Standard 18 : Matter and Energy Transformations

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A. All living things are composed of four basic categories of macromolecules and share the same basic needs for life.

B. Living organisms acquire the energy they need for life processes through various metabolic pathways (primarily photosynthesis and cellular respiration).

C. Chemical reactions in living things follow basic rules of chemistry and are usually regulated by enzymes.

D. The unique chemical properties of carbon and water make life on Earth possible.

General Information

Number: SC.912.L.18

Title: Matter and Energy Transformations

Type: Standard

Subject: Science

Grade: 912

Body of Knowledge: Life Science

Related Benchmarks

This cluster includes the following benchmarks

Code	Description
SC.912.L.18.1	Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules.
SC.912.L.18.2	Describe the important structural characteristics of monosaccharides, disaccharides, and polysaccharides and explain the functions of carbohydrates in living things.
SC.912.L.18.3	Describe the structures of fatty acids, triglycerides, phospholipids, and steroids. Explain the functions of lipids in living organisms. Identify some reactions that fatty acids undergo. Relate the structure and function of cell membranes.
SC.912.L.18.4	Describe the structures of proteins and amino acids. Explain the functions of proteins in living organisms. Identify some reactions that amino acids undergo. Relate the structure and function of enzymes.
SC.912.L.18.5	Discuss the use of chemiosmotic gradients for ATP production in chloroplasts and mitochondria.
SC.912.L.18.6	Discuss the role of anaerobic respiration in living things and in human society.
SC.912.L.18.7	Identify the reactants, products, and basic functions of photosynthesis.
SC.912.L.18.8	Identify the reactants, products, and basic functions of aerobic and anaerobic cellular respiration.
SC.912.L.18.9	Explain the interrelated nature of photosynthesis and cellular respiration.
SC.912.L.18.10	Connect the role of adenosine triphosphate (ATP) to energy transfers within a cell.
SC.912.L.18.11	Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions. Identify factors, such as pH and temperature, and their effect on enzyme activity.
SC.912.L.18.12	Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent.

Related Access Points

This cluster includes the following access points.

Independent

Access Point Number	Access Point Title
SC.912.L.18.In.1:	Identify that carbohydrates, fats, proteins, and nucleic acids (macromolecules) are important for human organisms.
SC.912.L.18.In.2:	Identify the products and function of photosynthesis.
SC.912.L.18.In.3:	Identify that cells release energy from food so the organism can use it (cellular respiration).
SC.912.L.18.In.4:	Recognize that plants give off oxygen that is used by animals and animals give off carbon dioxide that is used by plants.
SC.912.L.18.In.5:	Recognize that energy is stored in cells.
SC.912.L.18.In.6:	Recognize that enzymes break down food molecules during the digestive process.
SC.912.L.18.In.7:	Identify that special properties of water, such as the ability to moderate temperature and dissolve substances, help to sustain living things on Earth.

Supported

Access Point Number	Access Point Title

SC.912.L.18.Su.1:	Recognize that humans use proteins, carbohydrates, and fats.
SC.912.L.18.Su.2:	Recognize that the function of photosynthesis is to produce food for plants.
SC.912.L.18.Su.3:	Recognize that cells get energy from food.
SC.912.L.18.Su.4:	Recognize that people and animals breathe in the oxygen that plants give off.
SC.912.L.18.Su.5:	Recognize that food is broken down in digestion (use of enzymes).
SC.912.L.18.Su.6:	Identify the important role of water in sustaining life of plants and animals.

Participatory

Access Point Number	Access Point Title
SC.912.L.18.Pa.1:	Recognize that humans need different kinds of food.
SC.912.L.18.Pa.2:	Recognize that plants need water, light, and air to grow.
SC.912.L.18.Pa.3:	Identify that food is a source of energy.
SC.912.L.18.Pa.4:	Recognize that saliva helps people eat when they chew.
SC.912.L.18.Pa.5:	Recognize that plants and animals use water to live.

Related Resources

Vetted resources educators can use to teach the concepts and skills in this topic.

Original Student Tutorials

Name	Description
The Story of ATP Synthesis and the Role of Chemiosmosis:	The story of the role of chemiosmosis in ATP synthese is told through the animation of hydrogen ions in the last steps of cellular respiration.
The Macromolecules of Life: Carbohydrates:	Learn about the basic molecular structures and primary functions of carbohydrates with this interactive tutorial. This is part 2 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Overview • The Macromolecules of Life: Lipids • The Macromolecules of Life: Proteins • The Macromolecules of Life: Nucleic Acids
The Macromolecules of Life: Lipids:	Learn about the basic molecular structures and primary functions of lipids with this interactive tutorial. This is part 3 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Overview • The Macromolecules of Life: Carbohydrates • The Macromolecules of Life: Proteins • The Macromolecules of Life: Nucleic Acids
The Mystery of Muscle Cell Metabolism:	Explore the mystery of muscle cell metabolism and how cells are able to meet the need for a constant supply of energy. In this interactive tutorial, you'll identify the basic structure of adenosine triphosphate (ATP), explain how ATP's structure is related it its job in the cell, and connect this role to energy transfers in living things.
Enzymes are the Stuff of Life:	At any instant in your life, millions and millions of enzymes are hard at work in your body as well as all around you making your life easier! By the end of this tutorial you should be able to describe how enzymes speed up most biochemical reactions as well as identify the various factors that affect enzyme activity like pH and temperature.
The Macromolecules of Life: Proteins:	Learn about the basic molecular structures and primary functions of proteins with this interactive tutorial. This is part 4 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Overview • The Macromolecules of Life: Carbohydrates • The Macromolecules of Life: Lipids • The Macromolecules of Life: Nucleic Acids
Fueling the Body: Cellular Respiration:	Explore how organisms gain usable energy and compare the two types of cellular respiration; aerobic and anaerobic. In this interactive tutorial, you'll also learn about reactants and products of both aerobic and anaerobic respiration.
ATP: Fuel for Cells:	Explore how cells use ATP as an energy source for cellular activities in this interactive tutorial.
The Macromolecules of Life: Nucleic Acids:	Learn to identify and describe the structural and functional features of nucleic acids, one of the 4 primary macromolecule groups in biological systems, with this interactive tutorial. This is Part 3 in 5-part series. Click below to open the other tutorials in the series: • Macromolecules: Overview • Macromolecules: Carbohydrates • Macromolecules: Nucleic Acids • Macromolecules: Lipids • Macromolecules: Proteins

The Macromolecules of Life: Overview:	Learn to identify the four basic biological macromolecules (carbohydrates, lipids, proteins, and nucleic acids) by structure and function with this interactive tutorial. This is part 1 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Carbohydrates • The Macromolecules of Life: Lipids • The Macromolecules of Life: Proteins • The Macromolecules of Life: Nucleic Acids
Water and Life:	Learn how the chemical properties of water relate to its physical properties and make it essential for life with this interactive tutorial.
Photosynthesis: Capturing the Sun's Energy to Create Sugar:	Learn how to identify and describe the role of all of the major molecules needed for photosynthesis. You'll also be able to explain the role that photosynthesis plays in capturing carbon from the atmosphere to produce sugars.
Energy and Carbon in Photosynthesis and Cellular Respiration:	Learn more about photosynthesis and cellular respiration. In this interactive tutorial, you will gain awareness of the connections between these two very important processes with regard to energy and carbon.

Lesson Plans

Name	Description
Fueling Cells: Photosynthesis & Cellular Respiration :	This a lesson that focuses on the metabolic processes of photosynthesis and cellular respiration and how the two processes are related.
The Last Supper: Identifying Macromolecules:	The students will solve a mystery using laboratory tests for different types of macromolecules. They will use argumentation to justify and communicate their claim. They will construct explanations and communicate with one another to determine which macromolecule would be best to eat in different scenarios. Students will be able to identify the structure and functions of the four main types of macromolecules. The students will use laboratory testing to determine the identity of an unknown. They will fill in a chart about the structures, functions, and examples for each macromolecule type and then they will practice their knowledge by answering short response questions relating the macromolecules to the real world. Finally, they will review using a whole-class cooperative activity and take a quiz about the structures and functions of macromolecules.
ATP is Like a Wallet Full of Money!:	In this lesson, students will relate the role of ATP as an energy-carrying molecule to a wallet with money in it. This is a great lesson for visual and kinesthetic learners. This lesson involves hands on modeling, movement around the room, and conceptual learning.
Enzymes: The Greatest Biological Catalysts:	This lesson focuses on the role of enzymes as biological catalysts. The resource contains a lab that demonstrates enzyme reactions and a worksheet with activities for the students to select from.
Understanding Cellular Respiration and Photosynthesis:	Students will partake in an introduction of the processes of photosynthesis and cellular respiration and how they are interrelated. Within this lesson they will also receive data on how each of these processes relate to each each other in the real world. This lesson serves as a basic introduction to the standard.
Protein Folding: Predicting Structure:	In this lesson students will explore the different levels of protein structure with hands on manipulative to relate protein structures with their function. In addition, students will predict possible effects on protein function when the protein structure has been altered.
Macromolecules and the Athlete:	Students will analyze an athlete's diet to better understand the macromolecules needed for survival. Students will learn the primary function and structure of carbohydrates, lipids, and proteins.
A Day of Macromolecules:	The purpose of this lesson plan is to exercise students' knowledge of the structures and functions of the four major types of macromolecules by playing Macromolecular Go Fish, solving Macromolecular Math problems, and finally competing with one another in a macromolecule-style game of Names from a Hat.
Loss of Vision in Astronauts:	In this lesson plan, students will analyze an informational text intended to support reading in the content area. The article addresses the results of a new study that will help researchers identify which astronauts will develop vision problems in space. The text describes how Scott M. Smith from the Biomedical Research and Environmental Sciences Division at NASA's Johnson Space Center has found a metabolic pathway that is directly related to the vision problems some astronauts encounter. This pathway, called the one carbon metabolism pathway, moves single atoms from one organic compound to another. Astronauts who develop vision problems have been found to have a different genetic variant, which changes the way the enzymes of this pathway work. This will also affect people on Earth, as the same enzymes are also used here and are linked to other medical problems. The lesson plan includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric. Numerous options to extend the lesson are also included.
Photosynthesis: Let's Grow This!:	Students will learn the process of photosynthesis by designing an experiment to distinguish between the light and dark stages of photosynthesis.
Post-It Concept Map: Cellular Respiration :	Students will connect information learned about cellular respiration through a concept map using Post-It notes. This activity should be used as a review after learning the entire unit of cellular respiration.
Push-Up Challenge:	Students will compete in a push challenge to feel the effects of lactic acid fermentation on their body. Data about pain levels will be collected and analyzed to pinpoint when their body shifted from aerobic to anaerobic cellular respiration.
The Main Man - Mitochondria:	In this lesson students will demonstrate the process of aerobic and anaerobic cellular respiration and identify where it occurs within the cell. Students will review with a video, label a mitochondria, and create a eukaryotic cell tracing the path of cellular respiration.
Photosynthesis with Spinach:	This is an engaging lesson using probeware to look at photosynthesis and respiration with spinach leaves.

Homeostasis and Exercise:	This fun activity highlights the relationship of exercise to cellular respiration to gene energy.
Respiration of Yeast:	This follow-up activity lets student investigate cell respiration in the lab using yeast and Mantis probe-ware.
STEM Engineering Design Challenge: Yeast Fermentation:	Students will design an experiment to measure the effect of various macromolecules on fermentation rates of yeast. Students will imagine, plan, and implement their designs in a collaborative manner and then will improve their experiment after the first results. The ultimate goal is for students to be able to discuss the role of anaerobic respiration in living things and develop their scientific thinking skills as they solve a problem within a small group. This is an inquiry-based lab that is to be facilitated by the teacher but will provide the students the opportunity to test and defend their own thinking as they design their experiment and analyze their results.
ENERGY! Aerobic Cellular Respiration:	Students will sequence the steps of cellular respiration through a guided PowerPoint and WebQuest.
Reactants and Products of Cellular Respiration:	Students will be introduced to both aerobic and anaerobic cellular respiration through guided notes. They will practice what they learned through a guided practice and a handout, emphasizing the reactants and products of both types of cellular respiration.
A Whole New World: The Search for Water 5E Lesson:	In this lesson, students will run a variety of tests on different liquids. During their experimentation, students will collect data, graph data, collaborate and discuss their findings, compare their findings to known characteristics of water, make a claim, provide evidence and justification to support their claim, and create an advisory report of their findings. Students will run various tests on several different liquids and compare those characteristic to those of water. Students will gain an understanding that water is unlike other liquids in the way that it moderates temperature, in its cohesive strength, in its ability to expand upon freezing, in its pH neutrality, and in its designation as the "universal solvent."
Enzymes in Action 5E Lesson:	Students will predict, investigate, observe, and report on the effects that pH, concentration, and temperature have on catalase enzyme reactions. Students will conduct an experiment in which they will alter the pH, concentration, and temperature of the environment in which catalase enzyme reactions are taking place. Students will be able to describe how changes in these environmental conditions affect the action of the enzymes in living things.
Enzyme Kinetics Inquiry:	In this lesson, students work from lower to higher levels of scientific inquiry while studying enzyme kinetics in a practical, student-centered, flipped-classroom process. In addition to reviewing the importance of enzymes to biological systems and examining the factors that influence their activity, this is a good lesson to practice the scientific method, from replication of pre-designed experiments to asking questions, designing investigations, collecting and analyzing data, sharing findings, and engaging in peer review. Designed for higher-level classes, this lesson can be modified, simplified, or shortened for regular and honors classes.
Carbohydrates and Dehydration Synthesis:	The structure of carbohydrates is an important concept for students to understand. This lesson will discuss the structure of carbohydrates and their function in living things. The focus of the activity will be on the structure of disaccharides and how the bonds are formed.
Easy Enzymes:	In this lesson, students will learn how important enzymes are by functioning as a catalyst in most all biological processes. In learning about the functions of enzymes, they will also see how they are related to things they come across in everyday life. Students will observe the breakdown of hydrogen peroxide by catalase from potatoes.
Two Essential Life Processes Working Hand In Hand:	This lesson plan has been designed to help teachers instruct their students on the processes of photosynthesis and cellular respiration. The goal is for students to recognize the connection between the two. The resources in this lesson plan have been designed to help students investigate and deepen their knowledge on the concepts of photosynthesis and cellular respiration.
Carbohydrates and the Energy Mystery:	Students will be able to explore the structure and function of carbohydrates by building structural models and creating an inquiry lab that explores the energy capacity of monosaccharides, disaccharides, and polysaccharides.
ATP Please!:	This lesson aims to assist students in making the connection between cell respiration, mitochondria, and ATP. Using guided inquiry and independent reading, students will be prepared to present a clinical case study on a mitochondrial myopathy to the class.
Follow the Energy:	Students will describe the processes of photosynthesis and cellular respiration and explain how they work in tandem to convert sunlight into energy that cells can use.
Yeast Fermentation Inquiry - Predict, Observe, Explain:	Using the Predict, Observe, and Explain model, students will be able to identify the basic function of cellular respiration. Students will predict what is needed for yeast fermentation, why they do it and what gas is being released. With a teacher led debrief, students will then decide what factors allow fermentation to occur and finally explain why it's happening.
The Mitochondrial Mystery:	In this lesson students will explore aerobic and anaerobic respiration with a real world case of a 3-year-old boy who suffers from a mitochondrial disorder. Students will compare and contrast aerobic and anaerobic respiration and relate it with the boy's symptoms.
Learning Cell Respiration through Legos:	This activity will model the oxidation of glucose to CO_2, H_2O, and generation of ATP using Lego building blocks. Groups of 4 students will draw pertinent cell structures and identify the locations of the steps of cellular respiration as the activity proceeds. Lego blocks will be assembled into molecules and disassembled as respiration proceeds.
Comparing Carbohydrates:	Students will participate in a teacher-directed lesson on the structural differences of carbohydrates and their function in living things. Concept ideas will be organized with a graphic organizer that students will use in a group activity to create an original concept map demonstrating understanding of the topic. Student understanding will be assessed via a 2-3 paragraph summary.
	This lesson will allow students to observe and identify evidence of an enzyme's activity, lactase, and its function, and action on a substrate found in milk, lactose. They will then relate the absence of lactase to the condition of lactose

Got Lactase? :	intolerance, which many students or family members of students experience. Enzymes are a type of protein essential to life and necessary for many of the metabolic reactions that occur in the human body. Since these reactions occur at the molecular level within the body, students do not directly observe enzymes functioning.
Water as a Solvent:	The lesson is an activity introducing the versatility of water as a solvent. Students will initially predict the solubility of a substance by matching the substance with an appropriate solvent. Then the concepts involved in solubility, ionic compounds versus covalent compounds, and polar compounds versus non-polar compounds will be presented. Students will have an opportunity to present and discuss the reasoning behind making their selection of a solvent for a particular solute.
Enzymes, Eggs, and Active Sites - Factors that Affect their Activity:	This lesson will demonstrate enzyme-substrate complex and how they work in a biochemical reaction. It will also introduce factors that effect the rate of enzyme activity. Students will be asked to model enzymes and how they work in a biochemical reaction by interacting with an egg as the reactant/substrate and producing a fried egg over easy. Students will be asked a series of questions along the way and later will work in small groups to come up with their own model of a short biochemical pathway (1-2 steps) and identify the enzymes involved in the process. The model or process they choose should come from their every day experiences.
Meet Your Macromolecules:	This lesson teaches applied concepts associated with the four macromolecules: lipids, carbohydrates, proteins, and nucleic acids.
Complementarity of Photosynthesis and Cell Respiration:	Using sensor technology, the effect of living plants and animals on each other will be assayed to model the complementarity of the two metabolic processes.
The Drama of Glucose Regulation:	*Students will act out glucose metabolism - from the blood stream to cells where they will be converted to ATP, with help from insulin.*
Protein Synthesis: Transcription & Translation:	Students will explore the process of protein synthesis, specifically transcription and translation, using a sequenced graphic organizer and an interactive simulation (Lesson 1 & 2). This resource contains 3 lessons: • Lesson 1: Transcription & Translation • Lesson 2: Lac Operon • Lesson 3: Proteins & Cancer As an extension (Lesson 3) the students will justify the applications of biotechnology that uses transcription and translation to synthesize proteins that target cancer cells or reason the possibilities of the amplification of antibodies using immortal cells. They will explore how mutations, genetic or epigenetic (lifestyle-chemicals, radiation, viruses), resulting in cancer. The student will connect changes that occur in the genetic code, during transcription and translation, to the deleterious impact on proto oncogenes that promote cell division and tumor suppressor genes that normally inhibit it.
Where'd that come from?!?:	This is a lab activity resource to accompany learning of photosynthesis and the Calvin cycle. Students are able to measure change in water conditions and gaseous production associated with autotrophs.
Organic Macromolecules:	In this lesson students will be learning to recognize and compare and contrast the four different organic macromolecules. This lesson will require the viewing of a 7 minute video and will require 4 large groups of six students to work cooperatively together in a team effort to complete an organic macromolecule chart.
It's a Small World:	Students will create a closed system and investigate the effects of organisms on the pH of the closed system to examine the interrelated nature of photosynthesis and cellular respiration.
Just Breathe!:	Students will complete an experimental lab setup using snails and elodea in test tubes placed in light and dark conditions to test the outcomes.
Why Do Apples Turn Brown?:	Students design an experiment to determine the effects of pH and temperature on enzyme activity in apples.
Anaerobic Respiration and You:	This lesson plan explains anaerobic respiration and its role in human society. It is designed for two class periods, each 50 minutes in length, and one take home activity. Students are going to compare and contrast the physiology of two types of anaerobic respiration and identify different microorganisms that are used in the modern food industry. The teacher explains and presents the content and the procedures on the first day as a lesson walk through. There is an optional activity (yogurt making and bacterial smear) that can easily be performed in the classroom. It is highly recommended that Honors and AP students should be given the optional activity provided with this lesson plan.
Macromolecule Snack Attack:	In this MEA, students will be introduced to the four biological macromolecules through common snack foods found in vending machines. They will act as dietitians selecting and ranking snack foods based on given their nutrition labels and knowledge of the structure and function of the four biological macromolecules.
A Macromolecule Mystery: Who Took Jerell's iPod? :	Students use their knowledge of organic compounds to solve a simulated mystery (Who took Jerell's iPod) by testing for triglycerides, glucose, starch, and protein. This lab deepens student understanding of biological functions and food sources of various organic compounds.
Testing water for drinking purposes:	The importance of knowing what drinking water contains. How to know what properties are present in different bottled water. Knowing the elements present in water that is advantageous to growth and development of many things in the body. To know what to be alert for in water and to understand the importance of water in general.
Macromolecule Food Indicator Lab:	In this lesson students will complete a lab using indicators to determine which foods contain carbohydrates, lipids, proteins, and/or starches. The lab includes pre-lab questions, discussion, lab experimentation, post lab questions, results and conclusion. The students will submit a completed lab report that will be graded based on a rubric.

The Seven Major Properties of Water:	The goal of this lesson is that students will be able to conduct mini-experiments that demonstrate how water behaves. Students will perform the experiment, collect the data, diagram results, and generate a definition of the seven properties of water.
Corn Conundrum:	The Corn Conundrum MEA provides students with an agricultural problem in which they must work as a team to develop a procedure to select the best variety of corn to grow under drier conditions predicted by models of global climate change. Students must determine the most important factors that make planting crops sustainable in restricted climate conditions for the client. The main focus of this MEA is manipulating factors relating to plant biology, including transpiration and photosynthesis.
ATP: The Fuel of Life:	The goal of this lesson is to introduce students who are interested in human biology and biochemistry to the subtleties of energy metabolism (typically not presented in standard biology and biochemistry textbooks) through the lens of ATP as the primary energy currency of the cell. Avoiding the details of the major pathways of energy production (such as glycolysis, the citric acid cycle, and oxidative phosphorylation), this lesson is focused exclusively on ATP, which is truly the fuel of life. Starting with the discovery and history of ATP, this lesson will walk the students through 8 segments (outlined below) interspersed by 7 in-class challenge questions and activities, to the final step of ATP production by the ATP synthase, an amazing molecular machine. A basic understanding of the components and subcellular organization (e.g. organelles, membranes, etc.) and chemical foundation (e.g. biomolecules, chemical equilibrium, biochemical energetics, etc.) of a eukaryotic cell is a desired prerequisite, but it is not a must. Through interactive in-class activities, this lesson is designed to spark the students' interest in biochemistry and human biology as a whole, but could serve as an introductory lesson to teaching advanced concepts of metabolism and bioenergetics in high school depending on the local science curriculum. No supplies or materials are needed.
Enzymes Help Us Digest Food:	Students learn about enzyme function, enzyme specificity, and the molecular basis for lactose intolerance.

Perspectives Video: Experts

Name	Description
Glucose Metabolism:	It's not a secret - exercise and weight control key to a healthy metabolism! Download the CPALMS Perspectives video student note taking guide.
Invasive Ants and Competition in the Kenyan Savannah:	Patrick Milligan shares his research on invasive ant species in the Kenyan savannah. Download the CPALMS Perspectives video student note taking guide.
Hormone Functions in the Body: Oxytocin:	In this video, neuroscientist Liz Hammock explains the role of proteins in the body using the hormone oxytocin as an example. Download the CPALMS Perspectives video student note taking guide.
Enzymes and Energy:	Learn how enzymes play a key role in regulation of cellular energy and metabolism. Download the CPALMS Perspectives video student note taking guide.
Knot Theory Entangled in Cellular Biology:	This FSU professor describes how knot theory and cellular biology are intertwined. Researchers are still trying to determine how enzyme bridges are able to un-knot long strands of DNA to mitigate potential cell destruction. Download the CPALMS Perspectives video student note taking guide.
Protein Structure and Function:	Don't get twisted in a knot about proteins; learn about their structure! Download the CPALMS Perspectives video student note taking guide.
Photosynthesis in Space:	A NASA botanist explains how studying photosynthesis now can help feed astronauts in the future. Download the CPALMS Perspectives video student note taking guide.

Perspectives Video: Professional/Enthusiasts

Name	Description
Nestle Waters & Statistical Analysis:	Hydrogeologist from Nestle Waters discusses the importance of statistical tests in monitoring sustainability and in maintaining consistent water quality in bottled water. Download the CPALMS Perspectives video student note taking guide.
Fitness and Cell Respiration:	Oxygenate your cells through physical activity. Download the CPALMS Perspectives video student note taking guide.
Linseed Oil Properties for Oil Painting:	Oil paints certainly left their mark on history and are widely used in art today! Produced with funding from the Florida Division of Cultural Affairs. Download the CPALMS Perspectives video student note taking guide.
Oil Painting Technique:	Understanding the science behind oil painting can help you become a better artist! Produced with funding from the Florida Division of Cultural Affairs. Download the CPALMS Perspectives video student note taking guide.

Perspectives Video: Teaching Ideas

Name	Description
Photosynthesis or Cellular Respiration?:	Get organized with charts to help you understand major biochemical processes! Download the CPALMS Perspectives video student note taking guide.

Macromolecule Matching:	Learn about macromolecules with this tabletop exercise. Download the CPALMS Perspectives video student note taking guide.

Presentation/Slideshow

Name	Description
Cell Processes and Energy: Photosynthesis and Respirataion:	This presentation, a narrated PowerPoint, provides detailed information regarding photosynthesis and cellular respiration. It is provided by a teacher for his students, but is well-done and engaging enough to be useful for other students.

Resource Collection

Name	Description
Online Macromolecular Museum:	The Online Macromolecular Museum (OMM) is a site for the display and study of macromolecules. Macromolecular structures, as discovered by crystallographic or NMR methods, are scientific objects in much the same sense as fossil bones or dried specimens: they can be archived, studied, and displayed in aesthetically pleasing, educational exhibits. Hence, a museum seems an appropriate designation for the collection of displays that we are assembling. The OMM's exhibits are interactive tutorials on individual molecules in which hypertextual explanations of important biochemical features are linked to illustrative renderings of the molecule at hand.

Teaching Idea

Name	Description
Murder and A Meal:	In a "Murder Mystery" scenario, students will use their knowledge of the structure and properties of macromolecules to conduct a forensic investigation.

Text Resources

Name	Description
One Carbon Metabolism on the Space Station:	This informational text resource is designed to support reading in the content area. The text describes how a genetic variation in enzymes associated with the one carbon metabolic pathway can cause vision problems in astronauts. The research may lead scientists to predict which astronauts will develop vision problems, as well as develop new treatments for existing medical problems on Earth.
Captured: The Moment Photosynthesis Changed the World:	This informational text resource is intended to support reading in the content area. Geologists have made an important discovery about the origins of photosynthesis. According to evidence in South African rocks, before organisms were using water as the electron source for photosynthesis, they were using manganese - these rocks formed in anoxic conditions, but contain oxidized manganese. This evolution of photosynthetic organisms, which released atmospheric oxygen, laid the groundwork for more complex life forms, such as animals, to come into existence.
The Cell's Protein Factory in Action:	This informational text resource is intended to support reading in the content area. The ribosome, the site of protein synthesis, is the focus of this article. The text describes how a problem-some antibiotics are targeting the ribosomes of both harmful *and* beneficial bacteria-is being solved by studying the movement of ribosomes during translation.
New GPM Video Dissects the Anatomy of a Raindrop :	This informational text resource is intended to support reading in the content area. This article by NASA explains the physical reasons why the shape of a raindrop is more bun-shaped than tear-shaped.
Life's Little Essential:	This informational text resource is intended to support reading in the content area. The article explains why water is so essential and the properties of water that make it critical for life on Earth.

Tutorials

Name	Description
Photosynthesis: The Calvin Cycle:	This tutorial is a step by step explanation of what occurs in photosynthesis during the Calvin Cycle. It describes and uses visuals for the chemical reactions in this biochemical pathway. This challenging tutorial addresses the standard at a high level of complexity.
Photosynthesis: The Light Reaction:	This tutorial shows and describes what occurs during the light reactions of photosynthesis which is the first stage of photosynthesis when plants capture and store energy from sunlight. In this process, light energy is converted into chemical energy, in the form of the energy-carrying molecules ATP and NADPH.
Oxidation and Reduction in Cellular Respiration:	This Khan Academy video explains how oxidation and reduction reactions occur in cellular respiration. The chemical equation for cellular respiration is examined and broken down to show where each type of the reactions occur.
CAM Plants:	This Khan Academy video explains how CAM plants fix carbon dioxide at night so they do not lose water by opening their stomata during the day.
C4 Photosynthesis:	The Khan Academy video discusses how some plants avoid photorespiration by fixing carbon in the bundle sheath cells instead of the mesophylll cells.
Photorespiration:	This Khan Academy video reviews the Calvin Cycle in C3 photosynthesis and discusses the reactants and products of this process. The video then describes photorespiration which is what occurs when the enzyme RuBisCO fixes oxygen instead of carbon dioxide and explains why this is considered an inefficient pathway for plants.
DNA:	This Khan Academy video describes the structure of the molecule DNA in great detail. It also discuses the role DNA plays in the process of protein synthesis, explaining transcription and translation. The video discusses the relationship between DNA and chromosomes as well.

Oxidative Phosphorylation and Chemiosmosis:	This Khan Academy video explains how ATP is generated in the electron transport chain through the process of oxidative phosphorylation and chemiosmosis. It also explains the differences between oxidative phosphorylation and substrate level phosphorylation.
Cellular Respiration: The Electron Transport Chain:	This Khan Academy video explains how the NADH And FADH2 that were made during glycolysis and the Kreb's Cycle are used to generate ATP through the electron transport chain.
Cellular Respiration: Glycolysis:	This Khan Academy tutorial describes in detail the process of glucose being broken down into pyruvate during glycolysis. Glycolysis is the first biochemical pathway of cellular respiration.
Cellular Respiration: Kreb's Cycle:	This Khan Academy video describes how the pyruvate produced in glycolysis undergoes oxidation to produce Acetyl CoA. The video then explains what occurs when Acetyl CoA enters the Kreb's cycle and how NADH and FADH2 are produced.
Photosynthesis: The Light Reactions:	This Khan Academy tutorial explains in detail the process of the light reactions of photosynthesis including the importance of the thylakoid membrane and the products that are produced from this reaction.
Photosynthesis: The Calvin Cycle:	This Khan Academy tutorial explains how the by-products from the light reactions of photosynthesis are used to produce sugar molecules in the Calvin Cycle.
ATP: Adenosine Triphosphate:	This Khan Academy video explains how the molecule ATP stores the energy needed for biological systems within organisms.
Introduction to Cellular Respiration:	This Khan Academy video describes how energy is extracted from the glucose molecule to make ATP. Each biochemical pathway involved in cellular respiration is discussed.
How Glycolysis Works:	This animation shows the process of glycolysis. The reactants, products, and the basic functions of aerobic and anaerobic cellular respiration are identified.
Electron Transport System and ATP Synthesis:	This animation shows the electron transport chain, which is a series of compounds that transfers electrons from electron donors to electron acceptors via redox reactions. This electron transfer is coupled with the transfer of protons across a membrane. This animation addresses the concept at a high level of complexity.
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Amino Acids and Proteins:	This tutorial will help the learners to review the formation and 3D structures of amino acids with proteins.

Unit/Lesson Sequence

Name	Description
Enzyme Reactions:	This video shows an enzyme reaction lab. The teacher demonstrates how the enzyme, catalase, reacts with hydrogen peroxide (a substrate found in cells). The teacher first demonstrates a normal enzyme reaction. He or she then goes on to show how manipulating temperature and pH will affect the reaction of an enzyme.

Video/Audio/Animations

Name	Description
Carbohydrates:	This video resource was produced by Paul Andersen, a high school science teacher in Bozeman, Montana. He begins by explaining the structure and purpose of carbohydrates. He then describes and gives examples of monosaccharides, disaccharides, oligosaccharide and polysaccharides, and explains how they grow through dehydration reactions and shrink through hydrolysis.
Photosynthesis:	• Observe the photosynthesis mechanism in the plant • Learn about the main chemical reactions that takes place during photosynthesis • Learn how solar energy is converted into chemical energy
Test Your Science IQ: Proteins:	A collection of questions that tests students' knowledge about protein structures and their functions
Proteins:	Paul Anderson explains the structure and importance of proteins. He describes how proteins are created from amino acids connected by dehydration synthesis. He shows the importance of chemical properties in the R-groups of individual amino acids in the polypeptide.
Biological Molecules:	Paul Anderson describes the four major biological molecules found in living things. He begins with a brief discussion of polymerization. Dehydration synthesis is used to connect monomers into polymers and hydrolysis breaks them down again. The major characteristics of nucleic acids are described as well as there directionality from 3' to 5' end.
Water and Life:	Paul Anderson begins with a brief description of NASA discoveries related to Mars, Mercury and water. He then explains why water is required for life. He finally uses a simulation to show you why water acts as a wonderful solvent and provides a medium for metabolism.
Water: A Polar Molecule:	Mr. Andersen explains why water is a polar molecule. He also explains why this gives water properties like cohesion, high specific heat, less dense ice, and the ability to act as a solvent. All of these properties are due to hydrogen bonding.
MIT BLOSSOMS - Roots, Shoots, and Wood:	The topic of photosynthesis is a fundamental concept in biology, chemistry, and earth science. Educational studies have found that despite classroom presentations, most students retain their naïve idea that a plant's mass is mostly derived from the soil, and not from the air. To call students' attention to this misconception, at the beginning of this lesson we will provide a surprising experimental result so that students will confront their mental mistake. Next, we will help students better envision photosynthesis by modeling where the atoms come from in this important process that produces food for the planet. This lesson can be completed in 50-60 minutes, with the students working on in-class activities during 20-25 minutes of the lesson. As a prerequisite, students need an introductory lesson on photosynthesis, something that includes the overall chemical equation. If students have already studied the intracellular photosynthetic process in detail, this video can still be very helpful because students often miss the big picture about photosynthesis. Materials needed include red, white and black LEGO bricks (described in downloadable hand-out) or strips of red, white and black paper plus paper clips (directions provided in downloadable hand-out). In addition to class discussions, the major in-class activity of this video involves the students' modeling with LEGO® bricks or colored paper where the atoms come from in photosynthesis.
Cellular Respiration:	These animations show cell respiration as a big picture, and then go through the steps of cellular respiration: glycolysis, the Krebs cycle, and electron transport. Each animation is short and to the point.
Lipids:	Paul Anderson describes the lipids (of the fats). He explains how they are an important source of energy but are also required to cell membranes. He explains how the hydrocarbon tails in triglycerides contain energy available for life. He also explains how phospholipids construct, and cholesterol molecules main the cell membrane.
MIT BLOSSOMS - Methods for Protein Purification:	This Protein Purification video lesson is intended to give students some insight into the process and tools that scientists and engineers use to explore proteins. It is designed to extend the knowledge of students who are already somewhat sophisticated and who have a good understanding of basic biology. The question that motivates this lesson is, "what makes two cell types different?" and this question is posed in several ways. Such scientific reasoning raises the experimental question: how could you study just a subset of specialized proteins that distinguish one cell type from another? Two techniques useful in this regard are considered in the lesson. This video lesson will easily fit into a 50-minute class period, and prerequisites include a good understanding of cellular components (DNA vs. Protein vs. lipid) and some understanding of the physical features of proteins (charge, size etc). The simple cell model used here can be assembled in any kind of container and with any components of different solubility, density, charge etc. In-class activities during the video breaks include discussions, careful observations, and the use of a "very simple cell" model to explore two techniques of protein purification. Students and teachers can spend additional time discussing and exploring the question of "how we know what we know" since this lesson lends itself to the teaching of the process of science as well.
Photosynthesis:	This video provides an overview of photosynthesis.
Photosynthesis animation and other cell processes in animation:	This site has fantastic short Flash animations of intricate cell processes, including photosynthesis and the electron transport chain.
	This video gives more detail on the light reaction and photophosphorylation that occur in photosynthesis. **Photosynthesis: Light reactions and photophosphorylation**: More detail on the light reactions and photophorylation

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Virtual Manipulatives

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Enzyme-Substrate Docking:	This virtual manipulative will help the students learn about enzyme-substrate docking. Students will observe that the shapes of these surfaces and electrostatic forces are the major factors that govern docking.
The Tree of Life's Macromolecules - The Concord Consortium:	A Java Program that allows the students to explore the macromolecules via closer looks at different organisms. After exploring the macromolecules there are questions they can answer about the individual macromolecules and summary questions. The students can also print a report of their answers for the teacher.

Student Resources

Vetted resources students can use to learn the concepts and skills in this topic.

Original Student Tutorials

Title	Description
The Story of ATP Synthesis and the Role of Chemiosmosis:	The story of the role of chemiosmosis in ATP synthese is told through the animation of hydrogen ions in the last steps of cellular respiration.
The Macromolecules of Life: Carbohydrates:	Learn about the basic molecular structures and primary functions of carbohydrates with this interactive tutorial. This is part 2 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Overview • The Macromolecules of Life: Lipids • The Macromolecules of Life: Proteins • The Macromolecules of Life: Nucleic Acids
The Macromolecules of Life: Lipids:	Learn about the basic molecular structures and primary functions of lipids with this interactive tutorial. This is part 3 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Overview • The Macromolecules of Life: Carbohydrates • The Macromolecules of Life: Proteins • The Macromolecules of Life: Nucleic Acids
The Mystery of Muscle Cell Metabolism:	Explore the mystery of muscle cell metabolism and how cells are able to meet the need for a constant supply of energy. In this interactive tutorial, you'll identify the basic structure of adenosine triphosphate (ATP), explain how ATP's structure is related it its job in the cell, and connect this role to energy transfers in living things.
Enzymes are the Stuff of Life:	At any instant in your life, millions and millions of enzymes are hard at work in your body as well as all around you making your life easier! By the end of this tutorial you should be able to describe how enzymes speed up most biochemical reactions as well as identify the various factors that affect enzyme activity like pH and temperature.
The Macromolecules of Life: Proteins:	Learn about the basic molecular structures and primary functions of proteins with this interactive tutorial. This is part 4 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Overview • The Macromolecules of Life: Carbohydrates • The Macromolecules of Life: Lipids • The Macromolecules of Life: Nucleic Acids
Fueling the Body: Cellular Respiration:	Explore how organisms gain usable energy and compare the two types of cellular respiration; aerobic and anaerobic. In this interactive tutorial, you'll also learn about reactants and products of both aerobic and anaerobic respiration.

ATP: Fuel for Cells:	Explore how cells use ATP as an energy source for cellular activities in this interactive tutorial.
The Macromolecules of Life: Nucleic Acids:	Learn to identify and describe the structural and functional features of nucleic acids, one of the 4 primary macromolecule groups in biological systems, with this interactive tutorial. This is Part 3 in 5-part series. Click below to open the other tutorials in the series: • Macromolecules: Overview • Macromolecules: Carbohydrates • Macromolecules: Nucleic Acids • Macromolecules: Lipids • Macromolecules: Proteins
The Macromolecules of Life: Overview:	Learn to identify the four basic biological macromolecules (carbohydrates, lipids, proteins, and nucleic acids) by structure and function with this interactive tutorial. This is part 1 in a five-part series. Click below to explore other tutorials in the series. • The Macromolecules of Life: Carbohydrates • The Macromolecules of Life: Lipids • The Macromolecules of Life: Proteins • The Macromolecules of Life: Nucleic Acids
Water and Life:	Learn how the chemical properties of water relate to its physical properties and make it essential for life with this interactive tutorial.
Photosynthesis: Capturing the Sun's Energy to Create Sugar:	Learn how to identify and describe the role of all of the major molecules needed for photosynthesis. You'll also be able to explain the role that photosynthesis plays in capturing carbon from the atmosphere to produce sugars.
Energy and Carbon in Photosynthesis and Cellular Respiration:	Learn more about photosynthesis and cellular respiration. In this interactive tutorial, you will gain awareness of the connections between these two very important processes with regard to energy and carbon.

Perspectives Video: Experts

Title	Description
Protein Structure and Function:	Don't get twisted in a knot about proteins; learn about their structure! Download the CPALMS Perspectives video student note taking guide.
Photosynthesis in Space:	A NASA botanist explains how studying photosynthesis now can help feed astronauts in the future. Download the CPALMS Perspectives video student note taking guide.

Presentation/Slideshow

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Cell Processes and Energy: Photosynthesis and Respirataion:	This presentation, a narrated PowerPoint, provides detailed information regarding photosynthesis and cellular respiration. It is provided by a teacher for his students, but is well-done and engaging enough to be useful for other students.

Tutorials

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Photosynthesis: The Calvin Cycle:	This tutorial is a step by step explanation of what occurs in photosynthesis during the Calvin Cycle. It describes and uses visuals for the chemical reactions in this biochemical pathway. This challenging tutorial addresses the standard at a high level of complexity.
Photosynthesis: The Light Reaction:	This tutorial shows and describes what occurs during the light reactions of photosynthesis which is the first stage of photosynthesis when plants capture and store energy from sunlight. In this process, light energy is converted into chemical energy, in the form of the energy-carrying molecules ATP and NADPH.
Oxidation and Reduction in Cellular Respiration:	This Khan Academy video explains how oxidation and reduction reactions occur in cellular respiration. The chemical equation for cellular respiration is examined and broken down to show where each type of the reactions occur.
CAM Plants:	This Khan Academy video explains how CAM plants fix carbon dioxide at night so they do not lose water by opening their stomata during the day.
C4 Photosynthesis:	The Khan Academy video discusses how some plants avoid photorespiration by fixing carbon in the bundle sheath cells instead of the mesophylll cells.
Photorespiration:	This Khan Academy video reviews the Calvin Cycle in C3 photosynthesis and discusses the reactants and products of this process. The video then describes photorespiration which is what occurs when the enzyme RuBisCO fixes oxygen instead of carbon dioxide and explains why this is considered an inefficient pathway for plants.
DNA:	This Khan Academy video describes the structure of the molecule DNA in great detail. It also discuses the role DNA plays in the process of protein synthesis, explaining transcription and translation. The video discusses the relationship between DNA and chromosomes as well.

Oxidative Phosphorylation and Chemiosmosis:	This Khan Academy video explains how ATP is generated in the electron transport chain through the process of oxidative phosphorylation and chemiosmosis. It also explains the differences between oxidative phosphorylation and substrate level phosphorylation.
Cellular Respiration: The Electron Transport Chain:	This Khan Academy video explains how the NADH And FADH2 that were made during glycolysis and the Kreb's Cycle are used to generate ATP through the electron transport chain.
Cellular Respiration: Glycolysis:	This Khan Academy tutorial describes in detail the process of glucose being broken down into pyruvate during glycolysis. Glycolysis is the first biochemical pathway of cellular respiration.
Cellular Respiration: Kreb's Cycle:	This Khan Academy video describes how the pyruvate produced in glycolysis undergoes oxidation to produce Acetyl CoA. The video then explains what occurs when Acetyl CoA enters the Kreb's cycle and how NADH and FADH2 are produced.
Photosynthesis: The Light Reactions:	This Khan Academy tutorial explains in detail the process of the light reactions of photosynthesis including the importance of the thylakoid membrane and the products that are produced from this reaction.
Photosynthesis: The Calvin Cycle:	This Khan Academy tutorial explains how the by-products from the light reactions of photosynthesis are used to produce sugar molecules in the Calvin Cycle.
ATP: Adenosine Triphosphate:	This Khan Academy video explains how the molecule ATP stores the energy needed for biological systems within organisms.
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