# Macomb Intermediate School District
# High School Science Power Standards Document

## Biology

The Michigan High School Science Content Expectations establish what every student is expected to know and be able to do by the end of high school. They also outline the parameters for receiving high school credit as dictated by state law.

To aid teachers and administrators in meeting these expectations the Macomb ISD has undertaken the task of identifying those content expectations which can be considered power standards. The critical characteristics[1] for selecting a **power standard** are:

- ***Endurance* –** knowledge and skills of value beyond a single test date.
- ***Leverage* -** knowledge and skills that will be of value in multiple disciplines.
- ***Readiness* -** knowledge and skills necessary for the next level of learning.

The selection of **power standards** is not intended to relieve teachers of the responsibility for teaching all content expectations. Rather, it gives the school district a common focus and acts as a safety net of standards that all students must learn prior to leaving their current level.

The following document utilizes the unit design including the big ideas and real world contexts, as developed in the science companion documents for the Michigan High School Science Content Expectations.

[1] Dr. Douglas Reeves, Center for Performance Assessment

## Unit 1: Chemistry & Biochemistry

### Big Ideas

Living systems are made up of four major types of organic molecules: carbohydrates, lipids, proteins and nucleic acids.

Organisms are made up of different arrangements of these molecules, giving all life a biochemical framework.

Selected cells in multicellular organisms are specialized to carry out particular life functions.

### Contextual Understandings

Living things are made up of complex molecules (carbohydrates, lipids, proteins and nucleic acids) and their subunits. These subunits include simple sugars in carbohydrates, fatty acids in lipids, amino acids in proteins and nucleotides in nucleic acids.

Carbohydrates are a biochemical class made up of simple sugars which consist of a general atomic ratio of carbon (C) to hydrogen (H) to oxygen (O) of 1:2:1 ($C_nH_{2n}O_n$). They also include polymers of simple sugars. Carbohydrates function as short-term energy storage in the form of simple sugars and as intermediate-term energy storage as polysaccharides, specifically as starches in plants and glycogen in animals. Polysaccharides are also structural components in cells as cellulose in the cell walls of plants and many protists and as chitin in the exoskeleton of insects and other arthropods.

Lipids are involved mainly with long-term energy storage. Lipids make up such molecules as fats, oils and waxes and also contain carbon, hydrogen and oxygen. They are generally insoluble in polar substances such as water. Other functions of lipids are functional, as in the case of phospholipids as the major building block in cell membranes and some kinds of hormone messengers that have a role in communications within and between cells.

Proteins are very important in biological systems as control and structural elements. Control functions of proteins are carried out by enzymes and some kinds of hormones. Enzymes are biochemicals that act as organic catalysts to speed up the rate of a chemical reaction. These proteins are folded in intricate ways that produce shapes that "fit" corresponding features of specific substrates. This enzyme-substrate specificity is very important for students to understand. Structural proteins function in the cell as parts of the cell membrane, muscle tissue, and connective tissue types. Proteins are polymers of amino acids and contain, in addition to carbon, hydrogen and oxygen, also nitrogen and sometimes sulfur.

Nucleic acids are composed of very long chains of subunits called nucleotides, which contain carbon, hydrogen, oxygen, nitrogen and phosphorus. The two chief types of nucleic acids are DNA (deoxyribonucleic acid) which contains the hereditary information in all living organisms and RNA (ribonucleic acid) which delivers the instructions coded in a cell's DNA to its protein manufacturing sites.

Organisms make the molecules they need or obtain them from their diet. Specific proteins, for example, are required for specific cellular processes. Without these proteins, or with non-functioning proteins, certain processes may not be carried out at all.

Dehydration links smaller subunits into larger units by removing water and forming covalent bonds. Hydrolysis is a chemical reaction in which a compound reacts with water. This type of reaction is used to break down larger organic molecules into smaller subunits. Dehydration and hydrolysis are essentially the reverse of each other.

Energy is involved in the formation of chemical bonds. The breaking and reforming of new bonds by living things often involves a transformation of energy from higher energy bonds to lower energy bonds, allowing usable energy to be released for use by the organism. An example of high energy bonds are the phosphate bonds in ATP. When the third phosphate group of ATP is removed by hydrolysis, a substantial amount of free energy is released. For this reason, this bond is known as a "high-energy" bond.

| Power Standards | Additional Standards |
|---|---|
| B2.2C - Describe the composition of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).<br><br>B2.2D - Explain the general structure and primary functions of the major complex organic molecules that compose living organisms. | B2.5A - Recognize and explain that macromolecules such as lipids contain high energy bonds.<br><br>B2.2B - Recognize the six most common elements in organic molecules<br>(C, H, N, O, P, S).<br><br>B2.2E - Describe how dehydration and hydrolysis relate to organic molecules.<br><br>B2.2f - Explain the role of enzymes and other proteins in biochemical functions (e.g., the protein hemoglobin carries oxygen in some organisms, digestive enzymes, and hormones).<br><br>B2.4f - Recognize and describe that both living and nonliving things are composed of compounds, which are themselves made up of elements joined by energy-containing bonds, such as those in ATP.<br><br>B2.2A - Explain how carbon can join to other carbon atoms in chains and rings to form large and complex molecules. |

# Unit 2: Cells - Structure & Function

## Big Ideas

Cells are the basic units of life.

Cells combine to form more complex structures

## Contextual Understandings

Cells are the basic unit of all life and represent a vast array of types, yet they share many similarities. All living things are made up of cells whose work is carried out by many different types of molecules. Cellular and molecular biology has the power to explain a wide variety of phenomena related to the organization and development of living systems.

Modern cell theory states that
· All organisms are made up of cells.
· New cells are derived from pre-existing cells.
· The cell is the structural and functional unit of all living things.
· Cells contain hereditary information that is passed from cell to cell during cell division.
· All cells are basically the same in chemical composition and metabolic activities.

Endosymbiotic theory, which proposes the chloroplasts and mitochondria were once free-living prokaryotes that developed such close relationships with early cells and that they were eventually taken in as substructures, represents a major step in the evolution of eukaryotes, since it couples energetic processes to cell function. Evidence for the theory is striking:
· chloroplasts and mitochondria both contain circular DNA, similar to prokaryotes
· their cell membrane structures are similar to prokaryotes
· they reproduce by binary fission, as do prokaryotes
· their ribosomes are similar in structure to prokaryotes

Differences between types of cells: prokaryotic and eukaryotic, plant and animal, highlight features of form and function that relate to the specific role of a given cell to its organism type.

| Power Standards | Additional Standards |
|---|---|
| B2.5g Compare and contrast plant and animal cells.<br><br>B2.5h Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, and active transport). | B2.5i Relate cell parts/organelles to their function.<br><br>B2.4h Describe the structures of viruses and bacteria.<br><br>B2.4i Recognize that while viruses lack cellular structure, they have the genetic material to invade living cells.<br><br>B2.4g Explain that some structures in the modern eukaryotic cell developed from early prokaryotes, such as mitochondria, and in plants, chloroplasts. |

## **Unit 3: Cell Energetics**

### **Big Ideas**

Organisms need energy to do cell work.

Photosynthesis converts the sun's energy into the chemical potential energy of food.

Cell respiration converts the chemical potential energy stored in food to the chemical potential energy stored in ATP.

ATP supplies the energy to do cell work.

### **Contextual Understandings**

Matter and energy transformations are involved in all life processes, such as photosynthesis, growth and repair, cellular respiration, and the need of living systems for continual input of energy. All single-celled and multicellular organisms have the same basic needs: water, air, a source of energy and materials for growth and repair, waste disposal, and conditions for growth and reproduction. In terms of matter and energy transformations, the source of food is the distinguishing difference between plants and animals.

Both plants and animals require a source of energy and materials for growth and repair, and both plants and animals use high-energy compounds as a source of fuel and building material. Plants, and some bacteria, are distinguished from animals by the fact that plants have the capability (through photosynthesis) to take energy from light and form higher energy molecules containing carbon, hydrogen and oxygen (carbohydrates) from lower energy molecules.

Plants are similar to animals in that, to make other molecules for their growth and reproduction, they use the energy that is released as carbohydrates react with oxygen. In making these other molecules, plants use breakdown products of carbohydrates, along with minerals from the soil and fertilizers (known colloquially as "plant foods"), as building blocks. Plants also synthesize substances (carbohydrates, fats, proteins, vitamins) that are components of foods eaten by animals.

So, while synthesis and breakdown are common to both plants and animals, photosynthesis (the conversion of light energy into stored chemical energy) is unique to plants, making them the primary source of energy for all animals.

Basic needs are connected with the processes of growth and metabolism. Organisms are made up of carbon-containing molecules; these molecules originate in molecules that plants assemble from carbon dioxide and water. In converting carbon-containing molecules back to water and carbon dioxide, organisms release energy, making some of it available to support life functions. Matter and energy transformations in cells, organisms, and ecosystems have a chemical basis.

| Power Standards | Additional Standards |
|---|---|
| B2.1A - Explain how cells transform energy (ultimately obtained from the sun) from one form to another through the processes of photosynthesis and respiration. Identify the reactants and products in the general reaction of photosynthesis.<br><br>B3.1B – Illustrate and describe the energy conversions that occur during photosynthesis and respiration. (Also repeated in Ecology) | B2.4e – Explain how cellular respiration is important for the production of ATP (build on aerobic vs. anaerobic).<br><br>B2.5e – Explain the interrelated nature of photosynthesis and cellular respiration in terms of ATP synthesis and degradation.<br><br>B2.5f – Relate plant structures and functions to the process of photosynthesis and respiration. |

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| B2.5D – Describe how individual cells break down energy-rich molecules to provide energy for cell functions. | B3.1C – Recognize the equations for photosynthesis and respiration and identify the reactants and products for both. (Also repeated in Ecology)<br><br>B3.1f – Summarize the process of photosynthesis. |

## Unit 4: Comparative Structure and Function of Living Things

### Big Ideas

Different structures in different organisms accomplish the same or similar function.

Systems work together physiologically to support the needs of the entire organism and the cells of which it is composed.

### Contextual Understandings

At the cellular level we find biological molecules associated with one another to form complex, organized and highly specialized structures within the cell called organelles. These sub-cellular organelles are each designed to perform specific processes within the cell. The cell is the basic structural and functional unit of life. It is the smallest and simplest part of living matter that can carry on all the activities necessary for life. In most multicellular organisms, cells associate to form tissues, such as muscle tissue or nervous tissue. Tissues are arranged into functional structures called organs, such as the heart or stomach. Each major group of biological functions is performed by a coordinated group of tissues and organs called an organ system. Functioning together with great precision, organ systems (e.g., nervous, circulatory, digestive, respiratory) make up the complex multicellular organism.

Living things share common needs for food, cellular waste disposal, exchange of gasses, and means of reproduction. Different organisms have evolved different physical and biochemical mechanisms for accomplishing the same function. For example, single and multi-celled organisms display diverse structural variations that allow them to accomplish necessary tasks. Examples of these structural adaptations may include: gills versus lungs versus trachea (insects) to exchange gasses or body design that includes internal or external skeletons. For example, the malpighian tubule system in an earthworm and the kidneys in a mammal both remove nitrogenous waste but are not structurally similar. Plants often do not get their share of attention in such discussions, but they also have organs and tissue types that serve their own needs and should be included in the discussion of comparative structure and function. Analogous structures, the result of convergent evolution, have provided many different, but perfectly functional, solutions to needs shared by all organisms.

Cellular processes (e.g., transport of materials, energy capture and release, protein building, waste disposal) are similar in plants and animals. The structures that accomplish these processes, including organs and organ systems as well as tissue types may be similar or different in various life forms.

| Power Standards | Additional Standards |
|---|---|
| B2.4B Describe how various organisms have developed different specializations to accomplish a particular function and yet the end result is the same (e.g., excreting nitrogenous wastes in animals, obtaining oxygen for respiration.<br><br>B2.4C Explain how different organisms accomplish the same result using different structural specializations (gills vs. lungs vs. membranes).<br><br>B2.5B Explain how major systems & processes work together in animals and plants, including relationships between organelles, cells, tissues, organs, organ systems, & organisms. Relate these to molecular functions. | |

## Unit 5: Human Systems

### Big Idea

Cell differentiation occurs early in embryonic development and gives rise to all tissue types by a series of complex environmental and biochemical interactions.

Human systems work together to maintain the short and long term health of the organism.

### Contextual Understandings

The specialization process by which cells acquire an identity as cell type is called differentiation and occurs very early in the development of an embryo. Gastrulation, the division of embryonic cells into germ cell layers, occurs in humans during the second week after fertilization. Prior to these events, very early embryo cells are considered totipotent, capable of becoming any cell type. Embryonic stem cells, the subject of much controversy, are derived from these very early cells. Following gastrulation, the cells are destined to become only certain cell types. In embryos that have not undergone cellular differentiation, the transplantation of tissue from one region of the embryo to another has no effect. After embryonic cells have begun to specialize, however, transplanted cells lose this flexibility.

Specialization after germ cell formation is a complex process that involves the turning on and off of specific genes, input from neighboring cells and cues from the environment.

Much later in development and beyond, organs, made up of various tissue types, and organ systems work together physiologically to support the needs of the entire organism to support the major processes required for life.

| Power Standards | Additional Standards |
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| *While this unit has value, it did not contain content expectations that met the power standard criteria set by the committee.* | B2.1e Predict what would happen if the cells from one part of a developing embryo were transplanted to another part of the embryo.<br><br>B2.3d Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with one another.<br>B2.3g Compare the structure and function of a human body system or subsystem to a nonliving system (e.g., human joints to hinges, enzymes and substrate to interlocking puzzle pieces).<br><br>B4.3g Explain that cellular differentiation results from gene expression and/or environmental influence (e.g., metamorphosis, nutrition). |

## Unit 6: Homeostasis and Health

### Big Ideas

Body systems function together to maintain homeostasis as conditions inside and outside the body change.

Regulatory mechanisms are responsible for many of the homeostatic controls systems in living organisms.

### Contextual Understandings

Life processes are based on the maintenance of a relatively constant internal environment. Regulating this environment depends on the continual vigilance of many systems that monitor conditions both inside and outside an organism and work together to correct any significant deviations. The mechanisms involved in maintaining homeostasis require both communication in alerting the organism that changes have occurred as well as means to re-establish stable conditions. Some examples of life processes that require constant monitoring include many regulated by the nervous system (e.g., reactions, reflexes, reproduction, basic “housekeeping” functions) working in concert with the endocrine system and all other organ systems. These mechanisms are similar in all animals, although the specific conditions that are homeostatically regulated may be different.

Many of the regulatory responses to changes in an organism’s environment involve negative feedback. These mechanisms work by signaling changes in the body that allow it to reverse the direction of change. For example, if blood sugar gets too high, the hormone insulin is secreted by the pancreas and it acts on the liver to remove glucose from the blood and store it as glycogen. This restores the level to a normal range. Blood is buffered biochemically to maintain a certain pH. If the acidity level is significantly altered, the body responds by adjusting the equilibrium position of the formation of carbonic acid-bicarbonate buffer system to allow the pH to be restored to a normal level. This change in equilibrium is assisted by the respiratory system, as breathing is adjusted to regulate the amount of carbon dioxide in the bloodstream. Many other examples may be used to illustrate these kinds of homeostatic mechanisms. An organism can receive and act on signals received from external stimuli through the nervous system and through these signals can find food, shelter, reproduce, and escape from predators. Many chronic diseases are the result of the inability of the body to respond efficiently to changes.

| Power Standards | Additional Standards |
|---|---|
| B2.3A Describe how cells function in a narrow range of physical conditions, such as temperature and pH (acidity) to perform life functions.<br><br>B2.3B Describe how the maintenance of a relatively stable internal environment is required for the continuation of life.<br><br>B2.3C Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents. | B2.6a Explain that the regulatory and behavioral responses of an organism to external stimuli occur in order to maintain both short- and long-term equilibrium.<br><br>B2.3f Explain how human organ systems help maintain human health.<br><br>B2.3e Describe how human body systems maintain relatively constant internal conditions (temperature, acidity, and blood sugar). |

## **Unit 7: Matter and Energy in Ecosystems**

### Big Ideas

Energy transformations from the Sun to organisms provide energy for all life forms to exist.

Matter transfer in ecosystems between living and non-living organisms provides the materials necessary for all life.

Matter and energy are conserved in ecosystems, although their transformations are not efficient.

### Contextual Understandings

Life is comprised of many complex cellular processes that occur in all organisms, including plants and animals. These processes include: the transport of materials, energy capture and release, protein building and waste disposal.

The flow of energy into ecosystems is from the Sun to producers through the process of photosynthesis. Producers are able to use this energy to convert carbon dioxide, a gas, and water into energy-rich, highly-condensed carbon compounds, usually carbohydrates. Plants may then use these materials for their own cellular energy needs by the process of cellular respiration. Consumers also obtain usable energy from the biochemical breakdown of carbohydrates and molecules derived from them during respiration. In this way, derived directly or indirectly from a plant source, carbohydrates are foods that, when converted into waste materials, yield usable energy for the organism in the process of cellular respiration. Ultimately, nearly all organisms will be subjected to breakdown by decomposers, who themselves convert mass into waste materials, using the derived energy.

When consumers eat plants or other consumers, they are transferring matter, in the form of flesh, through an ecosystem. Energy is also being transferred as it is stored in the chemical bonds that bind the food molecules together. As this energy is transferred through ecosystems, liberated for organismal use by cellular respiration, conversions are not entirely efficient and heat is lost as a by-product at each step, dissipated into the environment, leaving less *usable* energy available to each successive trophic level.

Organisms may be classified as producers, consumers and decomposers, based on their feeding relationships within their particular food web. These food webs may be from ecosystems that are widely represented in textbooks and of importance to all students, even if they do not live near them.

Changes in relationships and populations of producers and consumers may occur as the result of the loss of one or more types of organisms in the ecosystem. The loss of any group of organisms from an ecosystem changes the flow of energy within that system.

The overall cycling of matter, specifically carbon and nitrogen, through ecosystems as it passes between living systems to abiotic components of ecosystems is very important because it shows the interdependence of organisms with their physical environment, and vice versa.

Human created disturbances in ecosystems or environments, including local and global climate change, uses of tilling and pesticides to favor human crops, human land use, harvesting of fish stocks, pollution, invasive species, and others are common to many ecosystems and represent problems that cause imbalances in the cycling of matter and the transformation of energy through ecosystems.

| Power Standards | Additional Standards |
|---|---|
| B2.1B - Compare and contrast the transformations of matter and energy during photosynthesis and respiration.<br><br>B2.5C - Describe how energy is transferred and transformed from the Sun to energy-rich molecules during photosynthesis.<br><br>B3.1A - Describe how organisms acquire energy directly or indirectly from sunlight.<br><br>B3.1B - Illustrate and describe the energy conversions that occur during photosynthesis and respiration.<br><br>B3.1C - Recognize the equations for photosynthesis and respiration and identify the reactants and products for both.<br><br>B3.2A - Identify how energy is stored in an ecosystem.<br><br>B3.2B - Describe energy transfer through an ecosystem, accounting for energy lost to the environment as heat.<br><br>B3.3A - Use a food web to identify and distinguish producers, consumers, and decomposers and explain the transfer of energy through trophic levels. | B2.1A - Explain how cells transform energy (ultimately obtained from the sun) from one form to another through the processes of photosynthesis and respiration. Identify the reactants and products in the general reaction of photosynthesis.<br><br>B3.1D - Explain how living organisms gain and use mass through the processes of photosynthesis and respiration.<br><br>B3.1e - Write the chemical equation for photosynthesis and cellular respiration and explain in words what they mean.<br><br>B3.2C - Draw the flow of energy through an ecosystem. Predict changes in the food web when one or more organisms are removed.<br><br>B3.3b - Describe environmental processes (e.g., the carbon and nitrogen cycles) and their role in processing matter crucial for sustaining life. |

## **Unit 8: Population Ecology and Human Impacts on Ecosystems**

### **Big Ideas**

Populations relate to each other within their ecosystem.

Ecosystems usually establish equilibrium between their biotic inhabitants and abiotic factors. These relationships typically are stable for long periods of time.

Ecosystems are characterized by both stability and change, on which human populations can have an impact.

### **Contextual Understandings**

Populations initially often grow exponentially in a favorable environment, but all population growth ultimately will level off (carrying capacity) when a resources (e.g., food, nest sites, cover) become limiting. Abiotic factors, such as temperature, rainfall, pH of aquatic systems, and seasonal variations can influence a population's growth rate and the carrying capacity it reaches. In general, density-dependent factors such as habitat size, disease, competition, floods, etc. regulate a population's size within an ecosystem.

Natural disturbances in ecosystems (e.g. fires, floods, sedimentation, and volcanoes) are density-independent and disrupt the community structure and consequently affect all populations.

There is a relationship between the stability of an ecosystem and its biodiversity. External events, either natural or man-made, can cause an ecosystem to change in many ways. These external forces affect ecological succession adversely, but if the ecosystem is then left undisturbed it will ultimately revert to its earlier form through stages of succession.

Humans have created disturbances in most ecosystems and environments. These disturbances have been as varied as local and global climate change, altering the land to favor crops, human land uses, harvesting of fish stocks, causing various forms of pollution and aiding in the introduction of invasive species. Invasive species and nutrient loading has changed the population dynamics of species within the Great Lakes. These disturbances change the population dynamics of species within an ecosystem.

Examples of human impact on other species include reducing the amount of Earth's surface available as habitats, interfering with food sources, changing the temperature and chemical composition of habitats, introducing foreign species into ecosystems, and altering organisms directly through selective breeding and genetic engineering.

A displaced organism will be tested when it encounters a new environment, but its ability to survive will depend on the degree to which the new surroundings meet its physiological needs and the amount of competition it encounters from native species. If it is able to establish a new niche, it can be successful….so successful, in fact, that it may place stress on the natural inhabitant.

Many scientists believe the zebra mussel colonization of the Great Lakes is concentrating biomass and nutrient energies in the benthic or bottom region of the lakes. This is biomass that was once available to other (often native) species. The full implications of zebra mussel colonization of the Great Lakes are still playing out and are not yet fully understood. There is growing evidence that the mussels are responsible for the decline of the native aquatic invertebrate Dioperia, which are an important food item for many fish in the Great Lakes. The changing populations of fish will bring their consequences, creating a cascade effect. Zebra mussels attach to most substrates including sand, silt, and harder substrates. Other examples of the interdependence of organisms include relationships between the environment and public health and between migration and the potential spread of diseases.

| Power Standards | Additional Standards |
| --- | --- |
| B3.5C - Predict the consequences of an invading organism on the survival of other organisms.<br><br>B3.4C - Examine the negative impact of human activities.<br><br>B3.5B - Explain the influences that affect population growth.<br><br>B3.4A - Describe ecosystem stability. Understand that if a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages of succession that eventually result in a system similar to the original one | B2.2g - Propose how moving an organism to a new environment may influence its ability to survive and predict the possible impact of this type of transfer. Incorrectly numbered<br><br>B3.4e - List the possible causes and consequences of global warming.<br><br>B3.5A - Graph changes in population growth, given a data table.<br><br>B3.5e - Recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of population dynamics within ecosystems.<br><br>B3.5f - Graph an example of exponential growth. Then show the population leveling off at the carrying capacity of the environment.<br><br>B3.4d - Describe the greenhouse effect and list possible causes. |

## Unit 9: Cell Division and Chromosome Mutations

### Big Ideas

The process of mitosis produces new cells needed for growth of an organism and these cells differentiate into specific cells with specialized functions.

Mitosis ensures genetic continuity. Mutations in genes that control mitosis may cause uncontrolled cell division which leads to cancer.

Meiosis produces sex cells for sexual reproduction that passes on genes to the next generation. Genetic mutations may be passed on from parent to offspring through these cells.

### Contextual Understandings

Students should know enough about atoms and molecules from earlier instruction to make sense of the idea that DNA carries instructions for the assembly of proteins, determining their structure and the rates at which they are made. Students' growing notion of systems can help them understand how turning instructions on and off can sequence developments over a lifetime and that each cell's immediate environment can influence its development, even though nearly all cells carry the same DNA instructions.

DNA provides for both the continuity of traits from one generation to the next and the variation that in time can lead to differences within a species and to entirely new species. Understanding DNA makes possible an explanation of such phenomena as the similarities and differences between parents and offspring, hereditary diseases, and the evolution of new species. This understanding also makes it possible for scientists to manipulate genes and thereby create new combinations of traits and new varieties of organisms.

| Power Standards | Additional Standards |
|---|---|
| B4.3A- Compare and contrast the processes of cell division (mitosis and meiosis), particularly as those processes relate to production of new cells and to passing on genetic information between generations.<br><br>B4.2A - Show that when mutations occur in sex cells, they can be passed on to offspring (inherited mutations), but if they occur in other cells, they can be passed on to descendant cells only (non-inherited mutations).<br><br>B2.1C - Explain cell division, growth, and development as a consequence of an increase in cell number, cell size, and/or cell products. | B2.1d - Describe how, through cell division, cells can become specialized for specific function.<br><br>B3.5d - Describe different reproductive strategies employed by various organisms and explain their advantages and disadvantages.<br><br>B4.3B – Explain why only mutations occurring in gametes (sex cells) can be passed on to offspring.<br><br>B4.3C - Explain how it might be possible to identify genetic defects from just a cerotype of a few cells.<br><br>B4.3d - Explain that the sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations from the offspring of two parents.<br><br>B4.3e - Recognize that genetic variation can occur from such processes as crossing over, jumping genes, and deletion and duplication of genes.<br><br>B4.3f - Predict how mutations may be transferred to progeny |

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| | B4.4b - Explain that gene mutation in a cell can result in uncontrolled cell division called cancer. Also know that exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer. |

# <u>Unit 10 and 11:</u> <u>DNA/RNA and Genetics</u>

Combined units 10 and 11 from MDE companion document to make this unit

## <u>Big Ideas</u>

The central dogma of biology states that DNA codes for proteins that are responsible for the production of inherited traits.

The processes by which proteins are made from DNA are transcription and translation.

DNA must replicate itself faithfully in order to pass all genetic information on to descendent cells, including sex cells.

DNA in genes codes for the production of proteins.

Mutations in the DNA code can lead to dysfunctional proteins -genetic disorders.

Cells differ in the genes they express-all genes are not used in all cells.

## <u>Contextual Understandings</u>

The biochemical identity of an organism is determined by its DNA, which is characteristic for each species and sometimes for each individual within that species. DNA codes, in nucleotides, the directions for making all the protein types required by individuals to express their heredity. The function of each protein molecule depends on its specific sequence of amino acids and the shape of the molecule. These proteins are characteristic of each species and many of them, enzymes, in particular, are responsible for allowing individuals to express genetic traits specific to each species.

DNA duplication in cell division involves the copying of all genetic material for descendent cells, whereas the process of gamete formation involves the apportioning of DNA to eggs/sperm with only half the DNA.

The processes of DNA duplication, transcription and translation are very complex, but provide the basis for the central dogma of biology – that in most cases, DNA information is copied onto messenger RNA by the process of transcription and proteins are synthesized using messenger RNA as a template and transfer RNA as delivery molecules that bring the appropriate amino acids to the ribosome for assembly. This process is called translation.

When errors occur in any of the processes described above, the results may be either positive, negative or neutral on the organism and/or its offspring. Mutations may result in changes in structure that render the protein non-functional, or they may result in insignificant changes that do no harm to the functioning of the protein and hence its expression in the individual. There are a number of common diseases that are inherited by offspring of parents who carry faulty genes. These include: sickle cell anemia which results in the manufacture of defective hemoglobin by the victim's red blood cells, phenylketonuria, a disease that results in the inability of a victim's liver to metabolize a common amino acid and cystic fibrosis, a disorder that causes lung damage in affected people.

## Genetics

Organisms closely resemble their parents; their slight variations can accumulate over many generations and result in more obvious differences between organisms and their ancestors. Recent advances in biochemistry and cell biology have increased understanding of the mechanisms of inheritance and enabled the detection of disease related genes. Such knowledge is making it possible to design and produce large quantities of substances to treat disease and, in years to come, may lead to cures.

All plants and animals (and one-celled organisms) develop and have the capacity to reproduce. Reproduction, whether sexual or asexual, is a requirement for the survival of species. Characteristics of organisms are influenced by heredity and environment. Genetic differences among individuals and species are fundamentally chemical. Different organisms are made up of somewhat different proteins.

Reproduction involves passing the DNA with instructions for making these proteins from one generation to the next with occasional modifications.

| Power Standards | Additional Standards |
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| B4.1B – Explain that the information passed from parents to offspring is transmitted by means of genes that are coded in DNA molecules. These genes contain the information for the production of proteins.<br><br>B4.2D – Predict the consequences that changes in the DNA composition of particular genes may have on an organism (e.g., sickle cell anemia, other).<br><br>B4.2C – Describe the structure and function of DNA.<br><br>B4.1A – Draw and label a homologous chromosome pair with heterozygous alleles highlighting a particular gene location. | B4.2B – Recognize that every species has its own characteristic DNA sequence.<br><br>B4.2E – Propose possible effects (on the genes) of exposing an organism to radiation and toxic chemicals.<br><br>B4.2f – Demonstrate how the genetic information in DNA molecules provides instructions for assembling protein molecules and that this is virtually the same mechanism for all life forms.<br><br>B4.2g – Describe the processes of replication, transcription, and translation and how they relate to each other in molecular biology.<br><br>B4.4c – Explain how mutations in the DNA sequence of a gene may be silent or result in phenotypic change in an organism and in its offspring.<br><br>B4.3g – Explain that cellular differentiation results from gene expression and/ or environmental influence (e.g., metamorphosis, nutrition).<br><br>B4.1d – Explain the genetic basis for Mendel's laws of segregation and independent assortment.<br><br>B4.1e – Determine the genotype and phenotype of monohybrid crosses using a Punnett Square.<br><br>B4.2h – Recognize that genetic engineering techniques provide great potential and responsibilities.<br><br>B4.4a – Describe how inserting, deleting, or substituting DNA segments can alter a gene. Recognize that an altered gene may be passed on to every cell that develops from it and that the resulting features may help, harm, or have little of no effect on the offspring's success in its environment.<br><br>B2.1e – Predict what would happen if the cells from one part of a developing embryo were transplanted to another part of the embryo.<br><br>B4.1c – Differentiate between dominant, recessive, co-dominant, polygenic, and sex-linked traits. |

## **Unit 12: Evolution**

**Big Ideas**
Evolution provides a scientific explanation for the history of life on Earth.

Evolution is the consequence of natural selection.

The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

**Contextual Understandings**

Current thinking about evolution (including natural selection and common descent) provide scientific explanations for life history on Earth. Evolution is depicted in the fossil record and in similarities evident within the diversity of existing organisms.

Evolution generally results from three processes: random mutation to genetic material, random genetic drift, and non-random natural selection within populations and species. These three processes result in major consequences, including the diversification of all forms of life from shared ancestors, and observable changes in the fossil record over long periods of time. Some examples of modern evolutionary changes in populations relating to natural selection are evident today (e.g., development of insect resistance to pesticides, bacterial resistance to antibiotics and viral strains).

There are many sources of similarities among all living organisms. They are due to common ancestry and the more closely related organisms share more recent common ancestors. Molecular evidence, shown by DNA similarity, supports the anatomical evidence for evolution and provides substantial detail about the branching of various lines of descent.

Biological classification is based on how closely organisms are related. Organisms are classified into a hierarchical groups and subgroups based on similarities which reflect their evolutionary relationships.

Greater diversity of species in an ecosystem often relates to greater stability. Increased numbers of species, with widely varied adaptations, provide enhanced opportunities that at least some will be able to survive major ecosystem change. This diversity generally originated over long periods of time and through natural selection.

Natural selection provides the following mechanism for evolution: some variation in heritable traits exists within any given species. Some of these characteristics give individuals an advantage in surviving and reproducing more offspring and those offspring, in turn, are more likely to survive and reproduce successfully. Over time, the proportion of these advantaged individuals in the population will increase. Since mutations occur randomly and are selected for if they help organisms survive and reproduce more successfully in their environment, the population changes as a result of this selection. Of course, those individuals that inherit traits that are selected against, are not as successful reproductively and eventually these traits may even die out of the population.

A species consists of individuals that are very similar in appearance, anatomy, physiology and genetics because they share relatively recent common ancestors. A species is often defined as all the individual organisms of a natural population that are capable of successfully interbreeding at maturity in the wild and whose interbreeding produces fertile offspring.

A population that becomes separated reproductively from others, either through geographic isolation or some other segregating factor, may be subject to different environmental conditions. Changes in the environment may select for different heritable traits that allow some individuals to be more reproductively successful. This selection may increase traits differentially in the divided population. If enough time passes, the selection for those specific traits might result in the development of a new species or variety.

Genetic drift is a cumulative process that involves the chance loss of some genes and the disproportionate replication of others over successive generations in a small population, so that the frequencies of genes in the population are altered. The process can lead to a population that differs genetically and in appearance from the original. The occurrence of random changes in gene frequencies within a small, isolated population over a short period of time, without mutation or selection, result in unique subpopulations. Along with natural selection, genetic drift is a principal force in evolution.

| Power Standards | Additional Standards |
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| B5.3A – Explain how natural selection acts on individuals, but it is populations that evolve. Relate genetic mutations and genetic variety produced by sexual reproduction to diversity within a given population.<br><br>B3.4B-Recognize and describe that a great diversity of species increases the chance that at least some living organisms will survive in the face of cataclysmic changes in the environment.<br><br>B5.1B-Describe how natural selection provides a mechanism for evolution.<br><br>B2.4A-Explain that living things can be classified based on structural, embryological, and molecular (relatedness of DNA sequence) evidence.<br><br>B2.4B Describe how various organisms have developed different specializations to accomplish a particular function and yet the end result is the same (e.g., excreting nitrogenous wastes in animals, obtaining oxygen for respiration. | B2.4d - Analyze the relationships among organisms based on their shared physical, biochemical, genetic, and cellular characteristics and functional processes.<br><br>B5.1A- Summarize the major concepts of natural selection (differential survival and reproduction of chance inherited variants, depending on environmental conditions).<br><br>B5.1c - Summarize the relationships between present-day organisms and those that inhabited the Earth in the past (e.g., use fossil record, embryonic stages, homologous structures, chemical basis).<br><br>B5.1d - Explain how a new species or variety originates through the evolutionary process of natural selection.<br><br>B5.1e - Explain how natural selection leads to organisms that are well suited for the environment (differential survival and reproduction of chance inherited variants, depending upon environmental conditions).<br><br>B5.1f - Explain, using examples, how the fossil record, comparative anatomy, and other evidence supports the theory of evolution.<br><br>B5.1g - Illustrate how genetic variation is preserved or eliminated from a population through natural selection (evolution) resulting in biodiversity.<br><br>B5.2a- Describe species as reproductively distinct groups of organisms that can be classified based on morphological, behavioral, and molecular structures.<br><br>B5.2b-Explain that the degree of kinship between organisms or species can be estimated from similarity of their DNA and protein sequences.<br><br>B5.2c- Trace the relationship between environmental changes and changes in the gene pool, such as genetic drift and isolation of subpopulations. |

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| | B5.3B – Describe the role of geographic isolation in speciation.<br><br>B5.3C – Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.<br><br>B5.3d – Explain how evolution through natural selection can result in changes in biodiversity.<br><br>B5.3e – Explain how changes at the gene level are the foundation for changes in populations and eventually the formation of a new species.<br><br>B5.3f – Demonstrate and explain how biotechnology can improve a population and species. |