how much ATP is produced
3. the general process of each step
4. how steps one and two (glycolysis and the Citric Acid Cycle, also called the Kreb's Cycle) facilitate the last.

Be familiar with the compartments of the mitochondria and understand where the phases mentioned above take place. This will require a review of the use of the electron carriers, where the electron carriers "take" and "drop off" electrons, and where the energy-rich electrons come from originally. A good way to think about this process on the whole is the stepwise breakdown of sugar to release energy. Other molecules can be used to produce ATP and we will explore alternative fuel sources for this process as well. We will compare fermentation and cellular respiration and, for the types of organisms that undergo both, determine which is more beneficial to the cell [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define the laws of thermodynamics and how they apply to energy transformations
- Recall that ATP facilitates most energy coupling in the cell
- Recall what ATP stands for and how it is used as energy in the cell
- State the difference between ADP and ATP
- Describe how ATP is recyclable.
- Answer the following questions regarding enzymes:
    - What type of organic molecules are most enzymes? And, given that answer, what subunits are they made of?
    - What allows for one enzyme to perform one function while another enzyme will perform a completely different function?
    - What provides enzyme specificity?
- Define metabolism

- Identify spontaneous and non-spontaneous reactions
- Discuss how temperature and pH affect enzyme function
- Define cofactors, coenzymes, enzyme inhibitors, and non-competitive inhibitors
- Describe how enzyme activity is regulated in the cell
- Define all of the bold terms within the chapter
- Define redox reactions
- Describe the process of cellular respiration
- Compare and contrast cellular respiration and fermentation
- Describe the overall reaction of cellular respiration and then break that reaction down into the three phases that make up the process
- For each of the phases of cellular respiration, describe where in the cell it takes place, what is required and produced for each phase/ step of this process, and how much ATP is generated
- State how the cell uses ATP for energy
- State which step generates the most ATP and how the other two steps power this process
- Name the final electron acceptor in cellular respiration
- Define ATP synthase and describe where it is found and what powers it
- Name the different compartments of the mitochondria [1].

11. Readings and Resources

Readings and Resources

Read the attached document, *Module 5 Readings* (Module_05_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2] .

PART VII

MODULE 6: PHOTOSYNTHESIS

12. Introduction

Module 6 – Photosynthesis

Introduction

In the last few modules, we looked at some of the processes that require energy at the cellular level and examined the production of energy through cellular respiration (the stepwise breakdown of the glucose molecule ("food")). In this module, we will explore the ability that some organisms have to produce their own food.

As you are likely aware, plants produce their own "food" or sugar through a process called *photosynthesis* . They are autotrophs while we are heterotrophs and cannot produce our own food. While there are other organisms that also produce their own food (and I challenge you to identify a few on your own), we will focus, in this module, on how plants produce their own food through the process of photosynthesis. Think of photosynthesis as the process of building complex molecules (sugar) that will later be broken down through cellular respiration to produce cellular energy (ATP).

As you work through this module, think first about the plant structures that facilitate photosynthesis and then examine the nature of sunlight and the energy used to power this process. Once you have a good general understanding of the structures involved and the nature of sunlight, break down photosynthesis further and explore the two essential stages of photosynthesis:

- the Light Reactions
- the Calvin Cycle

Think about how these processes lead to the production of sugar and oxygen as a by-product. Once you feel comfortable with these things, you will look at some of the alternative ways plants "fix" carbon.

One interesting thing to consider as you finish this module are the similarities between cellular respiration and photosynthesis. On the surface they may seem like completely opposite processes, but they have quite a few similarities including the following:

- both are multi-step processes within the cell
- both undergo chemiosmosis as part of the process and involve electron carriers
- both take place in organelles that are thought to have been acquired through endosymbiosis (The Theory of Endosymbiosis) [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define autotroph and heterotroph and give examples of each.
- Identify two organisms outside of plants that undergo photosynthesis.
- Define the following terms: *producer* , *consumer* , *chloroplast* , *chlorophyll* , *thylakoid* s , *grana* , *stroma* , *photosystems I and II* , *stomata* ,*guard cells* , *mesophyl* .
- Describe the overall reaction of photosynthesis, identify the reactants and products, and compare them to the reactants and products of cellular respiration.
- Answer the questions:
    - Where in the plant body does photosynthesis take place?
    - What structures are involved?
- Define pigment.
- Answer the questions:
    - What pigment promotes photosynthesis in the plant?
    - What qualities of light does it preferentially absorb?
    - What qualities will it reflect?
- Describe the two essential steps of photosynthesis (The light reactions and the Calvin cycle) and where (specifically) they take place in the chloroplast.
- Describe the properties of light.
- Answer the question:
    - How does this form of energy promote photosynthesis in the plant?
- State several similarities between the processes of cellular respiration and photosynthesis.
- Describe the differences between C3, C4, and CAM plants in terms of the process of photosynthesis [1] .

13. Readings and Resources

Readings and Resources

Read the attached document, *Module 6 Readings* (Module_06_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2].

PART VIII

MODULE 7: THE CELL CYCLE, MITOSIS, AND MEIOSIS

14. Introduction

Module 7 – The Cell Cycle, Mitosis, and Meiosis

Introduction

At this point in the semester, we have defined cells as the basic unit of life and we know that, as stated in the cell theory, all new cells come from pre-existing cells. We have examined the working parts of the cell, the nature of the molecules that compose the cell, the organelles found within the cell, how those organelles work together to produce proteins, lipids, and even (some) produce sugar and energy at the cellular level. For this next module, we will begin our work looking at the "life of a cell" or cell cycle in which we examine the steps needed to duplicate the contents of one cell so that one cell can undergo division (mitosis or meiosis) to produce new cells.

We will focus our work in this module on exploring the life cycle of animals and how/ when/ where duplication, division and fertilization take place. The animal life cycle is something you may already be familiar with. Think about what you already know:

Looking at the animal/ human life cycle: Can you name the first cell in the life cycle? What is the name of the first cell of a multicellular human being?

Since the cell theory states that all new cells come from pre-existing cells, where does this cell come from? Answer: The fusion of sex cells (the sperm and egg cell). Where do the sex cells come from? We will start with these questions and "follow the cell" through the cell cycle, and division (mitosis and meiosis).

Once we have completed this module, you should be familiar with the stages of the cell cycle, generally how long each stage takes to complete, and the stages of mitosis and meiosis.

Below are some questions that you should be able to answer following the completion of your work in this module:

- When during the animal life cycle does this process occur?
- For mitosis and meiosis, how many overall divisions will occur and what phases make up one division?
- How many daughter cells will be formed and will those daughter cells be identical to the parent cell?
- In addition, for meiosis, consider what processes contribute to genetic diversity in the sex cells that are produced and why genetic diversity is important in the first place [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define the following terms: *gene* , *genome* , *chromosome* , *diploid* , *haploid* , *centrosome* , *homologous chromosome* , *cytokinesis* ,*interphase* , *cytoskeletal fibers* , *centromere* , *sister chromatids* .
- Define the cell theory (as stated in Module 3).
- Describe the phases of the cell cycle (Interphase and the M phase) and what happens during each phase of the cycle.
- State the general time frame that the cell spends in each of the phases of the cell cycle.
- Define when mitosis and meiosis occur during the animal life cycle.
- Define fertilization.
- Name the cellular structures that are involved in the process of mitosis and meiosis.
- Describe what happens during each of the phases within mitosis and meiosis.
- Describe the differences in plant and animal cells in late telophase.
- Describe binary fission in bacteria.
- Describe crossing over and independent assortment.
- Describe the problems that can occur during the cell cycle and how those changes will affect the cells that are produced [1] .

15. Readings and Resources

Readings and Resources

Read the attached document, *Module 7 Readings* (Module_07_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2] .

PART IX

MODULE 8: DNA REPLICATION AND GENE EXPRESSION

16. Introduction

Module 8 – DNA Replication and Gene Expression

Introduction

In the last few modules, we learned that DNA is our genetic information and that segments of DNA, called *genes* , contain the information to produce specific proteins. We know that DNA is stored in the nucleus of eukaryotes, such as plants and animals. We even explored how these genes are passed from parent to offspring. In this module, we will examine how your genetic information, DNA, is used to produce specific proteins. For our work in this module, think first about the molecules that are involved in the process of using the information in DNA to produce a protein. You will want to review DNA, RNA, and proteins (first described in Module 2). Be familiar with their general structure, the monomers which make up the polymers, compare DNA and RNA in terms of structure. Become familiar with the three types of RNA that are mentioned as involved in the process of gene expression.

In the second half of the module, we will take a closer look at the "process" of gene expression. You know that DNA is found in the nucleus of eukaryotes and that proteins are synthesized at the ribosome. For this portion, you will break down the overall process of nuclear gene expression into three main step – transcription, mRNA processing/ editing, and translation.

In short, transcription is the process of using the information in DNA to make a piece of mRNA, the intermediate in the process of using a piece of DNA to produce a protein. RNA, and specifically

messenger RNA (mRNA) acts by taking the information found in the DNA (the code) to the ribosomes where protein synthesis will take place. Ask yourself:

- Why doesn't DNA just leave the nucleus and go to the ribosomes when a new protein is needed in the cell?
- Why have the intermediate?

You will work through RNA editing (which only takes place in eukaryotes) and alternative splicing. After transcription and RNA editing, your mature mRNA moves to the ribosomes in the cytoplasm which you know are little protein factories within the cell.

While most of your focus in this module will be in understanding the process of gene expression in eukaryotes, it is also important to consider that this process also takes place in prokaryotes. You know that prokaryotes, like bacteria, have genetic material found in the cell and have the need to make proteins. Ribosomes are found within prokaryotes and are the site of protein synthesis (translation). Once you have reached a good understanding of gene expression in eukaryotes, compare the process to prokaryotes [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are

encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define gene expression.
- Define gene.
- Answer the questions:
    - Where are genes found in eukaryotes vs. prokaryotes?
    - How are genes organized in eukaryotes vs. prokaryotes?
- Name the cellular structure in eukaryotes and prokaryotes where protein synthesis takes place.
- Describe the general structure of the DNA and RNA molecule.
- Name the three types of RNA discussed in this module. For each type (mRNA, tRNA, and rRNA), know where they are involved in gene expression, and what the small letter prior to the "RNA" represents.
- Describe the general differences between gene expression in eukaryotes and prokaryotes.
- Focusing on gene expression in eukaryotes, be able to answer the following questions as they relate to transcription in eukaryotes:
    - Name the enzyme that initiates transcription.
    - Identify where this process take place in the cell.
    - Name the general steps of the process.
    - Describe what allows the enzyme that initiates this process to begin in the correct location processes of transcription and translation.
    - Identify what signals the end of transcription.
- Describe the process of transcription and tranlation. State what signals the end of each process.
- Describe RNA editing/ processing in eukaryotes.

- Define alternative splicing.
- Be able to describe:
    - Translation.
    - Where in the cell this process takes place.
    - How the ribosome is able to “read” your transcript.
    - How rRNA and tRNA are involved in this process.
    - State what type of RNA allows for the change in message from nucleotides to amino acids (DNA and the mRNA intermediate are both composed of nucleotide subunits while protein is composed of amino acids) [1].

17. Readings and Resources

Readings and Resources

Read the attached document, *Module 8 Readings* (Module_08_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2] .

PART X

MODULE 9: GENETICS

18. Introduction

Module 9 – Genetics

Introduction

At this point in the course, we have discussed genetic material in some detail. You know the location of the genetic information in the cell, and where the genetic information of eukaryotes and prokaryotes can be found. In addition, we have examined the structure of the DNA molecule, examined how it is packaged into chromosomes in the cell, and how those chromosomes are passed from one cell to another through the cell cycle, and mitosis and meiosis. We also talked about how genetic diversity can be accomplished through the processes of crossing over and independent assortment in meiosis. In this module, we will begin our work in understanding the basics of genetics. Genetics is the study of "genes" and inheritance. One of the earliest scientists working in this field was Gregor Mendel. We'll look at his work with pea plants and the information that his work with plants elucidated.

Interestingly, at the time of Mendel's work, DNA had not been identified as the genetic material. The structure and the whereabouts in the cell of DNA were completely unknown. In addition, mitosis and meiosis had yet to be defined. Mendel was in essence experimenting with how genetic material was passed along without knowing what the genetic material was, what it looked like, or where it was found in the cell.

In this module, focus your efforts on understanding the basics of Mendelian genetics. Apply some of the things you have learned through your work in this course (like the definition of a gene, the

structure of DNA, and the process of gene expression) to examine how traits are inherited. By the end of this module, you should be able to perform genetic crosses when given the genetic information of the parents and the trait in question. You should be able to determine possible gametes from the parental genotypes, perform a cross (through the use of parental genotypes, produce a Punnett Square) and you should be able to analyze the offspring in terms of the expected genotypic and phenotypic ratio of the offspring.

Spend some time thinking about exceptions to the rule(s). When might you see inheritance patterns in offspring that do not follow normal Mendelian genetics? Examine situations where multiple alleles, codominance, and incomplete dominance play a role in a genetic cross [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define terms related to Mendelian genetics (all bolded terms within the text).
- Describe normal Mendelian Genetics.
- Complete Punnett Squares and determine expected genotypic and phenotypic ratios of offspring.
- Describe crossing over and independent assortment as related to Mendelian genetics.
- Describe inheritance patterns outside of normal Mendelian genetics patterns.
- Use genetic information to determine phenotypes.
- Define sex-linked traits.
- Perform 1 and 2 trait crosses.
- Perform a cross involving a sex-linked trait.
- Define the terms allele, complete dominance, incomplete dominance, and codominance.
- Perform crosses dealing with genes that demonstrate variations of dominance.
- State the genetic disorders covered in the reading for this module and describe the cellular events that cause each disorder.
- Discuss genetic testing and be able to perform pedigree analysis [1].

19. Readings and Resources

Readings and Resources

Read the attached document, *Module 9 Readings* (Module_09_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2].

PART XI

MODULE 10: BIOTECHNOLOGY

20. Introduction

Module 10 – Biotechnology

Introduction

Your readings define *biotechnology* as "the use of artificial methods to modify the genetic material of living organisms or cells to produce novel compounds or to perform new functions" [2]. Another way to think about biotechnology is as a "tool" or really "tools" that can be used to better our lives in a variety of ways. Biotechnology is an ever-changing, evolving, and exciting field. There are many methods/ technologies that fall under this heading. You will explore only a few in this module. It is important to consider that the technologies described in your readings only scratch the surface of the work that is being done now and being developed for future use [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.

- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define *Biotechnology* .
- Describe the technologies discussed in this module.
- Define: *clone* , *vector* , *plasmid* , *polymerase chain reaction (PCR)* , *recombinant DNA* , *stem cell* , *transformation* , *transgenic organism.*
- Answer the questions:
    - Why is it important to identify credible resources for exploring topics in science?
    - Why is evidence-based science important?
    - What damage does the spread of pseudo-science and anti-science do to society?
    - What can you do to identify credible information in the news, online, and in general? [1]

21. Readings and Resources

Readings and Resources

Read the attached document, *Module 10 Readings* (Module_10_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2].

PART XII

MODULE 11: DIVERSITY OF LIFE I

22. Introduction

Module 11 – Diversity of Life I

Module Introduction

Introduction

In Module 3, we defined cells as the basic unit of life and then went on to categorize all cells into one of two groups: eukaryotes or prokaryotes. You learned that all cells have an outer membrane called the plasma membrane and all cells have genetic material, DNA. While there are differences in the amount of genetic material, how the genetic material is organized, where it is found in the cell, and what it encodes, all cells have this material and in all cases the "code" in the genetic material is encrypted in a series of nucleotides. While the basic units for the "code" are the same, there is obviously so much diversity when you compare bacteria to animals and other organisms. What allows for that diversity?

In the these next two modules, we begin to explore the diversity of life and the three domains of life: Archea, Bacteria, and Eukarya. In this module, we will scan the following groups of organisms:

- bacteria
- archea
- protists
- fungi

We will even take a look at viruses, which are not classified as living things [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define the three domains of life: Archea, Bacteria, and Eukarya.
- Describe several ways microbes are essential to life.
- Describe how viruses "hijack" living cells and state the purpose of this "hijacking."
- Define several types of beneficial bacteria.
- Describe several types of bacteria that have ill effects on humans.
- Answer the questions:
    - What traits would an organism have in order to be classified as a protist?
    - What protists are able to undergo photosynthesis?

- Define *autotroph* and *heterotroph.*
- Define *pathogen* , *extremophile* , *mutualism* , and *binary fission.*
- Describe several roles for fungi in society and nature.
- Define *lichen* , *hyphae* , *sessile* , *spore* , *yeast* , *mutualism* .
- Answer the questions:
    - How do fungi obtain nutrients?
    - How is this similar/ dissimilar to the way humans obtain nutrients? [1]

23. Readings and Resources

Readings and Resources

Read the attached document, *Module 11 Readings* (Module_11_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2].

PART XIII

MODULE 12: DIVERSITY OF LIFE II

24. Introduction

Module 12 – Diversity of Life II

Introduction

In this module, we will explore the diversity within the plant and animal kingdoms. For each kingdom, begin with the basic concept of "What is a plant?" and "What is an animal?" What traits define these categories of life?

Begin by defining animal. While there is a lot of diversity within this category of life, and you will read about the nine phyla that fall under this category and the unique characteristics for each phyla, you should start by identifying what these organisms have in common. What must each have to remain under the classification "animal". As you work through the nine phyla, think about the progression of characteristics from one organism to the next. Compare their mode of reproduction, the way they obtain nutrients, and how they expel waste.

One concept that links this module to the last (Diversity of Life I) is the idea that all cells/ organisms need nutrients and make waste. Let's look at two types of heterotrophs, one from this module (animals) and one from last module (fungi). Both organisms must obtain their food from another source and cannot make their own food. Animals will consume/ take food into the body where digestive enzymes will break down the organic macromolecules which make up the food source into monomers inside the body and then transport the breakdown products to nourish the cells of the body (monomers that we have discussed: sugar, amino acids, etc.).

Fungi are also heterotrophs and unable to make their own food.

Rather than ingest complex food molecules and digest within the body, they release digestive enzymes outside of the body and then absorb the broken down products. In both cases, the multicellular organism is breaking down a polymer and obtaining the nutrients (monomers) of the breakdown process. In one case, this is happening within the body and in the other outside of the body [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define *animal* .
- Define each phyla under this category and describe several unique traits for each.
- Describe how animals reproduce: sexual vs. asexual methods that are found within these nine phyla
- Please describe what is meant by this statement: In animals, there is a level of protection for the egg following fertilization.

- Compare vertebrates and invertebrates. Which are we?
- Define circulation and organs. What benefit does our circulatory system provide us? What kind of things travel through our cardiovascular system?
- Define *sessile* .
- Compare the life cycles of animals to plants. What are the similar processes? What is different between the two life cycles?
- Describe the different types of land plants: nonvascular, vascular, seeded, nonseeded, gymnosperm and angiosperm
- What benefit does vascular tissue provide plants that contain it?
- Compare the vasculature of the plant to the cardiovascular system in animals. What similar functions do these systems provide the organisim?
- Name the parts of the flower and seed. Describe reproduction as it occurs in angiosperms and the floral structures they are involved.
- Describe the ways that plants can adapt to a changing environment and why this is important to plant survival [1] .

25. Readings and Resources

Readings and Resources

Read the attached document, *Module 12 Readings* (Module_12_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2] .

PART XIV

MODULE 13: EVOLUTION

26. Introduction

Module 13 – Evolution

Module Introduction

Introduction

What is *evolution* ? What does this term really mean? Evolution is something that is frequently referenced incorrectly. In this module, you will begin to better understand this term in general, how it applies to the development of new organisms, and agents that promote evolution.

One thing to consider as you begin your work in this module, is that evolution, as scientists speak of it, is the gradual (slow) change in species that can lead to the development of new organisms/ species over time. There are many factors that can contribute to the "change in species" that allow for development of new species and much of your work in this module will be in reviewing these factors.

Another important consideration is that some organisms may be able to "evolve" quicker than others. Consider bacteria, for example. These organisms have a faster life cycle than we do, they can exchange genetic information in many ways, and have a higher rate of mutation than us. All of these factors allow for more diversity and that diversity can set the stage for the production of a new species.

A mutation is a change in the DNA or the genetic material of the organism. There are different ways that mutations can result and when a mutation occurs, that change in the DNA might

- have no effect on the organism and proteins produced from this gene,
- produce a new protein that increases the "fitness" of the organism,
- produce a new protein that does not increase the "fitness" of the organism, etc.

It is important to consider that a bacteria cannot just decide that it would like to be resistant to a given antibiotic. Rather, a mutation may occur that allows for resistance to a give antibiotic and this resistance would provide the bacteria with a selective advantage and increased "fitness" when compared to other bacteria. By exposing resistant and susceptible bacteria to the antibiotic in question, the resistant bacteria would obviously have an advantage – they will not die [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Describe evolution, natural selection, and "survival of the fittest."
- State Darwin's work and the evidence of evolution.
- Identify agents of microevolution.
- Describe microevolution and macroevolution.
- Define *species* .
- Describe how new species arise.
- Define reproductive isolating mechanisms discussed in this module [1].

27. Readings and Resources

Readings and Resources

Read the attached document, *Module 13 Readings* (Module_13_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2] .

PART XV

MODULE 14: ECOLOGY

28. Introduction

Module 14 – Ecology

Introduction

Ecology can be defined as the study of the interrelationship of organisms to each other and to their physical surroundings. This module and the next are a fun way to end your work on the study of life. It is important to consider the diversity of life, the organisms that make up our environment, and then to consider the ways in which organisms interact with each other and with the environment.

As an introduction to this module, here is one way in which organisms interact with each other that benefits both organisms involved. Lichens, for example, represent two organisms involved in a symbiotic relationship (example of mutualism). The pair may be a fungi and a photosynthetic bacteria or a fungi and an algae that can undergo photosynthesis. In either case, the fungi is thought to provide shelter to the bacteria or algae while the bacteria or algae provide photosynthate (food).

You learned in Module 7 that some organisms can convert solar (light) energy to chemical energy (sugar) through the process of photosynthesis. While plants are likely the organisms that come to mind first when you consider organisms that undergo photosynthesis, some bacteria and also algae (protists) undergo this process as well. A lichen is an example of two organisms interacting to benefit one another, but in this module you will look at many other types of relationships. Challenge yourself to try to identify

the following community interactions in addition to the mutualism example given here:

- competition
- commensalism
- predation and parasitism [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define *ecology* .
- Define *community* , *biodiversity* , and *species diversity* .
- Define the types of interactions among community members.
- Describe interaction through competition and give an example.
- Describe interaction through predation and parasitism and give examples.
- Describe interactions through mutualism and commensalism

and give examples.

- Describe what is meant by "succession in communities." [1]

29. Readings and Resources

Readings and Resources

Read the attached document, *Module 14 Readings* (Module_14_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2].

PART XVI

MODULE 15: ECOSYSTEMS AND BIOMES

30. Introduction

Module 15 – Ecosystems and Biomes

Introduction

We began our work in this course looking at the smallest units of matter (as a reminder, matter is anything that has mass and takes up space). In this module, you should be able to apply everything we have discussed so far to your study of the ecosystem ("a community of organisms and the physical environment with which they interact") and biomes. One topic within this module that I would like for you to consider is global climate change [1].

Learning Outcomes

This module addresses the following Course Learning Outcomes listed in the Syllabus for this course:

- Demonstrate knowledge of biological principles.
- Demonstrate knowledge of scientific method.
- Communicate scientific ideas through oral or written assignments.
- Interpret scientific models such as formulas, graphs and tables.
- Demonstrate problem solving methods in situations that are encountered outside of the classroom [1].

Module Objectives

Upon completion of this module, the student will be able to:

- Define *ecosystem* and *biomes*.
- Describe how energy flows through the ecosystem.
- Explore Earth's physical environment.
- Define *climate*.
- Describe global climate change, the evidence for global climate change, and the effects of global climate change.
- Identify Earth's biomes.
- Describe aquatic ecosystems [1].

31. Readings and Resources

Readings and Resources

Read the attached document, *Module 15 Readings* (Module_15_Readings.pdf).

You will need Adobe Acrobat Reader to access this file [2] .

PART XVII
ATTRIBUTIONS

32. Footnote Attribution List

Attributions for Life in its Biological Environment

(1) Content by Florida State College at Jacksonville is licensed under Creative Commons Attribution 4.0 International License .

(2) OpenStax, Concepts of Biology. OpenStax CNX. Jun 13, 2017 http://cnx.org/contents/b3c1e1d2-839c-42b0-a314-e119a8aafbdd@9.22 .