تم تحميل هذا الملف من موقع المناهج الإماراتية

تجميعة صفحات الكتاب وفق الهيكل الوزاري الخطة C

موقع المناهج ⇦ المناهج الإماراتية ⇦ الصف الحادي عشر المتقدم ⇦ علوم ⇦ الفصل الثالث ⇦ الملف

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إعداد: ELD.SHAHID

التواصل الاجتماعي بحسب الصف الحادي عشر المتقدم

اضغط هنا للحصول على جميع روابط "الصف الحادي عشر المتقدم"

روابط مواد الصف الحادي عشر المتقدم على تلغرام

التربية الاسلامية	اللغة العربية	اللغة الانجليزية	الرياضيات

المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة علوم في الفصل الثالث

1	الهيكل الوزاري الجديد منهج بريدج الخطة C المسار المتقدم
2	مراجعة القسم الأول ديناميكية الجماعة الأحيائية
3	مراجعة القسم الثاني السكان من وحدة علم بيئة الجماعات الإحيائية
4	حل أسئلة الامتحان النهائي الالكتروني بريدج

المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة علوم في الفصل الثالث	
5	حل أسئلة الامتحان النهائي

Biology EOT Coverage Term 3 - 2024

11ADV - C

Dr. SHAHID.ELD

1	BIO.3.4.01.028 Describe the complementary processes of cellular respiration and photosynthesis with respect to the flow of energy and the cycling of matter within ecosystems, and explain how human activities can disrupt the balance achieved by these processes	U2M8L1		page 178

Transformation of Energy

Many chemical reactions and processes in your cells are ongoing, even when you might not think that you are using any energy. Macromolecules are assembled and broken down, substances are transported across cell membranes, and genetic instructions are transmitted. All of these cellular activities require **energy**–the ability to do work. **Figure 1** on the next page shows some of the major advancements in the study of cellular energy. **Thermodynamics** is the study of the flow and transformation of energy in the universe.

Laws of thermodynamics

The first law of thermodynamics is the law of conservation of energy, which states that energy can be converted from one form to another, but it cannot be created nor destroyed. For example, the stored energy in food is converted to chemical energy when you eat and to mechanical energy when you run or kick a ball.

The second law of thermodynamics states that energy cannot be converted without the loss of usable energy. The energy that is "lost" is generally converted to thermal energy. Entropy (EN truh pee) is the measure of disorder, or unusable energy, in a system. Therefore, the second law of thermodynamics can also be stated as "entropy increases." One example of the second law of thermodynamics is evident in food chains. Recall that at each step in a food chain, the amount of usable energy that is available to the next trophic level decreases.

Autotrophs and heterotrophs

All organisms need energy to live. Directly or indirectly, nearly all the energy for life comes from the Sun. Some organisms make their own food, while others must obtain it from other organisms. Organisms can be classified based on how they get the energy they need to live.

2	BIO.3.4.01.028 Describe the complementary processes of cellular respiration and photosynthesis with respect to the flow of energy and the cycling of matter within ecosystems, and explain how human activities can disrupt the balance achieved by these processes	U2M8L1		page 180

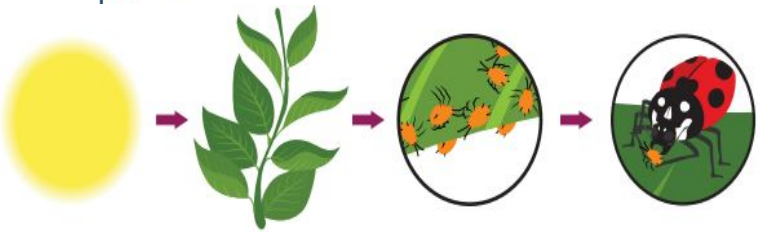

Figure 2 Almost all the energy in living organisms originates from the Sun, and energy flows from autotrophs to heterotrophs.

Autotrophs make their own food. Chemoautotrophs use inorganic substances such as hydrogen sulfide as a source of energy. Photoautotrophs, such as the plant in **Figure 2**, convert light energy from the Sun into chemical energy. Heterotrophs, such as the aphids and the ladybug in **Figure 2**, ingest food to obtain energy.

Metabolism

All of the chemical reactions in a cell are referred to as the cell's **metabolism.** As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. A series of chemical reactions in which the product of one reaction is the substrate for the next reaction is called a metabolic pathway. There are two main types of metabolic pathways: catabolic (ka tuh BAH lik) pathways and anabolic (a nuh BAH lik) pathways. Catabolic pathways release energy by breaking down larger molecules into smaller molecules. Anabolic pathways use the energy released by catabolic pathways to build larger molecules from smaller molecules. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.

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Energy continually flows between organisms. **Photosynthesis** is the anabolic pathway in which light energy is converted to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. The energy stored in glucose is transferred to other organisms when the molecules are consumed as food.

Cellular respiration is a catabolic pathway in which organic molecules are broken down to release energy. In cellular respiration, oxygen is used to break down organic molecules, producing carbon dioxide and water. Notice the cyclical nature of these processes in **Figure 3**.

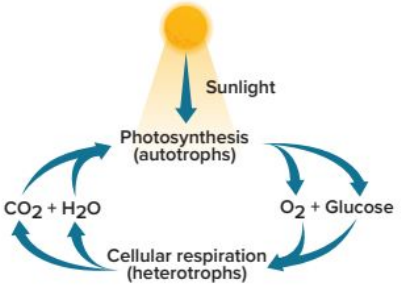


Figure 3 Photosynthesis and cellular respiration provide most of the energy for life processes.

ATP: The Unit of Cellular Energy

CHEMISTRY Connection Energy exists in many forms, such as mechanical energy and chemical energy. In organisms, chemical energy stored in biological molecules can be converted to other forms. For example, chemical energy is converted to mechanical energy when muscles contract. **Adenosine triphosphate** (uh DEN uh seen • tri FAHS fayt)—ATP—is the most important biological molecule that provides chemical energy.

3	BIO.3.4.01.025 Identify examples of the functions performed by the living organisms in which ATP is converted into ADP and inorganic phosphate.	U2M8L1	Figure 4	page 181

ATP structure

ATP is a multipurpose storehouse of chemical energy that can be used by cells in a variety of reactions. Although other carrier molecules transport energy within cells, ATP is the most abundant energy-carrier molecule in cells and is found in all types of organisms. ATP plays an important role in energy transfers within cells. As shown in **Figure 4**, ATP is a nucleotide made of an adenine base, a ribose sugar, and three phosphate groups.

ATP function

ATP releases energy when the bond between the second and third phosphate groups is broken, forming a molecule called adenosine diphosphate (ADP) and a free phosphate group, as shown in **Figure 4**. Energy is stored in the phosphate bond formed when ADP receives a phosphate group and becomes ATP. As shown in **Figure 4**, ATP and ADP can be interchanged by the addition or removal of a phosphate group. Sometimes ADP becomes adenosine monophosphate (AMP) by losing an additional phosphate group. There is less energy released in this reaction, so most of the energy reactions in the cell involve conversions between ATP and ADP.

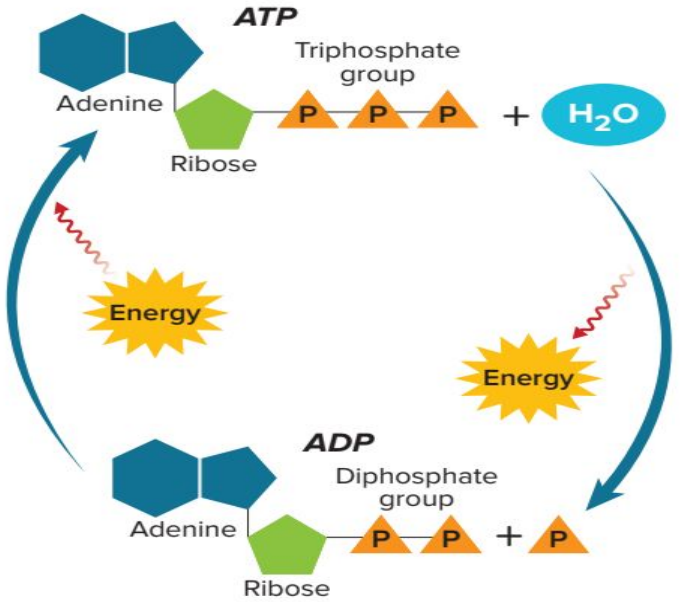


Figure 4 The breakdown of ATP releases energy for powering cellular activities in organisms.

4	BIO.3.4.01.027 Describe that photosynthesis converts carbon dioxide plus water into sugars plus oxygen, which is released.	U2M8L2		page 185

Electron transport

The structure of the thylakoid membrane is the key to efficient energy transfer during electron transport. Thylakoid membranes have a large surface area, which provides the space needed to hold large numbers of electron-transporting molecules and two types of protein complexes called photosystems. Photosystem I and photosystem II contain light-absorbing pigments and proteins that play important roles in the light reactions.

Follow along in **Figure 8** on the next page as you continue to read about electron transport.

- First, the light energy excites electrons in photosystem II. The light energy also causes a water molecule to split, releasing an electron into the electron transport system, a hydrogen ion (H^+)—also called a proton—into the thylakoid space, and the release of oxygen (O_2) as a waste product. This breakdown of water is essential for photosynthesis to occur.
- The excited electrons move from photosystem II to an electron-acceptor molecule in the thylakoid membrane.
- Next, the electron-acceptor molecule transfers the electrons along a series of electron-carriers to photosystem I.
- In the presence of light, photosystem I transfers the electrons to a protein called ferrodoxin. The electrons lost by photosystem I are replaced by electrons shuttled from photosystem II.
- Finally, ferrodoxin transfers the electrons to the electron carrier **$NADP^+$**, forming the energy-storage molecule NADPH.

The protons (H^+) released during electron transport accumulate in the interior of the thylakoid, creating a concentration gradient. As a result of a high concentration of H^+ in the thylakoid interior and a low concentration of H^+ in the stroma, H^+ protons diffuse down their concentration gradient out of the thylakoid interior into the stroma through ion channels spanning the membrane, as shown in **Figure 8.** These channels are enzymes called ATP synthases. As H^+ moves through ATP synthases, ATP is formed in the stroma.

Chemiosmosis ATP is produced in conjunction with electron transport by the process of chemiosmosis, the mechanism by which ATP is produced as a result of the flow of electrons down a concentration gradient. The breakdown of water is essential to this process, not only for providing the electrons that initiate the electron transport chain, but also for providing the protons (H^+) necessary to drive ATP synthesis during chemiosmosis.

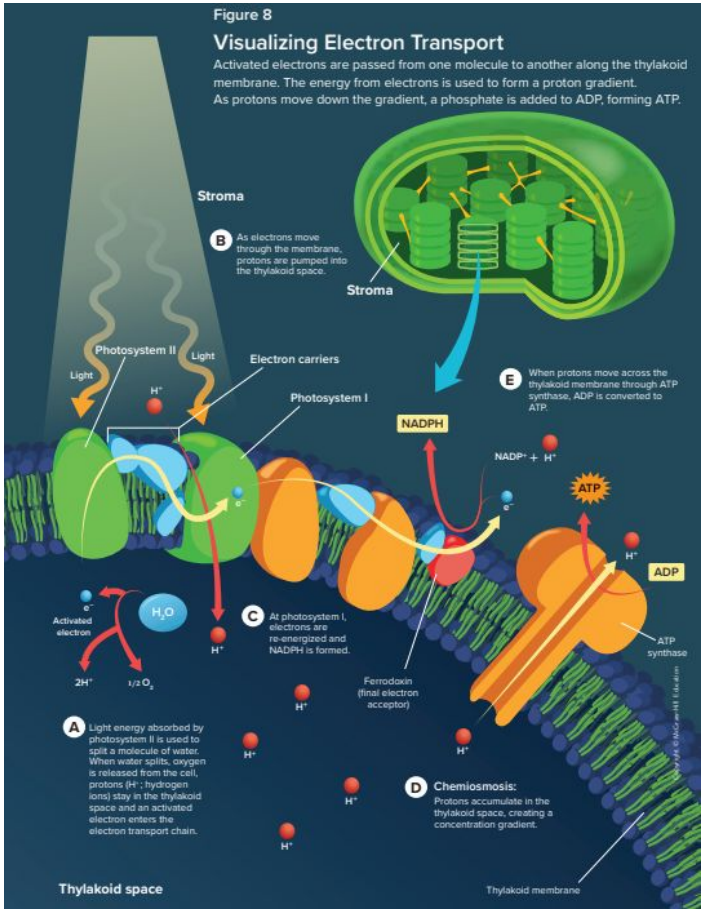
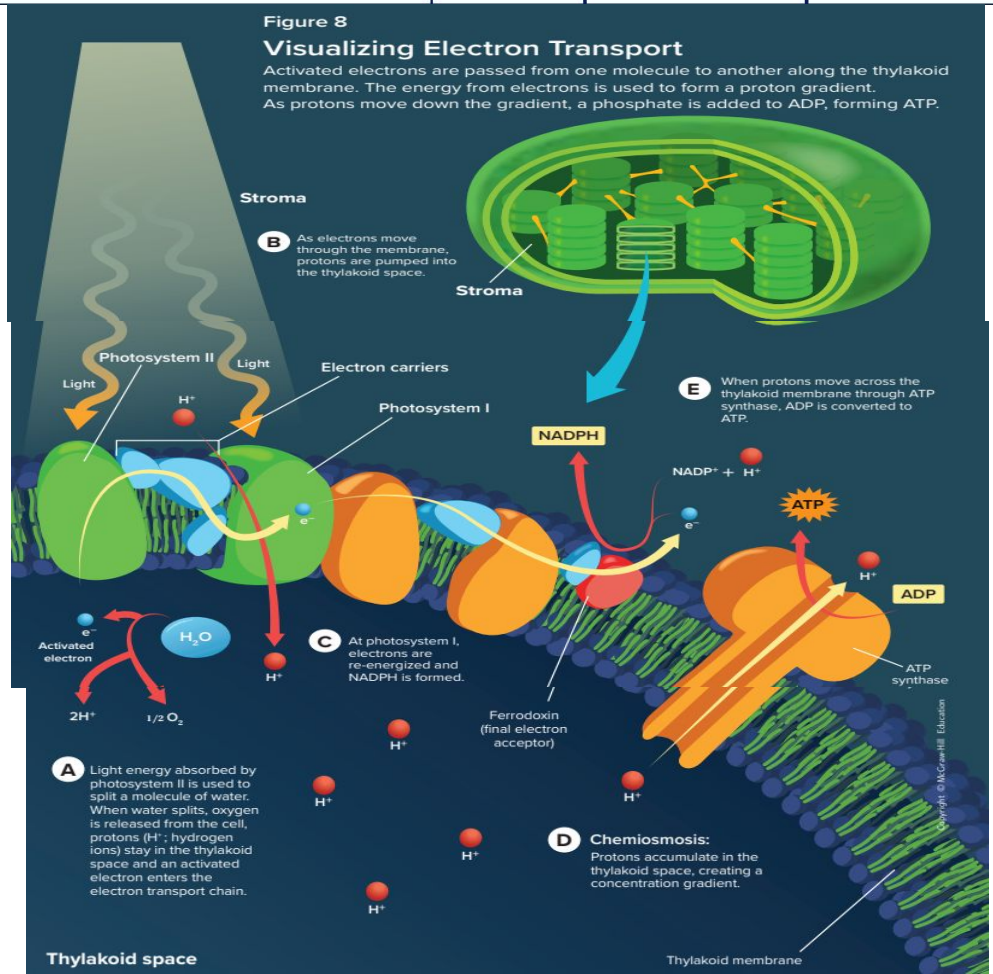


Figure 8
Visualizing Electron Transport
Activated electrons are passed from one molecule to another along the thylakoid membrane. The energy from electrons is used to form a proton gradient. As protons move down the gradient, a phosphate is added to ADP, forming ATP.
Stroma
B As electrons move through the membrane, protons are pumped into the thylakoid space.
Stroma
Photosystem II
Light
Light
Electron carriers
Photosystem I
E When protons move across the thylakoid membrane through ATP synthase, ADP is converted to ATP.
NADPH
NADP+ + H+
ATP
ADP
Activated electron
H2O
2H+
1/2 O2
C At photosystem I, electrons are re-energized and NADPH is formed.
Ferrodoxin (final electron acceptor)
ATP synthase
A Light energy absorbed by photosystem II is used to split a molecule of water. When water splits, oxygen is released from the cell, protons (H+; hydrogen ions) stay in the thylakoid space and an activated electron enters the electron transport chain.
D Chemiosmosis: Protons accumulate in the thylakoid space, creating a concentration gradient.
Thylakoid space
Thylakoid membrane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Thylakoid space
Thylakoid membrane

Phase Two: The Calvin Cycle

Although NADPH and ATP provide cells with large amounts of energy, these molecules are not stable enough to store chemical energy for long periods of time. Thus, there is a second phase of photosynthesis called the **Calvin cycle,** in which energy is stored in organic molecules such as glucose. The reactions of the Calvin cycle are also referred to as the light-independent reactions. Follow along in **Figure 9** as you learn the steps of the Calvin cycle.

- In the first step of the Calvin cycle, six carbon dioxide (CO_2) molecules combine with six 5-carbon compounds to form twelve 3-carbon molecules called 3-phosphoglycerate (fahs foh GLI suh rayt) (3-PGA). The joining of carbon dioxide with other organic molecules is called carbon fixation.
- In the second step, the chemical energy stored in ATP and NADPH is transferred to the 3-PGA molecules to form high energy molecules called glyceraldehyde 3-phosphates (G3P). ATP supplies the phosphate groups for forming G3P molecules, while NADPH supplies hydrogen ions and electrons.
- In the third step, two G3P molecules leave the cycle to be used for the production of glucose and other organic compounds.
- In the final step of the Calvin cycle, an enzyme called **rubisco** converts the remaining ten G3P molecules into 5-carbon molecules called ribulose 1, 5-bisphosphates (RuBP). These molecules combine with new carbon dioxide molecules to continue the cycle.

Because rubisco converts inorganic carbon dioxide molecules into organic molecules that can be used by the cell, it is considered one of the most important biological enzymes. Plants use the sugars formed during the Calvin cycle both as a source of energy and as building blocks for complex carbohydrates, including cellulose, which provides structural support for plants.

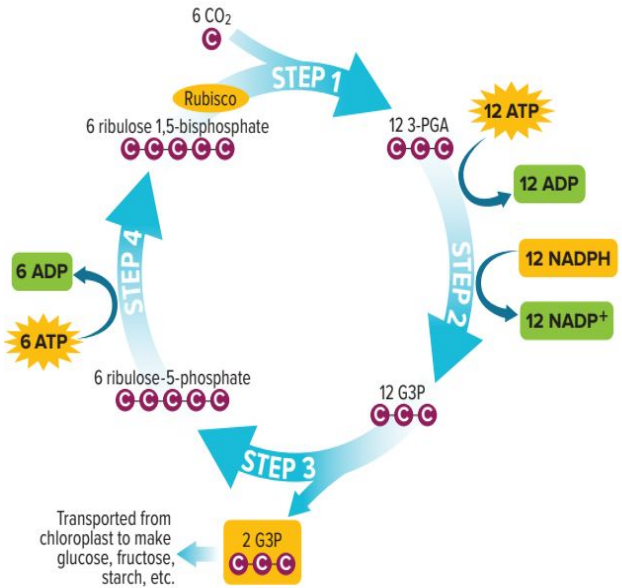

Figure 9 The Calvin cycle joins carbon dioxide with organic molecules inside the stroma of the chloroplast.

Determine *the compound in which energy is stored at the end of the Calvin cycle.*

7	BIO.3.1.02.028 Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy	U2M8L3	Figure 12	page 191

Preparatory reaction

Prior to the Krebs cycle, the three-carbon pyruvate first reacts with coenzyme A (CoA) to form a two-carbon intermediate called acetyl CoA and carbon dioxide (CO_2). NAD^+ is converted to NADH. Carbon dioxide is given off by the cell. Since there are two molecules of pyruvate for every preparatory reaction, it results in the production of two carbon dioxide molecules and two NADH molecules. Acetyl CoA then moves to the mitochondrial matrix.

Steps of the Krebs cycle

Follow along in **Figure 12** as you continue reading about the steps of the Krebs cycle.

- The Krebs cycle begins with acetyl CoA combining with a 4-carbon compound to form a 6-carbon compound known as citric acid.
- Citric acid is then broken down in the next series of steps, releasing two molecules of carbon dioxide and generating one ATP, three NADH, and one $FADH_2$. FAD is another electron carrier similar to NAD^+ and $NADP^+$.
- Finally, acetyl CoA and citric acid are generated and the cycle continues.

Recall that two molecules of pyruvate are formed during glycolysis, resulting in two "turns" of the Krebs cycle for each glucose molecule. The net yield from the Krebs cycle is six carbon dioxide molecules, two ATP, eight NADH, and two $FADH_2$. Ten NADH and two $FADH_2$ move on to play a significant role in the next stage of

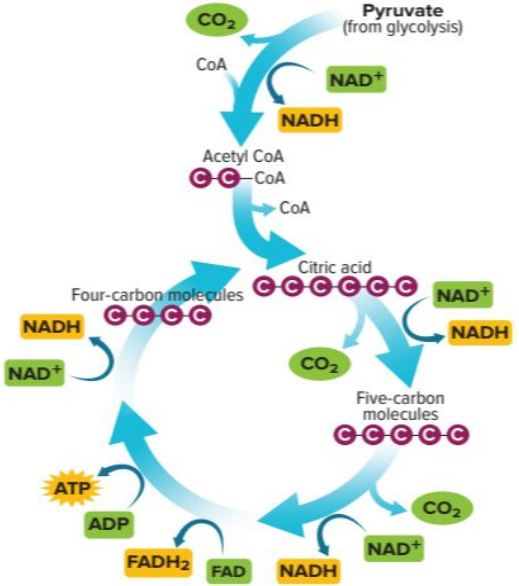

Figure 12 Pyruvate is broken down into carbon dioxide during the Krebs cycle inside the mitochondria of cells.

Trace *Follow the path of carbon molecules that enter and leave the Krebs cycle.*

8	BIO.3.1.02.028 Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy	U2M8L3		page 189, 190

Overview of Cellular Respiration

Organisms obtain energy in a process called cellular respiration, during which the bonds of food and oxygen molecules are broken and energy transfers from one set of interacting molecules to another. New compounds (ATP) form that can transport energy to muscles. Energy needed to maintain body temperature despite ongoing energy transfer to the environment is released. Cellular respiration is summarized in the equation and **Figure 10**.

$$C_6H_{12}O_6 + 6O_2 + 6H_2O \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

Cellular respiration has two main parts. Glycolysis is an anaerobic process. **Anaerobic processes** do not require oxygen. **Aerobic respiration** includes the Krebs cycle and electron transport and is an aerobic process. **Aerobic processes** require oxygen.

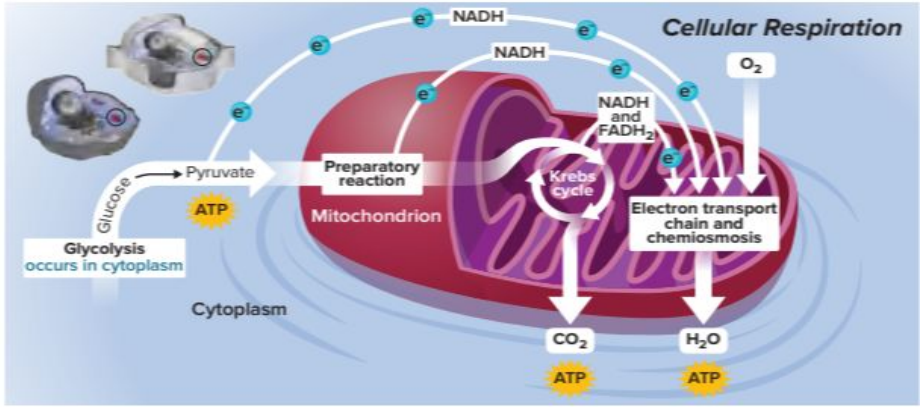

Figure 10 Cellular respiration occurs in the mitochondria, the energy powerhouse organelles of a cell.

Glycolysis

Glucose is broken down in the cytoplasm through the process of **glycolysis.** Two molecules of ATP and two molecules of NADH are formed for each molecule of glucose that is broken down. Follow along with **Figure 11** as you read about the steps of glycolysis. First, two phosphate groups, derived from two molecules of ATP, are joined to glucose. Notice that some energy, two ATP, is required to start the reactions that will produce energy for the cell. The 6-carbon molecule is then broken down into two 3-carbon compounds. Next, two phosphates are added and electrons and hydrogen ions (H^+) combine with two NAD^+ molecules to form two NADH molecules. NAD^+ is similar to NADP, an electron carrier used during photosynthesis. Last, the two 3-carbon compounds are converted into two molecules of pyruvate. At the same time, four molecules of ATP are produced.

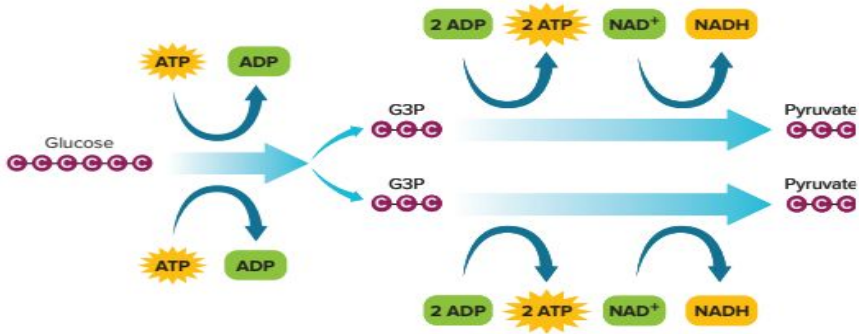

Figure 11 Glucose is broken down during glycolysis inside the cytoplasm of cells.

Krebs Cycle

Glycolysis has a net result of two ATP and two pyruvate molecules. Most of the energy from the glucose is still contained in the pyruvate. In the presence of oxygen, pyruvate is transported into the mitochondrial matrix, where it is eventually converted to carbon dioxide. The series of reactions in which pyruvate is broken down into carbon dioxide is called the **Krebs cycle,** or the tricarboxylic acid (TCA) cycle. This cycle also is referred to as the citric acid cycle.

9	BIO.3.1.02.028 Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy	U2M8L3		page 190

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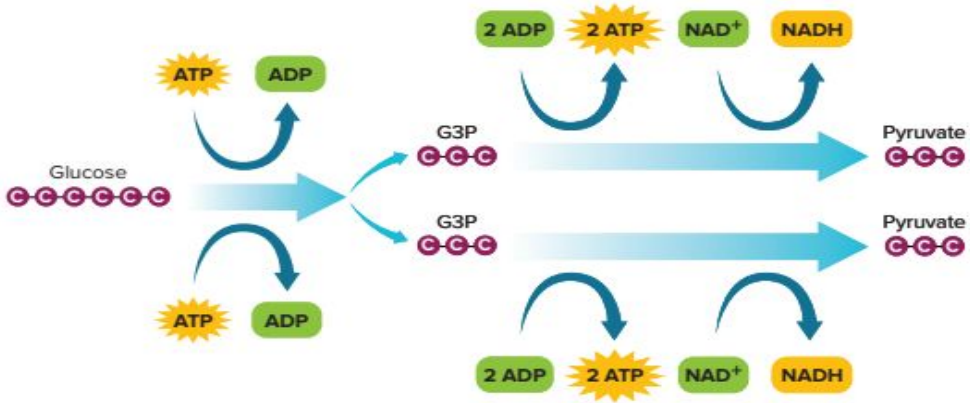


Figure 11 Glucose is broken down during glycolysis inside the cytoplasm of cells.

Germ Theory and Koch's Experiments

Before the invention of the microscope, people thought "something" passed from a sick person to a well person to cause an illness. Then, scientists discovered microorganisms and Louis Pasteur demonstrated that microorganisms from the air are able to grow in nutrient solutions. With the knowledge gained from these and other discoveries, doctors and scientists began to develop the germ theory. The germ theory states that some microorganisms are pathogens. However, scientists were not able to clearly demonstrate this theory until Robert Koch developed his postulates.

Identification of the first disease pathogen

In the late 1800s, Robert Koch, a German physician, was studying anthrax (AN thraks)—a deadly disease that affects cattle and sheep and can also affect people.

Koch isolated bacteria, like those in **Figure 1**, from the blood of cattle that had died from anthrax. After growing the bacteria in the laboratory, Koch injected the bacteria into healthy cattle. These animals developed the disease anthrax. He then isolated bacteria from the blood of newly infected cattle and grew the bacteria in the laboratory. The characteristics of the two sets of cultures were identical, indicating that the same type of bacteria caused the illness in both sets of cattle. Thus, Koch demonstrated that the bacteria he originally isolated were the cause of anthrax.

Get It?
Explain how Koch proved the germ theory correct.

Color-Enhanced SEM Magnification: unavailable

Figure 1 These rodlike bacteria cause the disease anthrax.

Koch's postulates

Koch established and published experimental steps known as **Koch's postulates,** which are rules for demonstrating that an organism causes a disease. These steps are followed today to identify a specific pathogen as the agent of a specific disease. Follow the steps in **Figure 2** as you read each of the four postulates.

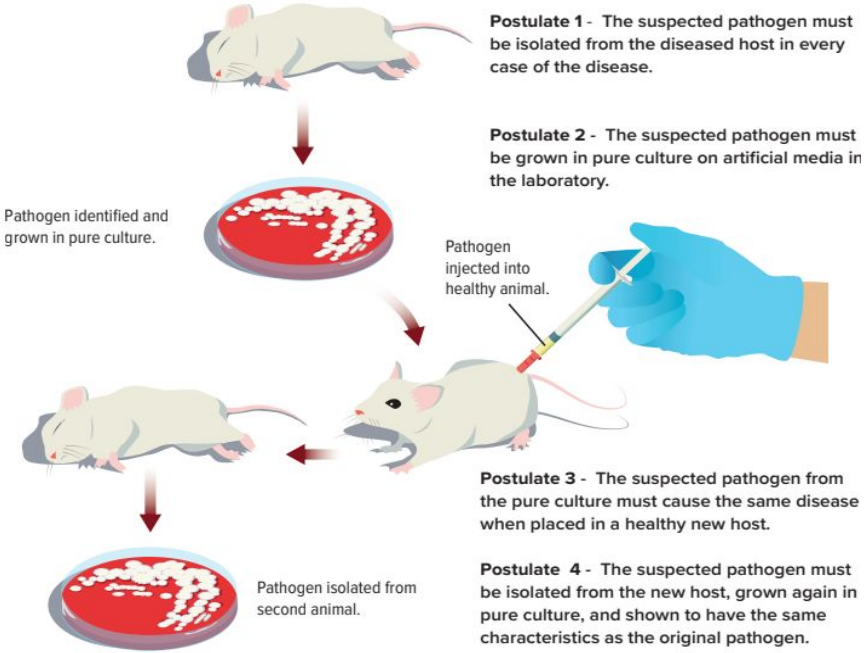


Figure 2 Koch's postulates demonstrate that a specific pathogen causes a specific disease.
Infer *what Koch demonstrated when he isolated the same bacteria from the cattle the second time.*

11	BIO.3.1.01.087 Explain the malfunctioning of biological systems based on hypotheses such as Koch's postulates, or on scientific examples of infectious diseases, their causes, transmission and treatments, and non-infectious diseases.	U6M27L1	Table 1	page 152

Some exceptions to Koch's postulates do exist. Some pathogens, such as the pathogen that is thought to cause syphilis (SIH fuh lus), cannot be grown in pure culture on artificial media. Artificial media are the nutrients that the bacteria need to survive and reproduce. Pathogens are grown on this media in the laboratory. Also, in the case of viruses, cultured cells are needed because viruses cannot be grown on artificial media.

Spread of Disease

Although there are a large number of microorganisms, only a few cause disease. Some might cause mild diseases, such as the common cold. Others cause serious diseases, such as meningitis, an infection of the coverings of the brain and spinal cord. **Table 1** lists some human infectious diseases. For a pathogen to spread, it must have both a reservoir and a way to spread. A disease **reservoir** is a source of the pathogen in the environment. Reservoirs might be animals, people, or inanimate objects, such as soil.

Human reservoirs

Humans are the main reservoir for pathogens that affect humans. Many pathogens might be passed on to other hosts before the person even knows he or she has the disease. An individual that is symptom-free but capable of passing the pathogen is called a carrier. Pathogens that cause colds, the flu, and sexually transmitted diseases, such as HIV, can be passed on without the person knowing he or she is infected.

Animal reservoirs

Other animals also are reservoirs of pathogens that can be passed to humans. Influenza and rabies are examples of human diseases listed in **Table 1** that are caused by pathogens passed to humans from other animals. Influenza can infect pigs. Rabies is found in domestic dogs and many wild animals, such as bats, skunks, and raccoons.

Table 1 Human Infectious Diseases

Disease	Cause	Affected Organ System	How Disease is Spread
Tetanus	Bacterium	Nervous system	Soil in deep puncture wound
Strep throat	Bacterium	Respiratory system	Droplets/direct contact
Lyme disease	Bacterium	Skeletal and nervous systems	Vector (tick)
Chicken pox	Virus	Skin	Droplets/direct contact
Rabies	Virus	Nervous system	Animal bite
Influenza (the flu)	Virus	Respiratory system	Droplets/direct contact
Hepatitis B	Virus	Liver	Direct contact with exchange of body fluids
Giardia	Protozoan	Digestive tract	Contaminated water
Malaria	Protozoan	Blood and liver	Vector (mosquito)
Athlete's foot	Fungus	Skin	Direct contact or contaminated objects

Symptoms of Disease

When you become ill with a disease such as the flu, why do you feel aches and pains, and why do you cough and sneeze? The pathogen, such as the influenza virus or bacteria, has invaded some of the cells of your body. The virus multiplies in the cells and leaves the cells either by exocytosis, or by causing the cell to burst. Thus, the virus damages tissues and even kills some cells. When pathogenic bacteria invade the body, harmful chemicals or toxins might be produced. The toxins can be carried throughout the body via the bloodstream and damage various parts of the body.

Toxins produced by some pathogens can affect specific organ systems. The tetanus bacteria produce a potent toxin that causes spasms in voluntary muscles. The disease botulism (BAH chuh lih zum) usually is caused when a person consumes food in which the botulism bacteria have grown and produced a toxin. This toxin paralyzes nerves. The toxin from the botulism bacteria can cause disease in humans even when no bacteria are present.

Some types of bacteria, some protozoans, and all viruses invade and live inside cells, causing damage. Because the cells are damaged, they might die, causing symptoms in the host. Some disease symptoms, such as coughing and sneezing, are triggered by the immune system, as discussed later in this module. For a closer look at research on the immune system, examine **Figure 4**, on the next page.

Get It?
Describe what happens when a person consumes food that contains botulism bacteria.

Disease Patterns

As outbreaks of diseases spread, certain patterns are observed. Agencies such as community health departments, the Centers for Disease Control and Prevention (CDC), and the World Health Organization (WHO) continually monitor disease patterns to help control the spread of diseases. The CDC, with headquarters in Atlanta, Georgia, receives information from doctors and medical clinics and publishes a weekly report about the incidence of specific diseases, as shown in **Figure 5**. The WHO similarly watches disease incidence throughout the world.

Some diseases, such as the common cold, are known as **endemic diseases** because small numbers of incidents are continually found within the population. Sometimes, a particular disease will have a large outbreak in an area and afflict many people, causing an **epidemic.** In 2003, there was an epidemic of severe acute respiratory syndrome (SARS). If an epidemic is widespread throughout a large region, such as a country, continent, or the entire globe, it is described as **pandemic.** HIV is an example of a pandemic. Influenza has led to several pandemics throughout history, including the Spanish flu in 1918, the Asian flu in 1957, and the Hong Kong flu in 1968. Each of the these flu pandemics killed millions of people worldwide.

TABLE 2. Reported cases of notifiable diseases,* by geographic division and area – United States, 2014

Area	Total resident population (in thousands)	Lyme disease
UNITED STATES	318,856	33,461
NEW ENGLAND	14,681	11,292
Connecticut	3,597	2,360
Maine	1,330	1,401
Massachusetts	6,745	5,304
New Hampshire	1,327	724
Rhode Island	1,055	904
Vermont	627	599
MID. ATLANTIC	41,471	14,509
New Jersey	8,938	3,286
New York (Upstate)	11,255	2,887
New York City	8,491	849
Pennsylvania	12,787	7,487
E.N. CENTRAL	46,740	1,950
Illinois	12,881	233
Indiana	6,597	110
Michigan	9,910	127
Ohio	11,594	119

Figure 5 The Centers for Disease Control and Prevention publish reports on the incidence of certain diseases.
Infer *how these reports are helpful in understanding disease patterns.*

Get It?
Compare and contrast an epidemic and a pandemic.

Nonspecific Immunity

At the time of birth, the body has a number of defenses in the immune system that fight off pathogens. These defenses are nonspecific because they are not aimed at a specific pathogen. They protect the body from any pathogen that the body encounters.

The nonspecific immunity provided by the body helps to prevent disease. Nonspecific immunity also helps to slow the progression of the disease while the specific immunity begins to develop its defenses. Specific immunity is the most effective immune response, but nonspecific immunity is the first line of defense.

Barriers

Like the strong walls of a fort, barriers are used by the body to protect against pathogens. These barriers are found in areas of the body where pathogens might enter.

Skin barrier The first major line of defense is the unbroken skin and its secretions. Skin contains layers of living cells covered by many layers of dead skin cells. By forming a barrier, the layers of dead skin cells help protect against invasion by microorganisms. Of the many different types of bacteria that normally live on the skin, most have little or no effect on our health. Many of the bacteria that live symbiotically on the skin digest skin oils to produce acids that inhibit many pathogens. **Figure 8** shows bacteria that are normally found on the skin and protect the skin from attack.

SEM Magnification: unavailable

Staphylococcus epidermidis

Figure 8 These bacteria are found on human skin and provide protection from pathogens.

Chemical barriers Saliva, tears, and nasal secretions contain the enzyme lysozyme. Lysozyme breaks down bacterial cell walls, which kills pathogens.

Another chemical defense is mucus, which is secreted by many inner surfaces of the body. It acts as a protective barrier, blocking bacteria from sticking to the inner epithelial cells. Cilia also line the airway. Their beating motion sends any bacteria caught in the mucus away from the lungs. When the airway becomes infected, extra mucus is secreted, which triggers coughing and sneezing to help move the infected mucus out of the body.

A third chemical defense is the hydrochloric acid secreted in your stomach. In addition to digestion, stomach acid kills many microorganisms found in food that could cause disease.

Get It?

Compare and contrast the different types of barriers of the immune system.

Nonspecific responses to invasion

Even if an enemy gets through the walls of a town's fort, defense doesn't end. Similarly, the body has nonspecific immune responses to pathogens that get beyond its barriers.

Cellular defense If foreign microorganisms enter the body, the cells of the immune system, shown in **Table 2**, on the next page, defend the body. One method of defense is phagocytosis. White blood cells, especially neutrophils and macrophages, are phagocytic. Recall that phagocytosis is the process by which phagocytic cells surround and internalize the foreign microorganisms. The phagocytes then release digestive enzymes and other harmful chemicals from their lysosomes, destroying the microorganism.

A series of about 20 proteins that are found in the blood plasma are called complement proteins. **Complement proteins** enhance phagocytosis by helping the phagocytic cells bind better to pathogens and activating the phagocytes. Some complement proteins can form a complex in the plasma membrane of a pathogen. This complex forms a pore, which aids in the destruction of the pathogen, as shown in **Figure 9**.

Interferon When a virus enters the body, another cellular defense helps prevent the virus from spreading. Virus-infected cells secrete a protein called **interferon.** Interferon binds to neighboring cells and stimulates these cells to produce antiviral proteins which can prevent viral replication in these cells.

Inflammatory response Another nonspecific response, the inflammatory response, is a complex series of events that involves many chemicals and immune cells that help enhance the overall immune response. When pathogens damage tissue, chemicals are released by both the invader and cells of the body. These chemicals attract phagocytes to the area, increase blood flow to the infected area, and make blood vessels more permeable to allow white blood cells to escape into the infected area.

This response aids in the accumulation of white blood cells in the area. Some of the pain, heat, and redness experienced during an infectious disease are the result of the inflammatory response.

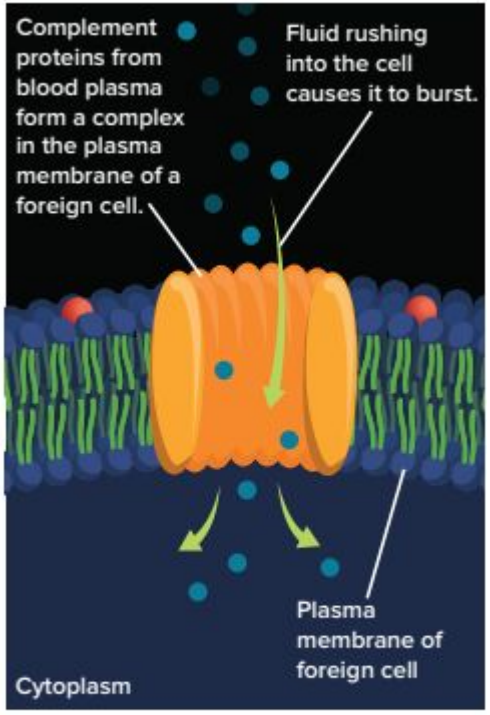


Figure 9 For some pathogens, complement proteins can form a pore in the plasma membrane of the invading cell.

Specific Immunity

Pathogens sometimes get past the nonspecific defense mechanisms. In this event, the body has a second line of defense that attacks the pathogens. Specific immunity is more effective and involves the tissues and organs found in the lymphatic system.

Lymphatic system

The lymphatic system, shown in **Figure 10**, includes organs and cells that filter lymph and blood, destroy foreign microorganisms, and absorb fat. Lymph is the watery part of the blood (the plasma) that leaks out of capillaries to bathe all the cells in the body. This clear fluid, containing oxygen, nutrients, and white blood cells, circulates among the tissue cells, is collected by lymphatic vessels, and is returned to the circulatory system via the veins near the heart.

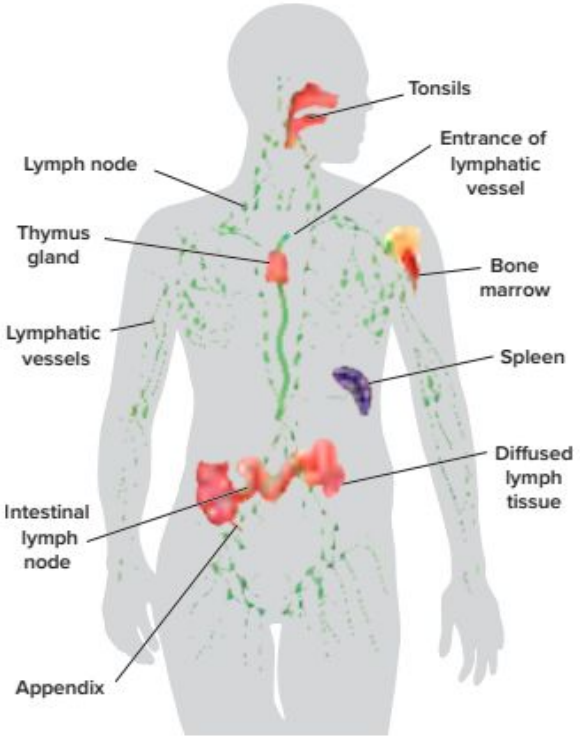
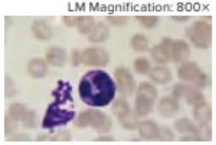
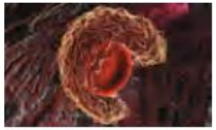
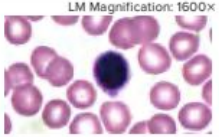


Figure 10 The lymphatic system contains the organs involved in the specific immune response.

Identify *the lymphatic organ where T cells mature.*

Table 2 Cells of the Immune System

Type of Cell	Example	Function
Neutrophils	LM Magnification: 800× 	Phagocytosis: blood cells that ingest bacteria
Macrophages		Phagocytosis: blood cells that ingest bacteria and remove dead neutrophils and other debris
Lymphocytes	LM Magnification: 1600× 	Specific immunity (antibodies and killing of pathogens): blood cells that produce antibodies and other chemicals

Lymphatic organs

The organs of the lymphatic system contain lymphatic tissue, lymphocytes, a few other cell types, and connective tissue. **Lymphocytes** are a type of white blood cell that is produced in red bone marrow. The lymphatic organs include the lymph nodes, tonsils, spleen, thymus (THI mus) gland, and diffused lymphatic tissue found in mucous membranes of the intestinal, respiratory, urinary, and genital tracts.

The lymph nodes filter the lymph and remove foreign materials from the lymph. The tonsils form a protective ring of lymphatic tissue between the nasal and oral cavities. This helps protect against bacteria and other harmful materials in the nose and mouth.

The spleen stores blood and destroys damaged red blood cells. It also contains lymphatic tissue that responds to foreign substances in the blood. The thymus gland, which is located above the heart, plays a role in activating a special kind of lymphocyte called T cells. T cells are produced in the bone marrow, but they mature in the thymus gland.

B Cell Response

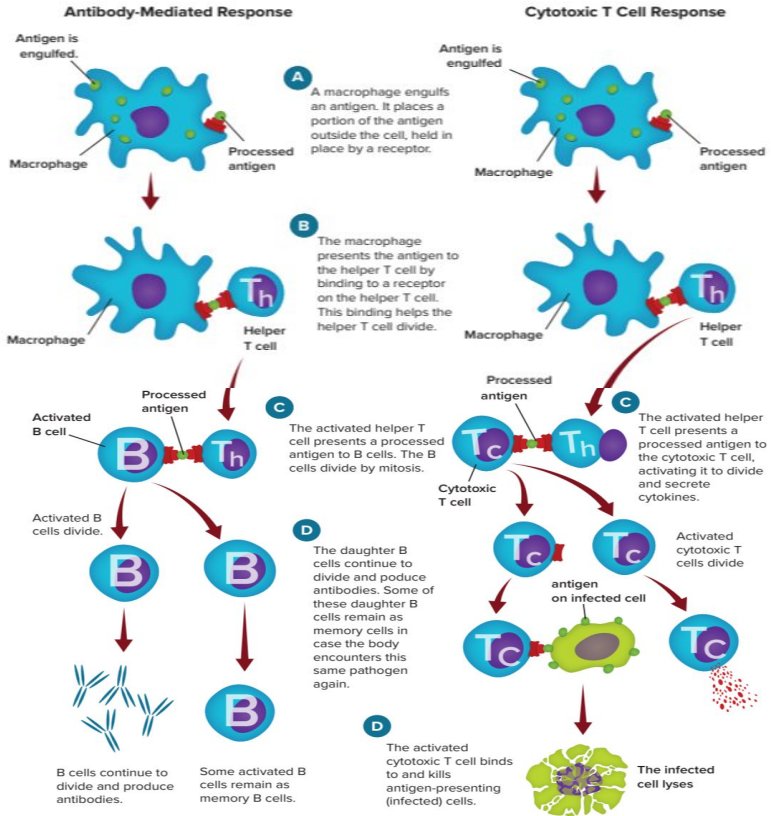
B lymphocytes, often called **B cells,** are located in all lymphatic tissues and can be thought of as antibody factories. **Antibodies** are proteins produced by B lymphocytes that specifically react with a foreign antigen. An antigen is a substance foreign to the body that causes an immune response; it can bind to an antibody or T cell. When a portion of a pathogen is presented by a macrophage, B cells produce antibodies. Follow along in **Figure 11** on the next page as you learn about how B cells are activated to produce antibodies.

When a macrophage surrounds, internalizes, and digests a pathogen, it takes a piece of the pathogen, which is called a processed antigen, and displays it on its membrane, as illustrated in **Figure 11**. In the lymphatic tissues, such as the lymph nodes, the macrophage, with the processed antigen on its surface, binds to a type of lymphocyte called a **helper T cell.** This process activates the helper T cell. This lymphocyte is called a "helper" because it activates antibody secretion in B cells and another type of T cell, which will be discussed later, that aids in killing microorganisms:

- The activated helper T cell reproduces, binds processed antigens, and attaches to a B cell.
- The new helper T cells continue the process of binding antigens, attaching to B cells, and reproducing.
- Once an activated helper T cell binds to a B cell holding an antigen, the B cell begins to manufacture antibodies that specifically bind to the antigen.
- The antibodies can enhance the immune response by binding to microorganisms, making them more susceptible to phagocytosis and, by initiating the inflammatory response, helping promote the nonspecific response.

Figure 11 Visualizing Specific Immune Responses

Specific immune responses involve antigens, phagocytes, B cells, helper T cells, and cytotoxic T cells. The antibody-mediated response involves antibodies produced by B cells and memory B cells. The cytotoxic T cell response results in cytotoxic T cell activation.



B cells make many combinations of antibodies by using DNA that codes for the production of various heavy and light protein chains that make up antibodies, as shown in **Figure 12.** Any heavy chain can combine with any light chain. If a B cell can make 16,000 different kinds of heavy chains and 1200 kinds of light chains, it can make 19,200,000 different types of antibodies (1200 × 16,000).

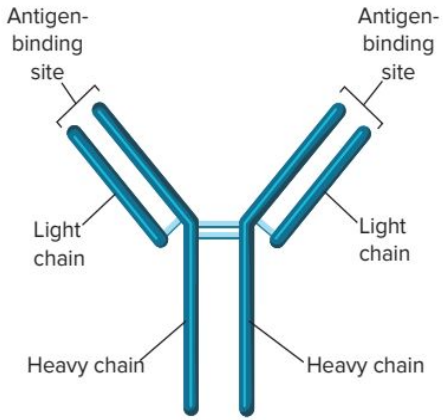


Figure 12 Antibodies are made up of two types of protein chains—heavy and light chains.

T Cell Response

Once helper T cells are activated by the presentation of an antigen by macrophages, helper T cells can also bind to and activate a group of lymphocytes called cytotoxic T cells. Activated **cytotoxic T cells** destroy pathogens and release chemicals called cytokines. Cytokines stimulate the cells of the immune system to divide and recruit immune cells to an area of infection. Cytotoxic T cells bind to pathogens, release a chemical attack, and destroy the pathogens. Multiple target cells can be destroyed by a single cytotoxic T cell. **Figure 11**, on the previous page, summarizes the activation of cytotoxic T cells.

Get It?

Summarize the role that lymphocytes play in immunity.

Passive and Active Immunity

The body's first response to an invasion by a pathogen is called the primary response. For example, if the viral pathogen that causes chicken pox enters the body, nonspecific and specific immune responses eventually defeat the foreign virus and the body is cleared of the pathogen.

One result of the specific immune response is the production of memory B and T cells. **Memory cells** are long-living cells that are exposed to the antigen during the primary immune response. These cells are ready to respond rapidly if the body encounters the same pathogen later. Memory cells protect the body by reducing the likelihood of developing the disease if exposed again to the same pathogen.

Passive immunity

Sometimes temporary protection against an infectious disease is needed. This type of temporary protection occurs when antibodies are made by other people or animals and are transferred or injected into the body. For example, passive immunity occurs between a mother and her child. Antibodies produced by the mother are passed through the placenta to the developing fetus and through breast milk to the infant child. These antibodies can protect the child until the infant's immune system matures.

Antibodies developed in humans and animals that are already immune to a specific infectious disease are used to treat some infectious diseases in others. These antibodies are injected into people who have been exposed to that particular infectious disease. Passive immune therapy is available for people who have been exposed to hepatitis A and B, tetanus, and rabies. Antibodies also are available to inactivate snake and scorpion venoms.

Active immunity

Active immunity occurs after the immune system is exposed to disease antigens and memory cells are produced. Active immunity can result from having an infectious disease or immunization. **Immunization,** also called vaccination, is the deliberate exposure of the body to an antigen so that a primary response and immune memory cells will develop. **Table 3** lists some of the common immunizations offered in the United States. Immunizations contain killed or weakened pathogens, which are incapable of causing the disease.

Most immunizations include more than one stimulus to the immune system, given after the first immunization. These booster shots increase the immune response, providing further protection from the disease-causing organism.

Get It?

Describe the difference between passive immunity and active immunity.

Autoimmunity

During the development of the immune system, the immune system learns not to attack proteins produced by the body. However, some people develop autoimmunity (aw toh ih MYOON ih tee) and do form antibodies to their own proteins, which injures their cells. **Figure 17** shows the hands of a person with rheumatoid arthritis—a form of arthritis in which antibodies attack the joints. Degenerative arthritis, the form of arthritis that you read about earlier in the section on degenerative diseases, is not caused by autoimmunity.

Rheumatic fever and lupus (LEW pus) are other examples of autoimmune disorders. Rheumatic fever is an inflammation in which antibodies attack the valves of the heart. This can lead to damage to the heart valves and cause the valves to leak or not close properly as blood moves through the heart. Lupus is a disorder in which autoantibodies are formed and attack healthy tissue. As a result, many organs are vulnerable to attack by the body's own immune system.

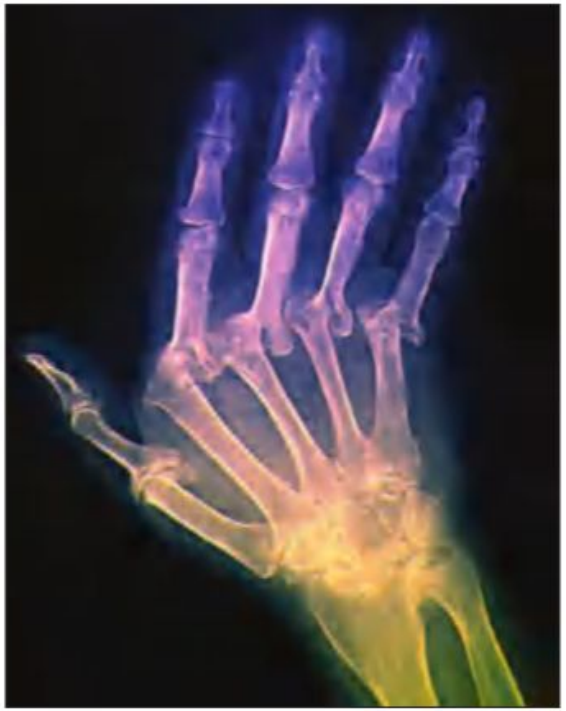


Figure 17 The large knobs and deformaties of these fingers are due to rheumatoid arthritis, an autoimmune disease.

Allergies

Certain individuals might have an abnormal reaction to environmental antigens. A response to environmental antigens is called an **allergy.** These antigens are called allergens and include things such as plant pollens, dust, dust mites, and various foods, as shown in **Table 4.** An individual becomes sensitized to the allergen and has a localized inflammatory response with swollen itchy eyes, stuffy nose, sneezing, and sometimes a skin rash. These symptoms are the result of a chemical called histamine, released by certain white blood cells. Antihistamine medications can help alleviate these symptoms.

Get It?

Explain how allergies are related to the immune system.

Severe allergic reactions to particular allergens can result in **anaphylactic** (an uh fuh LAK tik) **shock,** which causes a massive release of histamine. In anaphylactic shock, the smooth muscles in the bronchioles contract, which restricts air flow into and out of the lungs.

Common allergens that cause severe allergic reactions are bee stings, penicillin, peanuts, and latex, which is used to make balloons and surgical gloves. People who are extremely sensitive to these allergens require prompt medical treatment if exposed to these agents, because anaphylactic reactions are life-threatening. Allergies and anaphylactic reactions are known to have an inherited component.

Table 4 Common Allergens

Allergen	Example	Description
Dust mite	Color-enhanced SEM, magnification ×44 	Dust mites are found in mattresses, pillows, and carpets. Mites and mite feces are allergens.
Plant pollen	Color-enhanced SEM, magnification ×1000 	Different parts of the country have very different pollen seasons. People can react to one or more pollens, and a person's pollen allergy season might be from early spring to late fall.
Animal dander	Color-enhanced SEM, magnification ×100 	Dander is skin flakes. Cat and dog allergies are the most common, but people also are allergic to pets such as birds, hamsters, rabbits, mice, and gerbils.
Peanut		Allergic reaction to peanuts can result in anaphylactic shock. Peanut allergy is responsible for more fatalities than any other type of allergy.
Latex		Latex comes from the milky sap of the rubber tree, found in Africa and Southeast Asia. The exact cause of latex allergy is unknown.

Population growth rate

An important characteristic of any population is its growth rate. The **population growth rate** (PGR) explains how fast a given population grows. One of the characteristics of the population ecologists must know, or at least estimate, is natality. The natality of a population is the birthrate, or the number of individuals born in a given time period. Ecologists also must know the mortality—the number of deaths that occur in the population during a given time period.

The number of individuals emigrating or immigrating also is important. **Emigration** (em uh GRAY shun) is the term ecologists use to describe the number of individuals moving away from a population.

Immigration (ih muh GRAY shun) is the term ecologists use to describe the number of individuals moving into a population. In most instances, emigration is about equal to immigration. Therefore, natality and mortality usually are the most important factors in determining the population growth rate.

Some populations tend to remain approximately the same size from year to year. Other populations vary in size depending on conditions within their habitats. To better understand why populations grow in different ways, you should understand two mathematical models for population growth—the exponential growth model and the logistic growth model.

Exponential growth model Look at **Figure 7** to see how a population of mice would grow if there were no limits placed on it by the environment.

Assume that two adult mice breed and produce a litter of two young. Also assume the two offspring are able to reproduce in one month. If all of the offspring survive to breed, the population grows slowly at first. This slow growth period is defined as the lag phase. The rate of population growth soon begins to increase rapidly because the total number of organisms that are able to reproduce has increased. After only two years, the experimental mouse population would reach more than three million mice.

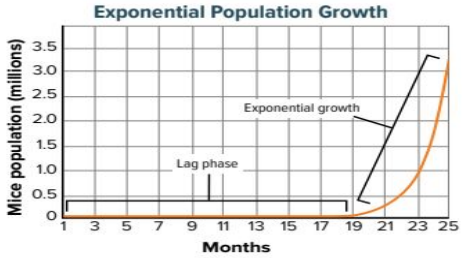


Figure 7 If mice were allowed to reproduce unhindered, the population would grow slowly at first but would accelerate quickly.

Infer *why mice or other populations do not continue to grow exponentially.*

MATH Connection Notice in **Figure 7** that once the mice begin to reproduce rapidly, the graph becomes J-shaped. A J-shaped growth curve illustrates exponential growth. Exponential growth, also called geometric growth, occurs when the growth rate is proportional to the size of the population. All populations grow exponentially until some limiting factor slows the population's growth. It is important to recognize that even in the lag phase, the use of available resources is exponential. Because of this, the resources soon become limited and population growth slows.

Logistic growth model Most populations grow like the model shown in **Figure 8** rather than the model shown in **Figure 7**. Notice that the graphs look exactly the same through some of the time period: the number of individuals begins very low, then increases very rapidly. During this period, competition for resources among individuals in the population is low.

The second graph, however, curves into the S-shape typical of logistic growth. Population growth stops increasing when an environment's carrying capacity has been reached.

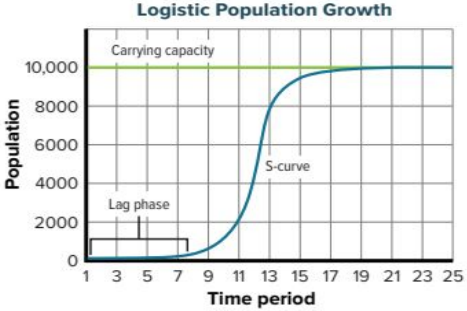


Figure 8 When a population exhibits growth that results in an S-shaped graph, it exhibits logistic growth. The population levels off at a limit called the carrying capacity.

Reproductive patterns

The graph in **Figure 8** shows the number of individuals increasing until the carrying capacity is reached. The graph is a useful population model, and can be used to predict how a population's number might change over time.

However, there are several additional factors that must be considered for real populations. Species of organisms vary in the number of births per reproduction cycle, in the age that reproduction begins, and in the life span of the organism. Both plants and animals are placed into groups based on their reproductive factors. However, not all organisms fit under a specific reproductive strategy.

Members of one of the groups are called the *r*-strategists. The rate strategy, or *r*-strategy, is an adaptation for living in an environment where fluctuation in biotic or abiotic factors occur. Fluctuating factors might be availability of food, changing temperatures, or migrating animals. An *r*-strategist is generally a small organism such as a fruit fly, a mouse, or the locusts shown in **Figure 9**. *r*-strategists usually have short life spans and produce many offspring.

The reproductive strategy of an *r*-strategist is to produce as many offspring as possible in a short time period in order to take advantage of some environmental factor. Organisms classified as *r*-strategists typically expend little or no energy in raising their young to adulthood. Populations of *r*-strategists are usually controlled by density-independent factors, and they usually do not maintain a population near the carrying capacity.

Figure 9 Locusts, which are an example of *r*-strategists, produce many offspring in their short lifetimes.

Infer *what specific factors might fluctuate in a locust's environment.*

Just as some environments fluctuate, others are fairly predictable. The elephants in **Figure 10** experience a carrying capacity that changes little from year to year. The carrying-capacity strategy, or *k*-strategy, is an adaptation for living in environments that are fairly stable.

A *k*-strategist generally is a larger organism that has a long life span, produces few offspring, and whose population reaches equilibrium at the carrying capacity.

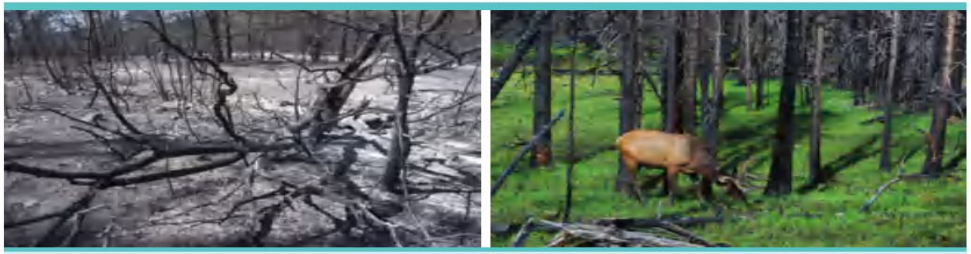
Figure 10 Elephants are *k*-strategists that produce few offspring, but they invest a lot of care in the raising of their offspring.

The reproductive strategy of a *k*-strategist is to produce only a few offspring that have a better chance of living to reproductive age because of the energy, resources, and time invested in the care for the young. The number of individuals in a population of *k*-strategists usually are controlled by density-dependent factors and not by density-independent factors. For example, a ten-degree change in temperature might be enough to drastically reduce the number of locusts in a population, but it would not likely influence the number of elephants in a population.

20	BIO.3.4.01.033 Explain that ecosystems are dynamic in nature and that their characteristics can vary over time BIO.3.4.01.042 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	U1M4L1		page 132, 133

Density-independent factors

Any factor in the environment that does not depend on the number of members in a population per unit area is a **density-independent factor.** These factors usually are abiotic and include natural phenomena such as weather events. Weather events that limit populations include drought or flooding, extreme heat or cold, tornadoes, hurricanes, or fires (as shown in **Figure 4**).



Crown fire damage | Managed ground fire damage

Figure 4 A crown fire is a density-independent factor that can limit population growth. However, small ground fires can promote growth in a forest community.

Explain *why these two situations involving fire have different results on the tree populations.*

Figure 4 on the last page shows an example of the effects that fire can have on a population. The ponderosa pines have been damaged by a crown fire, a fire that advances to the tops of the trees. In this example, the fire limits the population of ponderosa trees by killing many of the trees. However, smaller but more frequent ground fires have the opposite effect on the population. By thinning lower growing plants that use up nutrients, a healthier population of mature ponderosa pines is produced.

Populations can be limited by the results of human interference. For example, over the last 100 years, building dams and other human activities on the Colorado River have significantly reduced the river's water flow and changed its temperature. In addition, the introduction of nonnative fish species altered the river's biotic factors. Because of the changes in the river, the number of small fish called humpback chub was reduced. During the 1960s, the number of humpback chub dropped so low that they were in danger of disappearing from the Colorado River altogether. Air, land, and water pollution are the result of human activities that also can limit populations. Pollution reduces the available resources by making some of the resources toxic.

Density-dependent factors

Any factor in the environment that depends on the number of members in a population per unit area is a **density-dependent factor.** Density-dependent factors are often biotic factors such as predation, disease, competition, and parasites.

Predation A study of density-dependent factors was done on the wolf and moose populations in northern Michigan on Isle Royale, located in Lake Superior. The results of this study are shown in **Figure 5**.

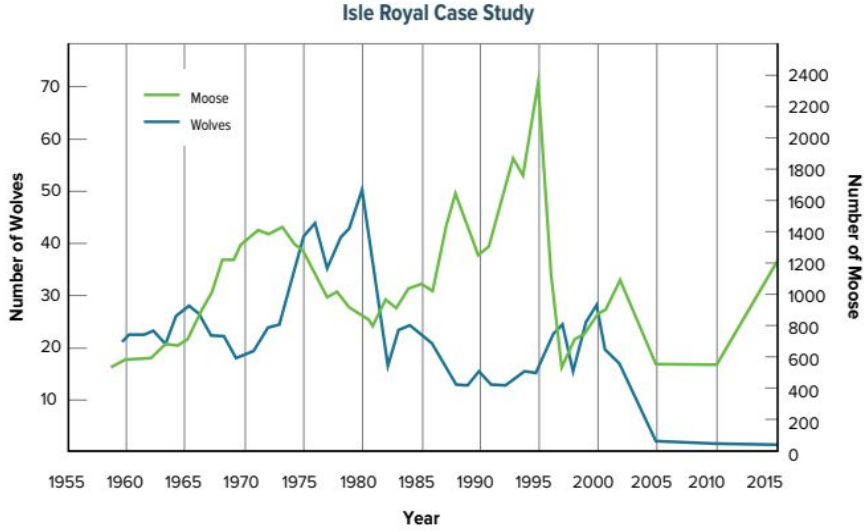


Figure 5 The long-term study of the wolf and moose populations on Isle Royale shows the relationship between the number of predators and prey over time.

Infer *what might have caused the increase in the number of moose between 1990 and 1995.*