From bacteria to parasites: Understanding infections

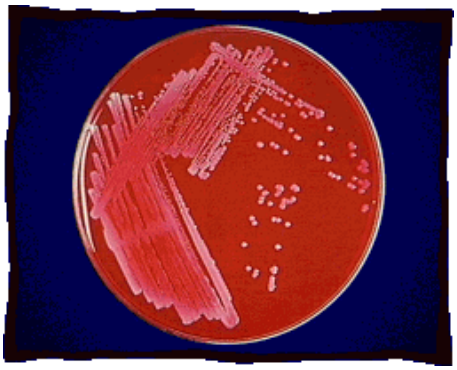
Substances that invade your body live everywhere — in the air, on food and plants, on and in animals, in the soil and water, and on just about every other surface. They range in size from microscopic single-cell organisms to parasitic worms that can grow to several feet in length.

Hardly any of these organisms produce disease because they're kept under control by your immune system. But if this system is weakened or you encounter an organism that you haven't built resistance to, illness may result.

Most of these organisms aren't harmful to you. But others can cause infection. Your immune system works to fight off an abundance of infectious agents, and it's a tough task. Viruses and bacteria are cunning adversaries, constantly seeking new ways to breach your immune system's defenses. Give your immune system a fighting chance by learning a little more about infectious agents, what you can do to prevent infection, and when you should seek advice from your doctor.

Infectious agents: A multitude of microscopic invaders

Bacteria



Bacteria are one-celled organisms visible only with a microscope. They're so small that if you lined up a thousand of them end to end, they could fit across the end of a pencil eraser. They're shaped like short rods, spheres or spirals. They're usually self-sufficient and multiply by subdivision.

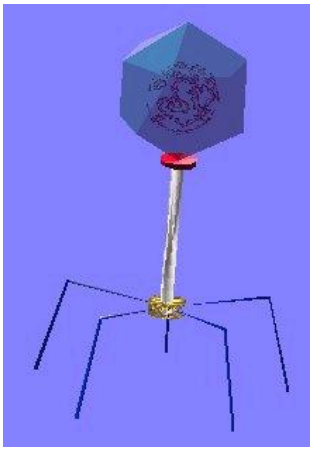
Among the earliest forms of life on earth, bacteria have evolved to thrive in a variety of environments. Some can withstand searing heat or frigid cold, and others can survive radiation levels that would be lethal to a human being. Many bacteria, however, prefer the mild environment of a healthy body.

Not all bacteria are harmful. In fact, less than 1 percent cause disease, and some bacteria that live in your body are actually of benefit. For instance, Lactobacillus acidophilus — a harmless bacterium that resides in your intestines — helps you digest food, destroys some disease-causing organisms and provides nutrients to your body.

But when infectious bacteria enter your body, they can cause illness. They rapidly reproduce, and many produce toxins — powerful chemicals that damage specific cells in the tissue they've invaded. That's what makes you ill. The organism that causes gonorrhea (gonococcus) is an example of a bacterial invader. Others include some strains of the bacterium Escherichia coli — better known as E. coli — which cause severe gastrointestinal illness and are most often

contracted via contaminated food. Other conditions caused by bacteria include strep throat and a staph infection.

Viruses



In its simplest form, a virus is a capsule that contains genetic material — DNA or RNA. Viruses are even tinier than bacteria. To see them, scientists must use an electron microscope, a high-powered instrument that produces enlarged images of minute objects. To put their size into perspective, consider that, according to the American Society for Microbiology, if you were to enlarge an average virus to the size of a baseball, the average bacterium would be about the size of the pitcher's mound. And just one of your body's millions of cells would be the size of the entire ballpark.

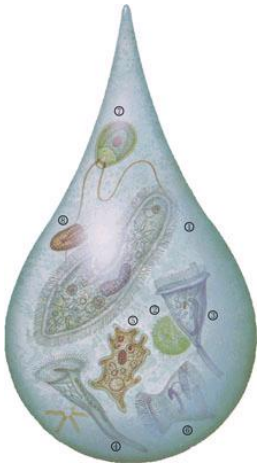
The main mission of a virus is to reproduce. However, unlike bacteria, viruses aren't self-sufficient — they need a suitable host to reproduce. When a virus invades your body, it enters some of your cells and takes over, instructing these host cells to manufacture the parts it needs for reproduction. Host cells are eventually destroyed during this process. Polio, AIDS and the common cold are all viral illnesses.

Fungi

Molds, yeasts and mushrooms are types of fungi. For the most part, these single-celled organisms are slightly larger than bacteria, although some mushrooms are multicelled and plainly visible to the eye — for instance, the mushrooms you may see growing in a wooded area or even in your backyard. Mushrooms aren't infectious, but certain yeasts and molds can be.

Fungi live in the air, water, soil and on plants. They can live in your body, usually without causing illness. Some fungi have beneficial uses. For example, penicillin — an antibiotic that kills harmful bacteria in your body — is derived from fungi. Fungi are also essential in making certain foods, such as bread, cheese and yogurt.

Other fungi aren't as beneficial and can cause illness. One example is candida — a yeast that can cause infection. Candida can cause thrush — an infection of the mouth and throat — in infants, in people taking antibiotics and in people with impaired immune systems. It's responsible for most types of infection-induced diaper rash.



Protozoa

Protozoa are single-celled organisms that behave like tiny animals — hunting and gathering other microbes for food. Protozoa can live within your body as a parasite. Many protozoa inhabit your intestinal tract and are harmless. Others cause disease, such as the 1993 Cryptosporidium parvum invasion of the Milwaukee water supply, sickening more than 400,000 people. Often, these organisms spend part of their life cycle outside of humans or other hosts, living in food, soil, water or insects.

Most protozoa are microscopic, but there are some exceptions. One type of ocean-dwelling protozoa (foraminifer) can grow to more than 2 inches in diameter.

Some protozoa invade your body through the food you eat or the water you drink. Others can be transmitted through sexual contact. Still others are vector-borne, meaning they rely on another organism to transmit them from person to person. Malaria is an example of a disease caused by a vector-borne protozoan parasite. Mosquitoes are the vector transmitting the deadly parasite plasmodium, which causes the disease.

Warding off infection

All of these agents can cause infection in a person. But there is a distinct difference between infection and disease. Infection, often the first step, occurs when bacteria, viruses, fungi or parasites enter your body and begin to multiply. Disease occurs when the cells in your body are damaged — as a result of the infection — and signs and symptoms of an illness appear.

When disease-causing infectious agents invade your body, a healthy immune system springs into action. An army of white blood cells, antibodies and other mechanisms goes to work to rid your body of the infectious organism. For instance, in fighting off the common cold, your body might react with fever, coughing and sneezing — all ways that your immune system wards off the virus.

You can take steps to prevent infection from occurring in the first place.

Hand washing. Often overlooked, hand washing is one of the easiest and most effective ways to protect yourself from most infections. Wash your hands thoroughly before preparing or eating food, after coughing or sneezing, after changing a diaper and after using the toilet. When soap and water aren't readily available, hand-sanitizing gels may offer protection.

Clean your hands: A simple way to prevent infection

Medicines. Some medicines can help you from becoming susceptible to infectious agents. For example, taking an antiparasitic medication might protect you from contracting malaria if you travel to or live in an area where your risk is high. After exposure to certain organisms — such as those that cause bacterial meningitis — your doctor may

prescribe antibiotics to lower your risk of infection. Or you may choose an over-the-counter antibiotic cream or ointment for minor cuts and scrapes. But long-term, indiscriminate use of antibiotics isn't recommended in most cases. It won't prevent bacterial infections and instead may result in a more resistant, harder-to-treat strain of bacteria when infections do occur.
Vaccines. Vaccination is your best line of defense for certain diseases. As researchers understand more about what causes disease, the list of vaccine-preventable diseases continues to grow. Currently there are more than a dozen. Many vaccines are given in childhood, but adults still need to be routinely vaccinated to prevent some illnesses, such as tetanus and influenza.

A nurse should recommend to a patient to consult a doctor if they suspect that you have an infection and you have experienced any of the following:

- ✓ **An animal bite**
- ✓ **Difficulty breathing**
- ✓ **A cough lasting longer than a week**
- ✓ **A fever of 100.4 F (38.0 C) or more**
- ✓ **Periods of rapid heartbeat**
- ✓ **A rash, especially if it's accompanied by a fever**
- ✓ **Swelling**
- ✓ **Blurred vision or other difficulty seeing**
- ✓ **Vomiting**
- ✓ **An unusual or severe headache**
- ✓ **Antibiotics are powerful drugs used for treating many serious and life-threatening infectious diseases. Most infections result from either bacteria or viruses.**

Bacteria are responsible for:

- **Most ear infections**
- **Some sinus infections**
- **Strep throat**
- **Urinary tract infections**

Viruses are responsible for:

- Colds
- Influenza
- Most sore throats
- Most cough

Antibiotics can help you get better if a bacterial infection causes your illness, but they'll have no effect at all if you have a virus. What's more, taking antibiotics when you don't need them can lead to germs that are antibiotic-resistant.

Superbugs: How antibiotic resistance develops

After the introduction of the first antibiotic (penicillin) in the 1940s, scientists created hundreds of other antibiotics to combat bacterial infections. It took only a few years of using antibiotics before a troubling pattern emerged. Bacteria frequently treated with the same antibiotic would eventually develop resistance to the drug, and a stronger medication would have to be used. The bugs soon learned to resist the stronger drug, too. Thus began a cycle of needing increasingly powerful drugs to treat infections.

When you take penicillin or another antibiotic for an infection, the drug usually kills most of the bacteria. But sometimes a few persistent germs survive. These surviving bacteria can multiply quickly and thrive despite the presence of an antibiotic.

Since bacteria can adapt their cellular structure, they can become resistant to future treatment by the same drug. As a result, the antibiotic-resistant bacteria — also known as superbugs — no longer respond to first- or even second-choice antibiotic therapy. This leaves fewer effective drugs available to treat common but potentially life-threatening illnesses. Unfortunately, superbugs can also exchange survival secrets with other bacteria, even different species, allowing additional resistant organisms to grow.

For years, the potent intravenous antibiotic vancomycin (Vancocin) provided a reliable last defense against some infections, notably those caused by staphylococcus and enterococcus bacteria. But in recent years, some superbugs have even figured out how to resist vancomycin. A strain of vancomycin-resistant enterococci (VRE) first appeared in the late 1980s and has thrived ever since. Scientists worry that VRE not only will continue to multiply but will share its genetic secrets for survival with other bacteria.

Consequences of antibiotic resistance

As antibiotics continue to be overused and misused, more and more resistant strains develop. As a result, most infections caused by these bacteria don't respond to typical treatments. Illnesses can last longer, and the risk of complications and even death can go up. Also, failure to treat a particular infection leads to longer periods in which a person is contagious and able to spread the resistant strains to others.

Another consequence is the increased costs associated with prolonged illnesses. According to the World Health Organization, these include the direct costs for additional laboratory tests, treatments and hospitalization along with the indirect costs from loss of income or time away from family. When infections become resistant to typical treatments, unconventional agents come into play. These are usually more costly, and they may have to be given by injection rather than by mouth.

Safeguard effective antibiotics:

Repeated use and improper use of antibiotics are two of the main causes of the increase in resistant bacteria. Here are some things you can do to promote proper use of antibiotics, which in turn ensures that the drugs will be effective when you need them.

- **Understand when antibiotics will work and when they won't work to treat an illness.** Don't expect to take antibiotics every time you're sick. Antibiotics are effective in treating most bacterial infections, but they're not useful in the fight against viral infections, such as colds or the flu. Each year in the United States, doctors write an estimated 50 million antibiotic prescriptions for viral illnesses — for which antibiotics offer no benefit. Sometimes it's hard to tell whether illnesses result from bacteria or viruses — talk with your doctor if you aren't sure.

- **Take antibiotics exactly as prescribed.** Follow your doctor's instructions in taking prescribed medication, including how many times a day and for how long. Don't stop taking the pills a few days early if you start feeling better. Not completing your full course of antibiotics adds to the antibiotic-resistance problem. A complete course of antibiotics is needed to kill all of the harmful bacteria. A shortened course of antibiotics often wipes out only the most vulnerable bacteria, which allows relatively resistant bacteria to survive and thrive.
- **Never take antibiotics without a prescription.** Antibiotics are drugs only available through prescription. However, if you didn't take the full course of antibiotics that were previously prescribed, you might be tempted to take some of that medication the next time you get sick. Or you might give them to a friend or family member who isn't feeling well. The problem with this practice is that the antibiotic might not be necessary in treating the illness, it might not be the right dose or it might not contain the proper active ingredient to fight the bacteria in your system. All of these can contribute to stronger strains of resistant germs.

- **Don't pressure your doctor for antibiotics if you have a virus.** A prescription for antibiotics won't do you any good if you have a cold or the flu. Instead, talk with your doctor about ways to ease the symptoms of your viral illness. For example, taking a decongestant can help clear a stuffy nose. Or taking medicine such as acetaminophen (Tylenol, others) may reduce fever or muscle aches often associated with influenza.
- **Protect yourself from infection in the first place.** You can keep many germs at bay — and avoid infection — by adopting preventive habits, such as cleaning your hands often, handling and preparing food in a safe manner, and keeping up-to-date on immunizations.

ANTIBIOTICS

Antibiotics are chemical compounds that stop the growth of or destroy different types of bacteria and other micro-organisms. They are used in dentistry to treat oral infections. They are also prescribed as a prophylactic (ward off disease) measure to prevent infective endocarditis (or IE) and in other medical conditions. Patients having history of infective endocarditis, rheumatic heart disease, artificial heart valves, and some heart murmurs are at high risk when involved in dental procedures that are likely to cause bleeding. They are prescribed a large dose of antibiotics before treatment and a smaller dose 6 hours after the initial dose. In all cases the dental officer will review the patient's health history and will prescribe an antibiotic if needed. Many types of antibiotics are available; listed are a few groups that are used.

Penicillin

Penicillin is one of the most important of the antibiotics. It is derived from a number of *Penicillium* molds commonly found on breads and fruits. It is one of the most effective and least toxic of the antimicrobial agents used in dentistry.

The penicillins are the oldest class of antibiotics, and have a common chemical structure which they share with the cephalopsorins. The two groups are classed as the beta-lactam antibiotics, and are generally bacteriocidal-that is, they kill bacteria rather than inhibiting growth. The penicillins can be further subdivided. The natural pencillins are based on the original penicillin G structure; penicillinase-resistant penicillins, notably methicillin and oxacillin, are active even in the presence of the bacterial enzyme that inactivates most natural penicillins. Aminopenicillins such as ampicillin and amoxicillin have an extended spectrum of action compared with the natural penicillins; extended spectrum penicillins are effective against a wider range of bacteria. These generally include coverage for *Pseudomonas aeruginaosa* and may provide the penicillin in combination with a penicillinase inhibitor.

Cephalosporins

Cephalosporins are a group of antibiotics that are structurally and pharmacologically related to the penicillin. Because the cephalosporins are structurally similar to pencillians, some patients who are allergic to penicillin may be allergic to a cephalosporin drug. So, special caution is necessary when taking cephalosporins.

Cephalosporins and the closely related cephamycins and carbapenems, like the pencillins, contain a beta-lactam chemical structure. Consequently, there are patterns of cross-resistance and cross-allergenicity among the drugs in these classes. The "cepha" drugs are among the most diverse classes of antibiotics, and are themselves subgrouped into 1st, 2nd and 3rd generations. Each generation has a broader spectrum of activity than the one before. In addition, cefoxitin, a cephamycin, is highly active against anaerobic bacteria, which offers utility in treatment of abdominal infections. The 3rd generation drugs, cefotaxime, ceftizoxime, ceftriaxone and others, cross the blood-brain barrier and may be used to treat meningitis and encephalitis. Cephalopsorins are the usually preferred agents for surgical prophylaxis.

Tetracyclines

The tetracyclines, introduced in 1948, were the first truly broad-spectrum antibiotics. Administration to children and pregnant women is not indicated because it may produce discoloration of the teeth and slow bone marrow growth.

Tetracyclines got their name because they share a chemical structure that has four rings. They are derived from a species of *Streptomyces* bacteria. Broad-spectrum bacteriostatic agents, the tetracyclines may be effective against a wide variety of microorganisms, including rickettsia and amebic parasites.

Erythromycin

Erythromycin has a bitter taste and is destroyed by gastric acids, and usually comes in the form of a coated tablet. Erythromycin is one of the drugs of choice when penicillin is contraindicated. Many patients cannot tolerate the nausea and stomach upset commonly associated with erythromycin, so the dentist may have to prescribe an alternate drug.

MACROLIDES

The macrolide antibiotics are derived from *Streptomyces* bacteria, and got their name because they all have a macrocyclic lactone chemical structure. Erythromycin, the prototype of this class, has a spectrum and use similar to penicillin. Newer members of the group, azithromycin and clarithyromycin, are particularly useful for their high level of lung penetration. Clarithromycin has been widely used to treat *Helicobacter pylori* infections, the cause of stomach ulcers.

Side effects

All antibiotics cause risk of overgrowth by non-susceptible bacteria. Manufacturers list other major hazards by class; however, the health care provider should review each drug individually to assess the degree of risk.

Generally, breastfeeding is not recommended while taking antibiotics because of risk of alteration to infant's intestinal flora, and risk of masking infection in the infant. Excessive or inappropriate use may promote growth of resistant pathogens.

Penicillins: Hypersensitivity may be common, and cross allergenicity with cephalosporins has been reported. Penicillins are classed as category B during pregnancy.

Cephalopsorins: Several cephalopsorins and related compounds have been associated with seizures. Cefmetazole, cefoperazone, cefotetan and ceftriaxone may be associated with a fall in prothrombin activity and coagulation abnormalities. Pseudomembranous colitis has been reported with cephalosporins and other broad spectrum antibiotics. Some drugs in this class may cause renal toxicity. Pregnancy category B.

Fluroquinolones: Lomefloxacin has been associated with increased photosensitivity. All drugs in this class have been associated with convulsions. Pregnancy category C.

Tetracyclines: Demeclocycline may cause increased photosensitivity. Minocycline may cause dizziness. Do not use tetracyclines in children under the age of eight, and specifically avoid during periods of tooth development. Oral tetracyclines bind to anions such as calcium and iron. Although doxycycline and minocycline may be taken with meals, patients must be advised to take other tetracycline antibiotics on an empty stomach, and not to take the drugs with milk or other calcium-rich foods. Expired tetracycline should never be administered. Pregnancy category D. Use during pregnancy may cause alterations in bone development.

Macrolides: Erythromycin may aggravate the weakness of patients with myasthenia gravis.

Azithromycin has, rarely, been associated with allergic reactions, including angioedema, anaphylaxis, and dermatologic reactions, including Stevens-Johnson syndrome and toxic epidermal necrolysis. Oral erythromycin may be highly irritating to the stomach and when given by injection may cause severe phlebitis. These drugs should be used with caution in patients with liver dysfunction. Pregnancy category B: Azithromycin, erythromycin. Pregnancy category C: Clarithromycin, dirithromycin, troleandomycin.

Aminoglycosides: This class of drugs causes kidney and ototoxicity. These problems can occur even with normal doses. Dosing should be based on renal function, with periodic testing of both kidney function and hearing. Pregnancy category D.