MedMyst Magazine

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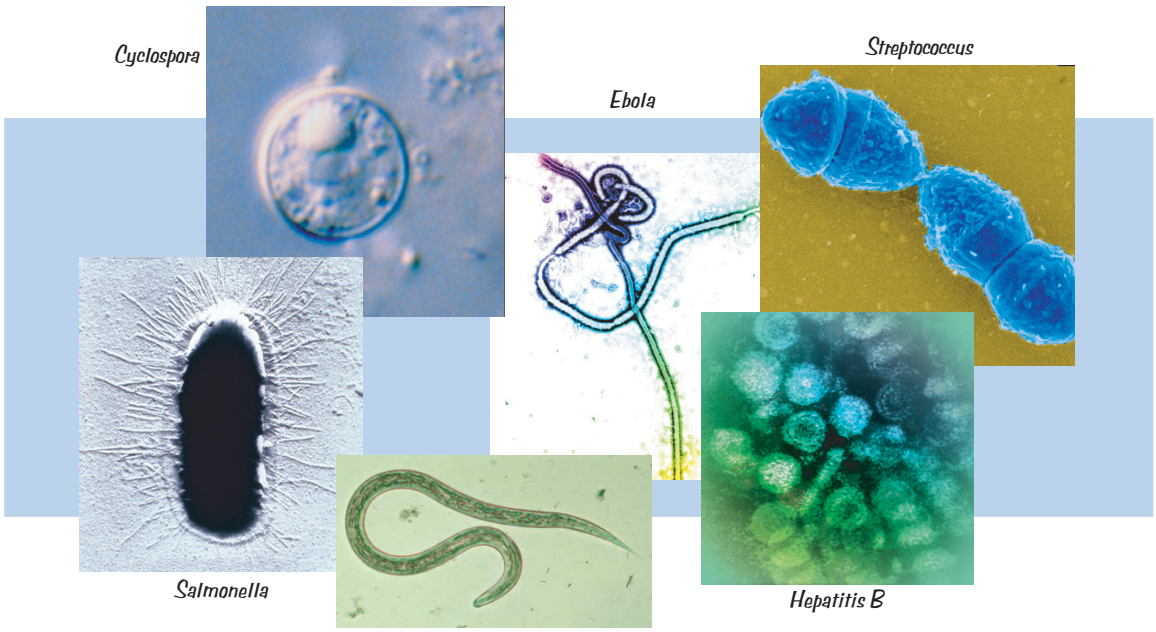
1.0 Infectious Diseases



EMERGING AND RE-EMERGING DISEASES

No one in the 1800s suffered from AIDS or Ebola. That's because new infectious diseases can appear with little warning. Even diseases that were thought to have been conquered can re-emerge.

The pathogens (germs) that cause infectious diseases are very clever in their survival strategies. Often they mutate, or they can remain dormant for a long while before re-emerging.

Want to learn more about Infectious Diseases? Where do they come from? How do you prevent them? Keep on reading!!

Infectious Diseases

Acknowledgments

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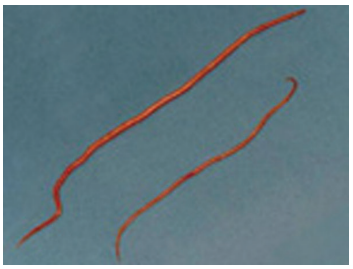
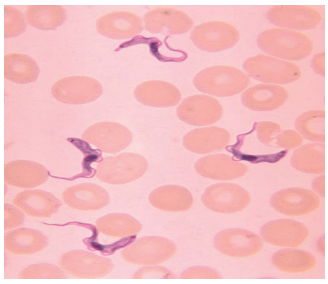
Infectious Diseases

Infectious diseases are **MEDICAL MYSTERIES**. See if you don't agree.

GERM THEORY RULES!



Helminths - Courtesy of Peter Dorben



Protozoa - Courtesy of CDC

Everyone knows that germs can make you sick, right? In the middle of the 1800s that wasn't the case. At that time, the French chemist, Louis Pasteur, was examining microbes (germs) with the aid of a microscope. Many physicians and scientists believed that diseases were not due to germs but from *miasmas (my-AS-mahs)*, foul-smelling vapors from decaying animal or vegetable waste. They believed that microbes were the result of diseases rather than the cause of them.

Pasteur was the first to put forward the idea that individual microorganisms caused a particular disease. This idea is known as *Germ Theory*. Through a series of experiments, he demonstrated that fermentation and putrefaction were caused by germs. Since germs caused these biological processes, they could be responsible for diseases as well. This theory is the foundation for the study of infectious diseases.

Our knowledge of infectious agents has grown since 1850. We now know that there are six broad categories of infectious agents (pathogens) that can enter and infect our bodies. Not all pathogens are microscopic. For example, some helminths (worms) can be seen without a microscope.

Infectious Agents

Bacteria and some fungi (such as yeast) are measured in micrometers. A micrometer is one millionth of a meter (1/1,000,000). Viruses and prions are measured in nanometers (nm), a billionth of a meter (1/1,000,000,000). Some helminths are microscopic, while others are measured in millimeters. Tapeworms may reach a length of 30 feet.

PRIONS Extremely small particles that consist only of protein. Resistant to heat and disinfectants.

VIRUSES Extremely small particles that can only reproduce and survive by taking over a living cell. They consist of nucleic acid enclosed in protein.

BACTERIA Very small, unicellular microorganisms that multiply by cell division and whose cell is typically contained within a cell wall. They may be spherical (coccus), rod-shaped (bacillus), or spiral forms (spirillum).

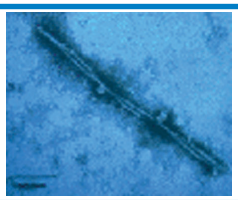
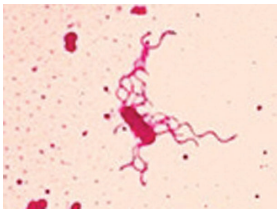
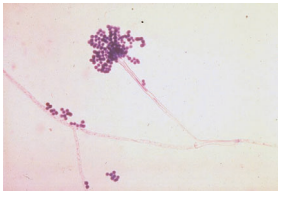
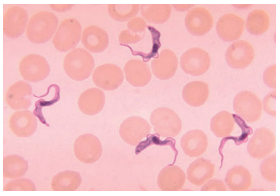
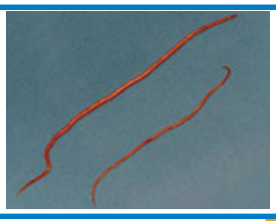
FUNGI Fungi have a cell wall and a cell membrane. They include the molds (filamentous, multicellular type) and the yeast (unicellular, spherical type).

PROTOZOA Simple single cell organisms such as the amoeba and paramecium. Some have flagella or cilia and are capable of rapid movement.

HELMINTHS Worms (multicellular) that can be parasites in the intestine, blood, or body tissue.

Infectious Diseases

A Closer Look at Infectious Agents

	What are these agents?	What are some infectious diseases they cause?	How do we treat the diseases they cause?	What are some examples of what they look like?
Prions	Extremely small particles that consist only of protein. Resistant to heat and disinfectants.	Mad Cow Disease, Creutzfeldt-Jacob Disease	No known treatment	 Courtesy Electron Microscope Unit, Vet. Lab. Agency, Woodham Lane, Addlestone, Surrey UK.
Viruses	Extremely small particles that can only reproduce and survive by taking over a living cell. They consist of nucleic acid enclosed in protein.	AIDS, Common Cold, Chickenpox, Influenza, Measles, Mononucleosis, Rabies, Hepatitis, West Nile Virus, Ebola, Hantavirus	Many are preventable with vaccinations; some can be treated with anti-viral drugs. Antibiotics don't work.	 Courtesy of CDC
Bacteria	Very small, unicellular microorganisms that multiply by cell division. Cell is typically contained within a cell wall. Found as spherical, rod, and spiral shapes.	Anthrax, Botulism, Cholera, Legionellosis, Lyme Disease, Salmonellosis, Strep throat, Tuberculosis, Typhoid	Many are treatable with antibiotics	 Courtesy of CDC
Fungi	Fungi have a cell wall and a cell membrane. They include molds (filamentous, multicellular type) and yeast (unicellular, spherical type).	Athlete's Foot, Histoplasmosis, Ringworm, Thrush	Antifungal medication; sometimes with antibiotics	 Courtesy of CDC
Protozoa	Simple, single-cell organisms such as the amoeba and paramecium. Some have flagella or cilia and are capable of rapid movement.	Chagas Disease, Amoebic Dysentery, Malaria	Antibiotics	 Courtesy of CDC
Helminths	Worms (multicellular) that can be parasites in the intestine, blood, or body tissue.	Swimmer's Itch, Hookworm, Tapeworm, Trichinosis, Filariasis, Pinworms	Medications to force evacuation or death of worms	 Courtesy of Peter Dorhen

Is it infectious, or is it contagious, or both?

A contagious disease is one that can easily spread from one person to the next. Influenza is a contagious disease because the virus that causes it can spread easily from the sick person's coughing or sneezing. Some other diseases (like anthrax, salmonella, or rabies) do not usually transfer directly from person to person, so although they are infectious, they are not contagious.

Infectious Diseases

Ways in Which Infectious Diseases Can Spread:

DIRECT CONTACT

Some infectious diseases are spread through sexual contact or by exposure to infected bodily fluids, such as blood or saliva.

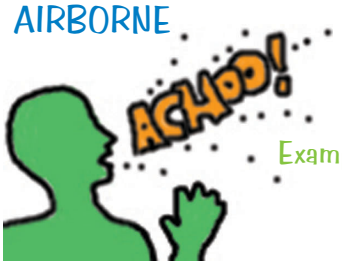
Examples: Mononucleosis, AIDS, Sexually Transmitted Diseases, Hepatitis B

VECTORS/RESERVOIRS

Some animals or insects can spread infectious diseases to humans, usually through a bite.

Examples: Lyme Disease, Malaria, Yellow Fever, Rabies

AIRBORNE



Infectious diseases can be spread through the air.

Examples: Colds, Flu, Tuberculosis, Smallpox, Chickenpox, Measles

FOOD & WATER

Water or food supplies can become contaminated and healthy people can get sick from drinking or eating them.

Examples: Cholera, Salmonella, Typhoid Fever, *E. coli*

INDIRECT CONTACT

Some pathogens can remain on surfaces (fomites) that were in contact with an infected person. If healthy persons touch those surfaces later, and forget to wash their hands, the pathogens could infect them.

Examples: Colds, Flu, Pinworms

Some Infectious Diseases Can Spread in More than One Way.

A Medical Milestone

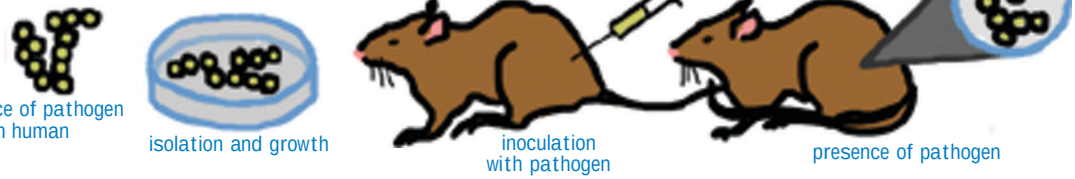
How do we know that pathogen X causes disease Y? That is the same question that the German physician and microbiologist Robert Koch (kawk) set about answering in 1890. A set of steps or requirements that have become known as Koch's Postulates provided the answer to this critical question.

1. *The pathogen must be present in every case of the disease.*
2. *The pathogen must be isolated from the host and grown in pure culture.*
3. *The disease must be reproduced when a pure culture of the pathogen is inoculated into a healthy, susceptible host.*
4. *The same pathogen must be recovered from the newly infected host.*

Robert Koch at work in his lab
The Granger Collection, New York

These requirements will often work to prove the cause of disease —but not always. These steps have their limitations. Some infectious agents are difficult to grow in the lab. Other infectious agents cannot be tested in animals because the pathogen only infects humans. This is true for a disease like cholera. Nevertheless, Koch's Postulates are a major contribution that helped scientists better judge whether there is a cause-effect relationship between a pathogen and a disease.

The four steps of Koch's Postulates.



Vectors on the Move

A VECTOR is any organism that carries an infectious agent such as a bacterium, a virus, or a protozoan from one organism to another. You can think of a vector much like a taxi or airplane. It is a transmission vehicle for pathogens. **Ticks, flies, lice, fleas,** and **mosquitoes** are examples of vectors.

Lyme disease is caused by a spirochete (a type of spiral-shaped bacteria) called *Borrelia burgdorferi* and transmitted to humans by a tick. At the site of the bite, people develop a red circular lesion that grows. Infected persons suffer fever, muscle aches, and pain in the joints. Most cases in the U.S. occur along the Atlantic coast.

From left to right: The deer tick *(Ixodes scapularis)* adult female, adult male, nymph, and larva on a centimeter scale (CDC)

LYME DISEASE is now the predominant vector-borne disease in the United States; but in other parts of the world MALARIA is the most frequently occurring vector-borne disease, with approximately 270 million people affected.

The *Anopheles* mosquito, which transmits the malaria parasite (CDC)

Malaria is the most prevalent parasitic infection of humans. It is caused by four parasites of the genus *Plasmodium*, and transmitted to humans by the *Anopheles* mosquito. Infected people suffer high fever, chills, and headaches, and if untreated, the disease can progress to coma and death. Diagnosis is made by detecting parasites in a blood smear. Malaria can be treated with chloroquine and other drugs. Some malaria parasites have become resistant to treatment.

Control of the vector and its habitat can lead to the prevention of some diseases. This requires knowledge about the vector's life cycle, preferred hosts, transmission cycles, as well as surveillance of people and habitats.

Kissing Bug Transfers PROTOZOA

Another interesting vector-borne disease is Chagas (SHA-gus) Disease. It was first identified by Carlos Chagas in Brazil in 1909. The disease-causing parasite (*Trypanasoma cruzi*) is spread through the kissing bug's feces. Chagas disease currently infects up to 18 million people in South and Central America.

Triatoma infestans, courtesy US Navy Disease Vector Ecology and Control

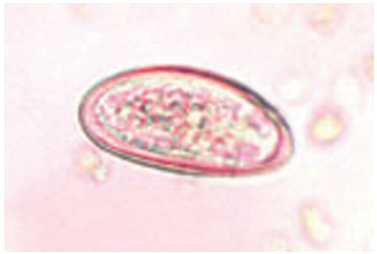
The insect vector, *Triatoma infestans*, is often called the kissing bug. It has a needle-like appendage through which it sucks human blood.

It is thought by some people that Charles Darwin was a victim of this disease. As a naturalist aboard the frigate *Beagle*, Darwin visited remote parts of the world. When he was in Argentina, he had an encounter with the Chagas vector. In his book, *The Voyage of the Beagle*, he writes: "At night I experienced an attack (for it deserves no less a name) of the Benchuca, a species of Reduvius, the great black bug of the Pampas. It is most disgusting to feel soft wingless insects, about an inch long, crawling over one's body. Before sucking they are quite thin but afterwards they become round and bloated with blood."

Chagas Disease is caused by the parasite, *Trypanosoma cruzi*, which enters the body through mucous membranes after a bite from a blood-sucking reduviid bug. Inside the host, the parasite passes through the circulatory system and invades many organs. They cause fever, loss of appetite, inflammation of the lymph nodes and the heart, liver enlargement, and other intestinal anomalies. It is diagnosed by finding the parasite on blood smears and is treated with antiparasitic drugs. It can be cured only when treated early.

There is a specialization devoted to the study of diseases and the insects that transmit them. It is known as Medical Entomology. If you like insects and human biology, this may be a career for you!

COMMON HELMINTH Causes Rear End Itch



Pinworm egg, courtesy Dr. J. Michael Miller, CDC

A very large percentage of pre-school and school-age children and their families are estimated to be infected by *Enterobius vermicularis* (EN-ter-O-be-us-ver-MIK-u-lar-is). This infection is caused by a small, white intestinal worm, more commonly known as a pinworm. Infected persons may not even know it. The only symptom is rear end itch.

Adult pinworm, courtesy Dr. J. Carl Fox, College of Veterinary Medicine, Oklahoma State University

Pinworms are about the length of a staple and live in the colon of humans. While an infected person sleeps, female pinworms leave the intestines through the anus and deposit eggs on the surrounding skin and then disintegrate.

Pinworm eggs are infective within a few hours after being deposited on the skin. They can survive up to two weeks on clothing, bedding, or objects. Imagine the case when a person scratches the rear end itch and then forgets to wash his or her hands. This is known as the ITCH-SCRATCH-LICK cycle. Once the eggs are ingested, larvae hatch in the small intestine, and the worms grow until the female worm comes out to lay her eggs. The cycle repeats itself.

Fortunately, once pinworms are discovered, they can be treated with prescription or over-the-counter drugs.

DISEASE DETECTIVES

History is filled with hard-working scientists who have made major discoveries about diseases. Their stories read much like detective novels. Could it be that these scientists thought of themselves as being DISEASE DETECTIVES? One disease detective from history who made major breakthroughs in science and medicine was Louis Pasteur.

ASTUTE PROBLEM SOLVER
Louis Pasteur 1822-1895

Louis Pasteur
Courtesy National Library of Congress

Born in a small town in France, Louis Pasteur grew up to become one of the great heroes in the history of science, but it didn't start out that way. As a child, Pasteur did poorly in school and preferred to draw and fish rather than study. However, as Pasteur grew, so did his interest in science and chemistry. He went on to study at a prestigious university in Paris. By the age of 31, Pasteur had become a chemistry professor and Dean of Sciences in Lille, France.

The Mystery of the Sour Wine

We take for granted the idea that liquids like milk and wine are easy to store for later drinking. Yet, before Louis Pasteur delved into the problem of "sour wine," this was not so easy. In 1857, French winemakers brought their problem to Pasteur. Examining wine samples with his microscope, Pasteur noted that many different microbes were living in the wine. He reasoned that some of these microbes caused the wine to turn sour and ruin. Similarly in milk, Pasteur also observed that bacteria were able to turn sugar into acid, thus making the milk sour.

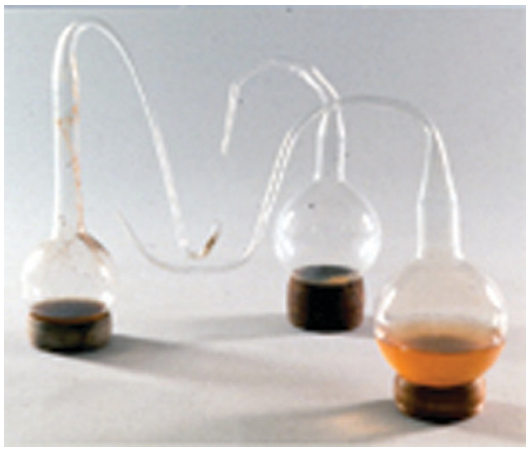
To solve this problem, Pasteur created a way to heat the wine to a temperature that killed the bacteria without ruining the wine. Now the process of using heat to kill germs in foods and liquids is called *pasteurization*. Milk, wines, and fruit juices are heated for about 30 minutes at 68°C (154.4°F) whereby living bacteria are destroyed, but the flavor is preserved. Next time you pour milk over your cereal, check out the label. Somewhere it will say that the milk is "pasteurized." This prevents infections, like streptococcus, Q fever, tuberculosis, and brucellosis from being transmitted in milk. REMEMBER – Louis Pasteur put the *"pasteur"* in *pasteurization*!

Killer Microbes

Pasteur's sour wine case also led to the development of the Germ Theory which opened the door for improving public health. Basically, Pasteur argued that if germs could invade wine and cause problems, these pathogens also could cause disease in

humans and animals. In the mid-1800s, a hospital stay often resulted in death. Simple things like washing hands and sterilizing equipment were not yet practiced.

Pasteur explained that " the open wound is exposed to millions of germs—in the air, on the hands of the surgeon who performs the operation, in the sponges that bathe the wound, in the instruments that pry into it, and on the bandages that cover it." Once doctors began to use sterile techniques to eliminate germs, fewer patients died as a result of hospitalization.



Used with permission. ©Institut Pasteur

Pasteur's experiments using swan neck flasks demonstrated how microbes could be trapped during pasteurization.

Anthrax and the Sheep Experiment

Courtesy Peter Drew & Nick Sellors

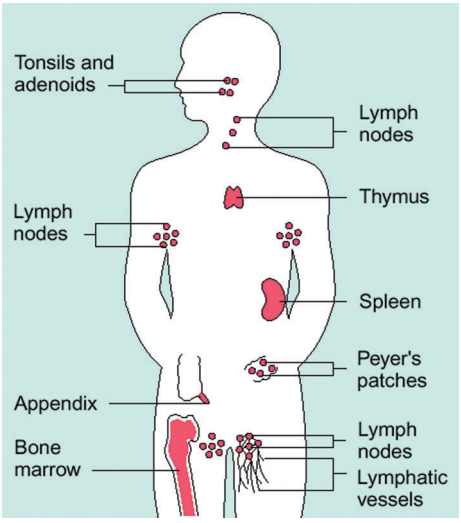
Although in the mid-1800s other scientists believed that germs could cause disease, not everyone supported Pasteur's ideas. A famous veterinarian, Monsieur Rossignol, not only rejected the Germ Theory, he was horrified by Pasteur's announcement that vaccinating animals with anthrax (injecting them with a strain of the microorganism), would protect them from the disease. Rossignol challenged Pasteur to prove the effects of vaccines, believing that in the end Pasteur would be wrong. Pasteur, who never shied away from a challenge, took the bet. Rossignol gave Pasteur 50 sheep from his farm, 25 of which received Pasteur's anthrax vaccine and 25 which were left alone. All 50 sheep were then injected with anthrax. Pasteur was proven right when only the vaccinated sheep lived. Pasteur's work with the anthrax vaccine led to the creation of vaccines for chicken cholera and rabies.

Pasteur's Passion

Pasteur is important in history for many of his individual discoveries, but he is particularly admired for the wide variety of scientific problems which he solved. During his lifetime, he had to endure much criticism for his "new" way of thinking. Yet, through it all, he spoke only of passion for his work in science, " I love science so deeply that it stirs my heart." Since its founding in Paris in 1888, the Pasteur Institute continues a tradition of research and solving medical mysteries.

Learn more about the Pasteur Institute at http://www.pasteur.fr

THE BODY FIGHTS BACK



The Immune System of the Human Body

The human body has a remarkable capacity to protect itself against disease-causing agents. These defenses are referred to as your IMMUNE SYSTEM. The immune system can be thought of as an army of organs, cells, and chemicals that work to protect the body from disease. When it is working correctly, the immune system does marvelous and ingenious things to protect you from bacteria and viruses. Without a good defense system, your body is not able to combat invading pathogens. Diseases like AIDS impair your immune system.

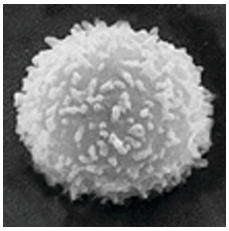
The skin and the mucous membranes are the first lines of defense against infections. They act as a barrier to all the pathogens that are waiting to enter your body. Despite the protection by the skin and mucous membranes, thousands of microbes are able to enter the body through other ways such as a cut in the skin, a tear in the mucous membranes, the nose, and the mouth. When a pathogen enters the body, it is initially met by a group of white blood cells from the immune system, called neutrophils, whose job is to seek out foreign invaders, surround them, and gobble them up.

Different parts of the immune system have specialized roles in protecting us from pathogens. Specific defects in the immune system make people susceptible to specific types of infections.

White Blood Cells Attack

The major soldiers in the immune system's army are the white blood cells. Your bone marrow produces white blood cells to battle infections. From the bone marrow base camp, the white blood cells are sent to the outposts of your immune system, such as the spleen, and lymph nodes to battle harmful bacteria and viruses.

Without healthy white blood cells the body cannot fight infections. Cancer patients who receive some types of treatments often have many of their white blood cells destroyed, particularly the kind that initially attack the microbes that breach the mucous membranes. These people often have fever and serious infections, even from "normal" bacteria in the body. AIDS patients, who have a severe decrease in one part of their immune system (the T cells), easily develop many infections that T cells are responsible for keeping in check. In other words, when your white blood cells are not on duty, it becomes easy for pathogens to invade your body.


White Blood Cell, Courtesy National Cancer Institute

Special Cells of Combat

Lymphocytes (LIM-fo-sites) are one type of white blood cell. Many of the bacterial and viral infections we get are controlled by the lymphocytes. In the immune system's army, there are B lymphocytes (B cells) whose job is to produce antibodies. Antibodies are specialized proteins that circulate the body and attach to foreign invaders (antigens) and mark them for destruction.

There are also T lymphocytes (T cells) which act more like generals in the army. The T cells regulate and coordinate the overall immune response. Some are involved in sending the B cells into action, while others actively attack and destroy the antigens.

Immunity: How do we get it?

We become immune or resistant to germs by different means. Did you know that before birth, we receive immunity to some germs from our mothers? Here are others ways to acquire immunity to a germ.

From An Infectious Disease:

The immune system has B cells whose job it is to create antibodies specially designed to recognize an invading infectious agent. Once antibodies recognize the invader, other special cells (phagocytes) are able to attack and destroy the invader. When the attack is over, some of these antibodies and antibody-producing cells go into a kind of "hibernation." If the body encounters the invader again, the immune system springs into action. In a sense, the immune system "remembers" its enemies. That is why many diseases produce complete immunity. For some diseases, like chickenpox and yellow fever, if you have them once you can't get them again.

From A Vaccine:

In 1796, Edward Jenner discovered that he could make people immune to a disease that they never had with a vaccine. Dr. Jenner developed a vaccine to prevent smallpox that was made from the fluid of a cowpox blister. The body responded to the infectious agent in the fluid as if it were under attack by smallpox.

Thanks to Jenner's early discoveries, vaccines are now available for a wide variety of infectious diseases such as measles, polio, and chickenpox. Scientists are working to develop new types of vaccines that would provide immunity for many other diseases.

Courtesy Canadian Immunization Awareness Program

What if You Do Get Sick?

When vaccines and other methods can't prevent an infectious disease, what can be done to treat them? For many infectious diseases (particularly those caused by bacteria) doctors can prescribe antibiotics. Antibiotics treat infectious disease by interfering with the way an infectious agent lives or works. For instance, some antibiotics can damage the cell walls of bacteria, so that the bacteria will die. Unfortunately, antibiotics don't work on all types of pathogens. They are usually best at fighting infectious diseases caused by bacteria, fungi, and protozoa, but they are not effective in treating diseases caused by viruses, prions, and helminths.

Antibiotics should be used with caution. Microorganisms can become resistant to these drugs. For example, Penicillin was one of the first antibiotics discovered. Initially, it could easily kill one of the bacteria that causes pneumonia *(Streptococcus pneumoniae)*, and was prescribed often. Over time many of the bacteria that were susceptible to penicillin were killed off, leaving behind only resistant bacteria. Because bacteria are clever at devising ways to become resistant, doctors must be very selective as to when to use antibiotic approaches. In addition, new antibiotics for infectious diseases must be continually developed.

Pathogens Don't Need Passports

Infectious agents do not recognize international borders. The modern world is a very small place where any city in the world is only a plane ride away from any other. Pathogens can easily travel across borders within their human or animal hosts, or in the food and products we trade. No nation is free from these health threats.

Growing global population, changes in climate, massive shifts in population due to war or disaster are a few of the ways infectious diseases can become more widespread. Poverty, deforestation, pollution, and other imbalances between people and nature also contribute to increases of infectious diseases. Industrialization and even health technologies such as the production of antibiotics have had unintended consequences, including the prevalence of antibiotic resistance. The battle against infectious diseases is one that every nation in the world must take part in, especially now that **bioterrorism** presents an unfortunate way for humans to inflict diseases on one another intentionally.

Infectious Diseases Jumble

Unscramble the "jumbled" words to spell words found in this issue of MedMyst Magazine. Then arrange the circled letters to get the answer to Beta's question.

*Turn the page upside down if you need a hint.

M I B C S O E R

Another word for pathogen.

T B R A C E I A

Comes in three shapes: cocci, bacilli, and spirilla.

P T S A E R U

Had a Theory about germs.

C C I V A N E

Used to create immunity.

"What are these critters in my coffee?"

The "taxicab" for infectious agents.