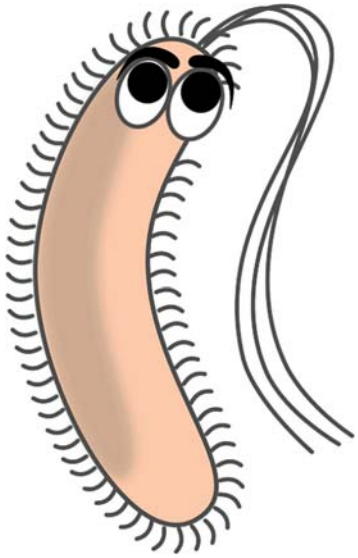
Bacteria

Bacteria are a kind of microorganism that consist of only a single cell. Bacteria have cell walls that are a lot like plants cells. Also like plant cells, bacteria do not have a nucleus. They can be different shapes, including rods, spirals, and spheres. Some bacteria use long tails called flagella to propel themselves forward with a swimming time motion. Some float or glide. Bacteria are everywhere. They live in the air, in the water, in the ground, on our skin, and even inside of our bodies.

We classify certain bacteria as "good" bacteria because they are an important part of our body's system. We actually can't live without them. For example, the bacteria in our digestive system, referred to as the gut microbiome, helps us to digest food and extract nutrients from it. It also plays a role in the functioning of our immune system. Other good bacteria play a similarly critical role in our planet's ecosystem. For example, bacteria called decomposers are a key part of the planet's food chain. These bacteria break down dead organic matter and recycle nutrients to the soil. Other bacteria called Rhizobium help fertilize soil by adding nitrogen, which plants need in order to grow.

Some bacteria, however, can be dangerous to human beings, other animals, or plants. We call these "bad" bacteria pathogens because they cause disease or make us sick. Leprosy, food poisoning, pneumonia, tetanus, and typhoid fever are all pathogens. A special medicine that kills pathogens is called an antibiotic. We also use special cleansing agents called antiseptics to keep bacteria out of wounds or to wash bad bacteria off of our hands.



There is even bacteria in some of our foods. Yogurt, cheese, pickles, and soy sauce are all made using specific strains of bacteria which help to preserve food while giving it a unique flavor.

QUESTIONS: Bacteria

Circle the correct answer.

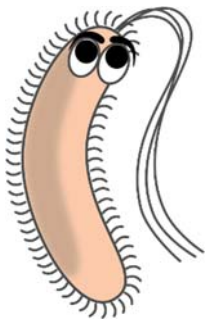
1. What are bacteria?
   A. long tails that propel single-celled organisms forward
   B. single-celled organisms that help fertilize soil by adding nitrogen
   C. a kind of microorganism that consist of only a single cell
   D. a special medicine that kills pathogens

2. Which of the following is NOT an example of "good" bacteria?
   A. the bacteria in our digestive system
   B. decomposers
   C. pathogens
   D. Rhizobium

3. Which of the following is NOT a pathogen?
   A. Rhizobium
   B. leprosy
   C. food poisoning
   D. pneumonia

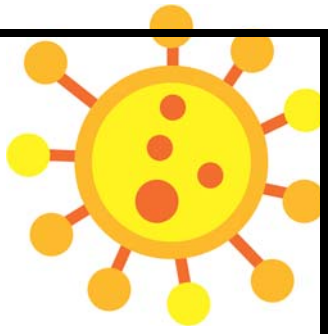
4. What is an antibiotic?
   A. bad bacteria that make us sick
   B. a special cleansing agent that kills bacteria
   C. a kind of microorganism that consist of only a single cell
   D. a special medicine that kills pathogens

5. Which of the following food does NOT contain bacteria?
   A. yogurt
   B. pickles
   C. ketchup
   D. soy sauce



ANSWERS

1. C
2. C
3. A
4. D
5. C



Viruses

Viruses are a kind of microorganism. They contain several strands of genetic material (DNA or RNA) and are surrounded by a layer of protein called the CAPSID. A virus does not have a nucleus.

Viruses are able to make animals and plants sick because when they enter a living system, they inject their DNA directly into their host's cells and begin to replicate. The more copies of itself the virus is able to make, the more of its hosts cells it takes over.

Scientists disagree on whether or not viruses are themselves living things. Some argue that they are not living creatures because they don't metabolize food into energy or have organized cells. They are also not generally able to reproduce outside of a host and are inactive when not inside a living cell.

Viruses can cause all different kinds of diseases. Some, like the common cold, can be fairly mild. Others can be very serious and even deadly. Ebola, HIV, and smallpox are all caused by different kinds of viruses. In many cases, there is no medicine to fight a virus. It is up to our body's immune system to fight the virus off.

Viruses are so tiny and so lightweight that they are able to spread very easily through the air, through the water, or even through skin contact. Many viruses are usually spread through the respiratory droplets that leave a person's body when they cough or sneeze. Viruses can also move from person to person when you shake hands with someone, or when you touch something that someone with a virus has touched. Some viruses are passed from host to host by insect bites (like Zika, which is passed through mosquitoes or the bubonic plague, which was spread through the fleas living on rats), animal bites (like rabies), or through bad food.

QUESTIONS: Viruses

1. What is a virus?

2. What is the layer of protein that encases a virus called?

3. How do viruses make animals and plants sick?

4. Why do some scientists think that viruses are not living things?

5. What are some examples of viruses?

6. What kind of medicine fights a virus?

7. How do viruses travel between hosts?

ANSWERS

1. Viruses are a kind of microorganism. They contain several strands of genetic material (DNA or RNA) and are surrounded by a layer of protein called the CAPSID.

2. CAPSID

3. When they enter a living system, they inject their DNA directly into their host's cells and begin to replicate. The more copies of itself the virus is able to make, the more of its hosts cells it takes over.

4. Some argue that they are not living creatures because they don't metabolize food into energy or have organized cells. They are also not generally able to reproduce outside of a host and are inactive when not inside a living cell.

5.the common cold, Ebola, HIV, and smallpox

6. In many cases, there is no medicine to fight a virus. It is up to our body's immune system to fight the virus off.

7. Many viruses are usually spread through the respiratory droplets that leave a person's body when they cough or sneeze. Viruses can also move from person to person when you shake hands with someone, or when you touch something that someone with a virus has touched. Some viruses are passed from host to host by insect bites, animal bites (like rabies), or through bad food.

Viruses: Size, Shape, and Reproduction

Both viruses and bacteria are microscopic, but viruses are much smaller than bacteria. Bacteria are single-celled living organisms. Viruses, however, are not considered to be living organisms. They are acellular (not cellular), meaning that they have no cell configuration. To put the size of viruses into perspective, a human egg cell is around 120 micrometers in diameter. Most viruses are between 20 and 400 nanometers. There are 1000 nanometers in a micrometer. We were not able to see viruses until the electron microscope was invented in the 1940s.

Viruses can be shaped like rods or like spheres. Viruses that infect bacteria, called bacteriophages, take a third shape. They have a geometric head and very thin, threadlike tail fibers. Regardless of their shape, all viruses contain either DNA or RNA and have an outer shell made of protein called a capsid.

Viruses are able to make animals and plants sick because when they enter a living system, they inject their DNA directly into their host's cells and begin to replicate. The more copies of itself the virus is able to make, the more of its hosts cells it takes over.

Viruses use either the lytic cycle or the lysogenic cycle to replicate. Some use only the lytic cycle. In the lytic cycle, the virus fastens itself to the host cell and inserts its DNA into the host cell. The viral DNA then starts to replicate and form proteins, using the cellular metabolism of the host. This produces more and more fully-formed viruses which lyse (break) the host cell and move to other cells to repeat the process. In the lysogenic cycle, the virus also fastens itself to the host cell and inserts its DNA, but the viral DNA gets incorporated into the DNA of the host cells. Then, as the host's cells replicate, the DNA of the virus is replicated at the same time. In this way, the virus' genetic material gets spread throughout the host without any of the host cells being broken.

QUESTIONS: Viruses: Size, Shape, and Reproduction

Circle the correct answer.

1. Viruses are:
   A. acellular
   B. microscopic
   C. much smaller than bacteria
   D. all of the above

2. How are viruses shaped?
   A. rods
   B. spheres
   C. rods, spheres, or they have a geometric head and very thin, threadlike tail fibers
   D. a geometric head and very thin, threadlike tail fibers

3. How do viruses make animals and plants sick?
   A. they inject their DNA directly into their host's cells
   B. they have no cell configuration
   C. all viruses contain either DNA or RNA
   D. using either the lytic or the lysogenic cycle

4. How do viruses replicate?
   A. lytic cycle
   B. lysogenic cycle
   C. lytic or lysogenic cycle
   D. capsid cycle

5. All viruses:
   A. have DNA or RNA
   B. have an outer shell of protein called a capsid
   C. use either the lytic cycle or the lysogenic cycle to replicate
   D. all of the above
   E. none of the above

ANSWERS

1. D
2. C
3. A
4. C
5. D

Health Consequences of Bacteria and Viruses

Bacteria and viruses are both microorganisms that can make people, animals, or plants sick. However, both also have positive health aspects.

Bacteria are the cause of many serious human illnesses, like leprosy, food poisoning, pneumonia, tetanus, and typhoid fever. The toxins that bacteria produce fasten themselves to cellular structures and prevent the cell from working properly. Bacteria can be ingested through food or drink, inhaled, or it can enter the bloodstream through an open wound. Any part of the body can be infected by bacteria, but some bacteria only affect specific body parts.

Viruses are able to make animals and plants sick because when they enter a living system, they inject their DNA directly into their host's cells and begin to replicate. The more copies of itself a virus is able to make, the more of its hosts cells it takes over.

A special medicine that kills bacteria is called an antibiotic. But antibiotics are not effective against viruses. The best way to avoid getting sick from a virus is to get vaccinated against the illnesses caused by specific viruses. There are some anti-viral drugs available which can keep viruses from replicating. For example, Human Immunodeficiency Virus (HIV) is typically treated with antiviral drugs.

Not all bacteria make us sick. In fact, our bodies contain many kinds of bacteria that help us to digest our food. Bacteria also plays a role in how our immune system functions.

Viruses have been very important for us in the development of gene therapy. We have used their method of incorporating viral DNA into host cells as a model for how to introduce beneficial genes into host cells. We have also reengineered viruses to reproduce in cancer cells, resulting in the immune system killing the cancer cells.

QUESTIONS: Health Consequences of Bacteria and Viruses

1. How to bacteria make people sick?

2. How do bacteria get into the human body?

3. How do viruses make people sick?

4. What is an antibiotic?

5. What's the best way to avoid getting sick from a virus?

6. What does an anti-viral drug do?

7. What are some positive things that bacteria do in our body?

ANSWERS

1. The toxins that bacteria produce fasten themselves to cellular structures and prevent the cell from working properly.

2. Bacteria can be ingested through food or drink, inhaled, or it can enter the bloodstream through an open wound.

3. Viruses are able to make animals and plants sick because when they enter a living system, they inject their DNA directly into their host's cells and begin to replicate.

4. a special medicine that kills bacteria

5. The best way to avoid getting sick from a virus is to get vaccinated against the illnesses caused by specific viruses.

6. keep a virus from replicating

7. help us digest our food and play a role in our immune system

Bacteria: Size, Shape, and Reproduction

Bacteria are a kind of microorganism that consist of only a single cell. Bacteria sometimes group together in pairs, chains, or clusters.

Bacteria are prokaryotic, which means that they don't have a nucleus. Unlike eukaryotic cells, which do have a nucleus, bacteria have a cell wall. Different kinds of bacteria have different kinds of cell walls, which makes it easier for scientists to tell different kinds of bacteria apart.

Bacteria come in all kinds of shapes and sizes, but they can generally be grouped according to whether or not they most resemble a rod, a sphere, or a curve. The five classifications of bacteria within those categories are: spherical (cocci), rod (bacilli), spiral (spirilla), comma (vibrios) and corkscrew (spirochaetes).

Bacteria reproduce using a process called binary fission, which means that a single bacteria cell splits itself into two identical daughter cells. First, the bacterium's DNA makes a copy of itself. The cell then grows longer and splits into two cells, each of which contain a strand of DNA identical to that of the parent cell. These daughter cells are actually clones of the original cell.

Some bacteria reproduce very quickly. Under the right conditions, at the right temperature and with proper nutrients available, some bacteria can divide every 20 minutes. At this rate, one bacterium can produce over two million copies of itself in just seven hours. Within another hour, it can have made a total of over 16 million copies. Some bacteria make us very sick very fast because bacteria can colonize the human body so quickly.

Bacteria can be hard to kill because of their ability to go dormant by forming endospores. In this dormant state, they are very resistant to being destroyed by heat, UV radiation, and disinfectant.

QUESTIONS: Bacteria: Size, Shape, and Reproduction

Circle the correct answer.

1. Bacteria can consist of:

   A. only a single cell
   B. pairs
   C. chains
   D. clusters
   E. all of the above

2. A _____ cell doesn't have a nucleus.

   A. prokaryotic
   B. eukaryotic
   C. bacilli
   D. spirilla

3. Bacteria can generally be grouped according to whether or not they most resemble:

   A. a rod, a sphere, or a curve
   B. a single cell, pairs, chains, or clusters
   C. spherical, rod, spiral, comma, or corkscrew
   D. DNA or RNA

4. Binary fission is:

   A. the name of cells that don't have a nucleus
   B. one of the classifications of bacteria
   C. what bacteria form when they go dormant
   D. the process by which bacteria reproduce

5. What is an endospore?

   A. one of the shapes of bacteria
   B. one of the classifications of bacteria
   C. what bacteria form when they go dormant
   D. the process by which bacteria reproduce

ANSWERS

1. E
2. A
3. A
4. D
5. C

The Gut Microbiome

Human gastrointestinal microbiota, also known as the gut microbiome, are the microorganisms that live in the digestive tracts of humans and many non-human animals, including insects. These bacteria that live in our digestive tract play an important role in our physical, mental, and emotional health. Recent research has linked the gut microbiome to a person's susceptibility to obesity, allergies, asthma, rheumatoid arthritis, Type I diabetes, multiple sclerosis, irritable bowel syndrome, cirrhosis of the liver, cardiovascular disease, anxiety attacks, and possibly even autism. Scientists estimate that our gut bacteria produce 90 percent of serotonin in the body—a brain neurotransmitter that regulates our mood, sexual activity, appetite, sleep, memory, and learning.

We start accumulating our gut bacteria from our mother's milk as soon as we are born. The helpful bacteria transmitted through Mother's milk to the baby's gut helps to prevent infections. It also gives those bacteria something good to eat so that they can multiply and flourish. As babies crawl around and come into more and more contact with the world, put things in their mouths, etc., they acquire more and more bacteria in their bodies. By the time children are three and eating solid foods, their gut microbiome is fully established.

The lining of the digestive tract, called the epithelium, acts as a barrier between the bacteria in our digestive tract and the rest of the body. Beneficial bacteria in the gut normally keep the cells of the epithelium healthy by providing them with short-chain fatty acids and other nutrients that they need. But when beneficial bacteria are absent, the epithelium starts to break down, which lets bacteria and their toxic byproducts into the bloodstream. The immune system responds, but if this situation goes on for too long, the resulting chronic inflammation can lead to many chronic diseases.

QUESTIONS: The Gut Microbiome

1. What is the gut microbiome?

2. Why is the gut microbiome important?

3. Recent research has linked the gut microbiome to a person's susceptibility to what diseases?

4. What is serotonin?

5. How does our gut bacteria form?

6. What is the epithelium?

7. What happens when there aren't enough bacteria in the epithelium?

ANSWERS

1. the microorganisms that live in the digestive tracts of humans and many non-human animals, including insects

2. The bacteria that live in our digestive tract play an important role in our physical, mental, and emotional health.

3. obesity, allergies, asthma, rheumatoid arthritis, Type I diabetes, multiple sclerosis, irritable bowel syndrome, cirrhosis of the liver, cardiovascular disease, anxiety attacks, and possibly even autism

4. a brain neurotransmitter that regulates our mood, sexual activity, appetite, sleep, memory, and learning

5. We start accumulating our gut bacteria from our mother's milk as soon as we are born. As babies crawl around and come into more and more contact with the world, put things in their mouths, etc., they acquire more and more bacteria in their bodies.

6. The lining of the digestive tract acts as a barrier between the bacteria in our digestive tract and the rest of the body.

7. the epithelium starts to break down, which lets bacteria and their toxic byproducts into the bloodstream

Antibiotic Resistant Bacteria

Bacteria are continually evolving, and there are now forms of bacteria that are not affected by antibiotics, which means that people now suffer and sometimes die from illnesses caused by forms of bacteria that we cannot control. This type of bacteria is called antibiotic resistant bacteria.

Antibiotic resistant bacteria is a big problem because when it comes to treating the specific illnesses they cause, we are essentially set back to where we were before we had antibiotics at all. The World Health Organization says that antibiotic resistance is one of the greatest threats that we face in the 21st century. Currently, antibiotic resistant bacteria kills hundreds of thousands of people every year.

Antibiotic resistant bacteria has evolved as the result of a combination of natural selection, as described by Charles Darwin, and a recently understood evolutionary mechanism called horizontal gene transfer. Horizontal gene transfer describes a phenomenon in which genes move between individuals, species, and even kingdoms of creatures on a short piece of genetic code called an episome. An episome replicates independently of the cell's chromosome. It carries code that is mostly useful during adverse conditions like drought tolerance or immunity to a poison. Horizontal gene transfer has played a key role in the history of life on Earth, and it is very common among bacteria.

Antibiotic resistance was first recognized in Japan after World War II with a type of dysentery that is a severe form of shigellosis. At first, different strains of the bacteria each only resisted one drug. In 1955, however, a woman became ill from a new strain of Shigella that was resistant to four kinds of antibiotics: sulfas, streptomycin, tetracycline, and chloramphenicol. A similar phenomenon was seen in E. coli. We now know that episomes can move between every group of bacteria that live within human intestines (called enteric bacteria).

QUESTIONS: Antibiotic Resistant Bacteria

Circle the correct answer.

1. Antibiotic resistant bacteria is:
   A. an illness caused by forms of bacteria
   B. new forms of bacteria not affected by antibiotics
   C. easy to treat
   D. uncommon

2. A phenomenon in which genes move between individuals, species, and even kingdoms of creatures is called:
   A. natural selection
   B. episomes
   C. horizontal gene transfer
   D. drought tolerance

3. The piece of genetic code that features in horizontal gene transfer is called a(an):
   A. antibiotic
   B. chromosome
   C. shigellosis
   D. episome

4. Antibiotic resistance was first recognized in:
   A. Japan B. the World Health Organization
   C. men D. women

5. What was the first disease that showed antibiotic resistance?
   A. sulfas
   B. tetracycline
   C. E coli
   D. Shigella

ANSWERS

1. B
2. C
3. D
4. A
5. D

Contagion

When a disease can be spread from person to person, we say it is contagious. Contagious diseases can spread through contact with an infected person. They can spread through contact with something that an infected person has touched. They also be spread by inhaling the respiratory droplets of someone who is infected, for instance, when you are very close to a sick person when they talk, cough, or sneeze. Viruses and bacteria that make people sick are called contagions. The disease caused by these pathogens can also be called a contagion.

Different contagious diseases have different incubation periods. This is the amount of time that a contagion needs to be in your body before it actually makes you sick. Different diseases are also contagious for different periods of time. For example, the flu (caused by a virus) is contagious from the day before symptoms develop until five to seven days after symptoms appear. The common cold, another viral infection, is contagious beginning a few days before symptoms appear until all symptoms have disappeared, which can take a few weeks. A person with a cold is most contagious during the first few days of the infection, when they feel the worst.

When an unusually large number of people in a community, state, or country contract a contagious disease at more or less the same time, it is called an epidemic. Typhus, influenza, the Black Death (Bubonic Plague), malaria, and smallpox are all examples of epidemics in history. When an epidemic grows so much that people in multiple countries and across multiple continents get sick, it is called a pandemic. The most recent pandemic was coronavirus 19 (COVID-19), which began in China in late 2019 and quickly spread throughout the world.

QUESTIONS: Contagion

1. What is a contagion?

2. How do contagious diseases spread?

3. What is a disease's incubation period?

4. Are all diseases contagious for the same amount of time?

5. What is an epidemic?

6. What is a pandemic?

7. What are some epidemics from history?

ANSWERS

1. a disease caused by pathogens

2. through contact with an infected person, through contact with something that an infected person has touched, by inhaling the respiratory droplets of someone who is infected, for instance, when you are very close to a sick person when they talk, cough, or sneeze.

3. the amount of time that a contagion needs to be in your body before it actually makes you sick.

4. no, contagious disease are contagious for different periods of time

5. when an unusually large number of people in a community, state, or country contract a contagious disease at more or less the same time

6. when an epidemic grows so much that people in multiple countries and across multiple continents get sick

7. Typhus, influenza, the Black Death (Bubonic Plague), malaria, and smallpox are all examples of epidemics in history

Viruses and Vaccines

Viruses are highly contagious microscopic organisms that can make humans, animals, or plants sick. In order to avoid extinction, a virus has to enter a host, replicate itself, and repeat the process by getting some of those copies into its next host. Different kinds of viruses enter and leave the host body in different ways. For example, morbilliviruses enter the body system through cells in the immune system. A different family of viruses, the coronaviruses, enter the body by way of the respiratory system. Many viruses leave the body through the epithelial cells, which are the cells that make up the thin tissue on the outer layer of skin, the alimentary canal (the route that food takes from the time it enters your body until the time it leaves it), and other hollow structures, like your mouth and your nasal cavities. This is why viruses can be so easily transmitted when someone talks, coughs, or sneezes.

Some viruses have what we call a "one and done" strategy. This means that they can only infect the same host once. Once your body recovers from these kinds of viral infections, your immune system will protect you from getting sick from the same virus again. "One and done" viruses need to be extremely contagious in order to proliferate. Measles, which is highly contagious, is an example of this kind of virus. Other kinds of viruses do not spread very easily or quickly. For example, the virus that causes Ebola is not very good at getting to its next host. While you will probably get the measles if you sit next to someone on a bus who has it, you can sit next to someone with Ebola and not necessarily get sick.

This "one and done" concept is what makes vaccines so effective. Vaccines work because they "teach" your immune system to recognize a particular kind of virus and to fight it off before it gets a chance to proliferate

QUESTIONS: Viruses and Vaccines

Circle the correct answer.

1. What does a virus have to do to avoid extinction?
   A. enter a host
   B. replicate itself
   C. get copies of itself into a new host
   D. all of the above

2. How do viruses enter and leave the host body?
   A. through the immune system
   B. through the respiratory system
   C. through the epithelial cells
   D. different viruses enter the body in different ways

3. Where are epithelial cells located?
   A. on the outer layer of skin
   B. in the alimentary canal
   C. in the respiratory system
   D. A and B

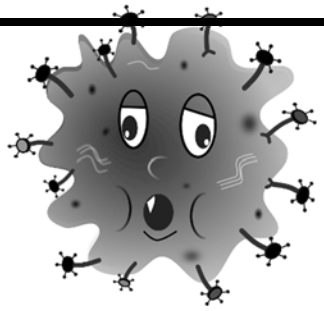
4. A "one and done" strategy means:
   A. a virus can infect a host over and over again
   B. a virus can only infect one host
   C. a virus can only infect the same host once
   D. a virus can only replicate once

5. How do vaccines work?
   A. they teach your immune system to recognize and fight a virus
   B. they prevent viruses from replicating
   C. they prevent viruses from spreading
   D. they keep a virus from infecting the same host more than once

ANSWERS

1. D
2. D
3. D
4. B
5. A

Name _____ Bacteria and Viruses



Are Viruses Alive?

Scientists do not agree on whether or not viruses are living creatures. This is because not all scientists think that viruses meet the criteria of what we understand that it means to be alive.

Living things have cells. Some living things, like bacteria, are cells. This is why we call them single-celled organisms. Viruses do not have cells like every other living thing we are aware of on Earth. A virus consists only of its genetic material (DNA or RNA) in a protective coat of protein.

Living things reproduce. Cells make a copy of their DNA in order to reproduce. Viruses are not able to copy their DNA themselves, and they only become active when they come into contact with a host cell. Then they inject their DNA into the cells of their hosts, so that the host cells make copies of the virus' DNA instead. (Recently, though, a new kind of virus called a mimivirus has been discovered that does have its own tools for copying its DNA.)

Living things use energy. Viruses do not use energy unless they are in contact with a host cell. Then they hijack the host cell's energy and tools to reproduce themselves. Not all scientists think this is a valid argument, though, since a type of bacteria called obligate intracellular parasites also rely on the energy of their hosts.

Living things respond to their environment, and there is debate about whether or not viruses do this. They interact with host cells, but some scientists consider this to be more about the virus' chemical makeup and environment than it is an active process.

Even when they apply these criteria to viruses, scientists cannot agree on whether or not they are living creatures, partly because they can't agree on whether or not viruses meet some of the criteria. They clearly have DNA or RNA, which we consider to be the "building blocks of life." Perhaps as we come to understand them better, we will find the answer to this question.

Name _____ Bacteria and Viruses

QUESTIONS: Are Viruses Alive?

1. Why don't scientists agree on whether or not viruses are alive?

2. How are viruses different from every other living thing we are aware of on Earth?

3. Why do viruses not meet the criteria of being able to reproduce?

4. What is the mimivirus?

5. Do viruses use energy?

6. Do viruses respond to their environment?

7. What one indicator of life do scientists agree that viruses have?

ANSWERS

1. not all scientists think that viruses meet the criteria of what we understand that it means to be alive

2. viruses don't have cells

3. Viruses are not able to copy their DNA themselves, and they only become active when they come into contact with a host cell. Then they inject their DNA into the cells of their hosts, so that the host cells make copies of the virus' DNA instead.

4. a new kind of virus that has been discovered that does have its own tools for copying its DNA

5. Viruses do not use energy unless they are in contact with a host cell. Then they hijack the host cell's energy and tools to reproduce themselves.

6. They interact with host cells, but some scientists consider this to be more about the virus' chemical makeup and environment than it is an active process.

7. DNA and RNA