LESSON 4.2 WORKBOOK

Toxins — Botox, tetanus, hamburger disease, and MRSA

In the last lesson, we learned that pathogens cause illness by damaging host cells. We also learned that this damage can come directly from the pathogen or indirectly through the immune system. This lesson continues to explore the mechanisms of bacterial pathogenicity but with a focus on toxins.

What is a toxin?

A toxin is a poisonous substance that is produced by living cells or organisms. It is usually a protein, sometimes a lipid, and is capable of causing disease when introduced into the body. Toxins can be produced by most microbes, and by multicellular organisms. For example, bee venom is a toxin, in fact a mixture of different ones, as is the irritating substance in poison ivy.

However, when pathogenic microbes produce toxins, it can dramatically increase their virulence. Toxin production is a powerful adaptation because toxins can cause cell damage both directly, by actually destroying cells, and indirectly by triggering an immune response that destroys host cells. This damage provides bacteria access to new areas of the body to inhabit, and new nutrients. In this lesson, we will outline some examples of toxin-producing bacteria, and discuss how their toxins impact the bacteria’s life cycle, and their hosts.

DEFINITIONS OF TERMS

Virulence — the degree of severity of a disease that a pathogen can cause.

For a complete list of defined terms, see the Glossary.

Figure 1: The honey bee venom is a mix of toxins.
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What is Methicillin-resistant *Staphylococcus aureus* (MRSA)?

*Staphylococcus aureus*, like other kinds of bacteria, normally lives on our skin and in our nose, and is usually non-pathogenic. However, sometimes it causes a variety of pus-forming infections in humans. It can cause skin lesions such as boils, more serious infections such as pneumonia, mastitis (inflammation of the breast), meningitis (inflammation of the brain), urinary tract infections, and deep-seated infections, such as inflammation of the bone, and endocarditis (inflammation of the heart).

*S. aureus* causes disease by releasing **exoenzymes** (enzymes that are secreted by the bacteria in the surrounding environment), and **exotoxins** (toxins that are secreted by the bacteria in the surrounding environment). *S. aureus* produces a variety of such enzymes and toxins that can lyse red blood cells and white blood cells. It also produces an enzyme that can cause blood clots. In this way it is able to break host barriers to migrate or wall itself off from immune cells.

What is MRSA and how is it related to *S. aureus*?

In the 1960s, after antibiotics became widely used to treat bacterial infections, strains (types) of *S. aureus* that were resistant to antibiotics began to emerge. The most notorious strain is MRSA — Methicillin-resistant *Staphylococcus aureus*. MRSA is different from other types of *Staph.*, because it cannot be treated with common antibiotics such as the penicillin class of antibiotics (methicillin, oxacillin, etc.), and cephalosporin antibiotics.

How do bacteria become resistant to antibiotics?

The cells in a bacterial population are always different from each other. Some of these bacteria will be naturally resistant to an antibiotic, just by chance. Given enough time and the presence of antibiotics in their environment, such resistant cells will be naturally selected. How? The bacteria susceptible to the antibiotic will be killed, and will free resources to the resistant ones. This resistant population will now grow and spread. When such bacteria cause an infection, it becomes harder to find an antibiotic to kill them. This is why MRSA, and other antibiotic-resistant bacteria, are sometimes called “super bugs.”
HOW DOES ONE GET INFECTED WITH MRSA?

MRSA, like all Staph. bacteria, can be spread from one person to another through casual contact or through contaminated objects. But having the bacteria on our skin does not usually lead to an infection; infections commonly occur through cuts or wounds. In fact, about 1% of all people have MRSA on them but do not display symptoms. MRSA generally infects people with chronic illnesses, but it is becoming more common in healthy people, especially if they end up in a hospital.

WHAT ARE THE SYMPTOMS OF MRSA?

Symptoms of a MRSA infection depend on where the infection is. If MRSA is causing an infection in a skin wound, that area of the skin may be red or tender. If it causes pneumonia, the symptom will include a cough and shortness of breath. Community-associated MRSA commonly causes skin infections, such as boils or local infections called abscesses. Often, people think these symptoms are from spider or insect bites rather than MRSA. Because MRSA infections can become serious quickly, it is important to see your doctor right away if you notice a boil or other skin problem that is getting worse quickly.

HOW IS AN INFECTION DIAGNOSED?

If your doctor thinks that you are infected with MRSA, he or she will send a sample from your infected wound, blood, or urine to a lab. The lab will then try to grow the bacteria and test to see which antibiotics kill them. The test may take several days. You may also be tested if your doctor suspects that you are a MRSA carrier. A MRSA carrier is a person who has the bacteria on the skin or in the nose but who is not displaying symptoms. This is done by taking a swab from the nostrils or skin.

TREATING MRSA

How do we treat infections caused by this super bug? Most cases of MRSA begin as mild skin infections such as pimples or boils. The doctor may be able to treat these infections without antibiotics or with a minor surgical procedure that opens and drains the sores. Depending on how serious the infection is, the doctor may drain the wound, prescribe antibiotics, give an IV (intravenous) antibiotic, or recommend hospitalization. One might also be given an ointment to put on their skin or inside their nose and be asked to wash their skin daily with an antibiotic soap to reduce the number of MRSA bacteria on the skin.
How can I prevent getting or spreading MRSA?

- Keep your hands clean by washing them frequently and thoroughly with soap and warm water or using an alcohol-based hand sanitizer.

- In a hospital setting, remind doctors and nurses to wash their hands before they touch you. Hospitals are still a major source of MRSA infections.

- If you are a carrier, avoid spreading the infection by telling your family, and other people with whom you are in close contact to wash their hands often with soap and warm water or use an alcohol-based hand sanitizer.

- Keep cuts and scrapes clean and covered with a bandage, and avoid contact with other peoples’ wounds or bandages.

- Do not share personal items such as towels, washcloths, razors or clothing.

- Wash your sheets, towels, and clothes with warm water and detergent, and dry them in as a hot dryer as much as possible.

- Keep your environment clean by wiping all frequently touched surfaces (such as counter tops, doorknobs, and light switches) with disinfectant.

- Be smart about using antibiotics. Know that antibiotics can help treat bacterial infections but they can’t cure viral infections. Always ask your doctor if antibiotics are absolutely needed if he wants to prescribe them and avoid pressuring your doctor to prescribe antibiotics.

3. Which is false about MRSA?
   a. It usually spreads through the air like the common cold or flu virus.
   b. It’s spread from one person to another through casual contact or through contaminated objects.
   c. Many of the people infected with MRSA do not display symptoms.
   d. Infections can occur among people who have cuts or wounds and then come into close contact with one another.
**Lesson Readings**

**Escherichia coli (E. coli)?**

What is *E. coli*?

As we learned in Unit 3, commensal bacteria are crucial for a healthy body. *Escherichia coli* (*E. coli*) is a common commensal bacterium that lives in the intestines of people and animals. There are many strains (types) of *E. coli*. Most *E. coli* strains are non-pathogenic, meaning they do not cause disease in the intestines. Nevertheless, these non-pathogenic *E. coli* can cause disease if they spread outside of the intestines, for example, into the urinary tract (where they cause bladder or kidney infections) or into the bloodstream (causing sepsis). Some strains of *E. coli* are primary pathogens, meaning they can cause disease in a healthy host. These pathogenic strains of *E. coli* may cause diarrhea by producing and releasing toxins.

What is *E. coli* O157:H7 and where did it come from?

*E. coli* O157:H7 is a strain of *E. coli* that produces a toxin called **Shiga toxin** that can bind to a number of host cells disrupting their normal function. It causes a diarrheal illness which was first recognized when the CDC isolated *E. coli* O157:H7 from patients in two separate outbreaks in Oregon and Michigan in 1982. The illness was associated with eating hamburgers at the restaurants of a national food chain. Since then, hemorrhagic colitis due to *E. coli* O157:H7 has been commonly referred to as ‘hamburger disease’.

But where did this strain come from? Cattle can be asymptomatic carriers of this strain of *E. coli*. Unlike humans, cows don’t get sick because their cells don’t bind the Shiga toxin, making them a perfect reservoir, spreading the bacteria in their feces. The meat can then be contaminated with bacteria as well as groundwater or manure. If such water is used for crop irrigation or the manure for crop fertilization, the crops can become contaminated.

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**Definitions of Terms**

- **Sepsis** — a severe overreaction of the immune system to a pathogen which can be deadly to the host.

- **Hemorrhagic colitis** — acute inflammation of the colon which results in watery diarrhea and possibly bloody stools.

For a complete list of defined terms, see the **Glossary**.
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How exactly does \textit{E. coli} O157:H7 make us sick?

The Shiga toxin affects the cells lining the small blood vessels in the intestine. This damage results in bloody diarrhea which is usually the first symptom of the disease. The toxin then enters the bloodstream where it can bind to white blood cell, platelets, and red blood cells. As the kidneys filter the blood, the toxin can make its way into kidney cells damaging them as well. This extensive damage to host cells leads to \textbf{hemolytic-uremic syndrome (HUS)} which is a serious and potentially fatal illness. “Hemolytic” refers to the breakup of red blood cells, which leads to an inability to carry oxygen throughout the body. Platelets are also destroyed which, in turn, promotes abnormal bleeding. “Uremic” refers to failure of the kidneys. Severe disease is most common in children under the ages of 10 years, and is the leading cause of sudden loss of normal kidney function in infants and young children.

How do people get \textit{E. coli} O157:H7?

Infection is transmitted primarily by food or drink and less commonly by direct contact contaminated swimming water. Generally, \textit{E. coli} O157:H7 infection comes from eating raw or undercooked hamburger or from drinking raw (unpasteurized) milk. Products that have been found to be infected include ground beef, salami, raw milk, alfalfa sprouts, and unpasteurized apple cider and apple juice. Although cattle are an important reservoir, contaminated pork, poultry and lamb have also been encountered.

What are \textit{E. coli} symptoms, and how is it diagnosed?

The incubation period between exposure to the bacteria and onset of symptoms is usually 3–4 days. Symptoms of such an infection include severe abdominal pain and tenderness, often associated with bloody diarrhea. Curiously, there often is little or no fever and diarrhea typically lasts for 6–8 days.

For patients suspected of having \textit{E. coli} O157:H7 infection (for example, if they have bloody diarrhea, severe abdominal pain, and tenderness but no fever), a stool specimen is tested for the presence of \textit{E. coli} O157:H7. There are two common methods of testing for \textit{E. coli} O157:H7 in stool samples: 1) growing the bacteria on selective agar plates, or 2) testing for the presence of Shiga toxin.

To look for the development of hemolytic-uremic syndrome, blood

4. Which is false about \textit{E. coli}?
   a. They are normal, non-pathogenic inhabitants of the small intestine and colon.
   b. \textit{E. coli} O157:H7 produces a toxin called Shiga toxin that damages the intestines causing colitis and bloody diarrhea.
   c. One of the \textit{E. coli} infections is \textbf{hemolytic-uremic syndrome (HUS)}, which is a minor illness.
   d. none of the above
**LESSON READINGS**

Tests such as complete blood count (CBC), and blood levels of electrolytes, blood urea nitrogen (BUN, waste product of protein metabolism), and creatinine (waste product filtered by the kidneys) are performed periodically.

**What is the treatment for *E. coli* O157:H7?**

Infection with *E. coli* O157:H7 should be treated by a physician. The use of antibiotics is somewhat controversial since some studies have shown that antibiotic use does not affect the duration of bloody diarrhea, and may even increase the chances of developing hemolytic-uremic syndrome. Treatment is mostly close medical observation, and includes replacing fluids and electrolytes to prevent dehydration. Patients with kidney failure may need dialysis. Even after the acute phase, the value of antimicrobial agents in treating Shiga toxin-producing *E. coli* infections is not clear. Using anti-diarrhea medications should also be avoided because they appear to prolong bloody diarrhea and increase the incidence of hemolytic uremic syndrome.

**Clostridium botulinum**

**What is *Clostridium botulinum*?**

*Clostridium botulinum* is a bacterial species commonly found in soil. The cells are rod-shaped organisms that grow best in anaerobic conditions (absence of oxygen). The bacteria form spores, which allow them to survive harsh conditions in a dormant state until they make it into an environment which can support their growth.

**How does *Clostridium botulinum* cause a disease?**

The bacterium *Clostridium botulinum* produces a neurotoxin that causes a rare but serious paralytic illness called botulism. The botulinum toxin causes these effects by preventing the release of the neurotransmitter acetylcholine, thereby interfering with neurotransmission to the muscles. Although rarely seen in the United States, botulism is one of the most feared diseases because of the incredible potency of the botulinum toxin; given its potency, botulinum toxin is a potential weapon of bioterrorism that could be used to contaminate food or water. For this reason, detecting the bacterium and its toxin might help to prevent both the natural form of the disease and the use of the toxin as a biological weapon.

There are three main kinds of botulism. One, foodborne botulism is usually caused by eating foods...
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that contain the botulism toxin. Two, wound botulism is caused by the toxin produced in an infected wound. Three, infant botulism is caused by consuming the spores of the botulinum bacteria. The spores germinate in the intestines, the bacteria start growing, and producing the toxin.

*C. botulinum* spores are normally found in soil or marine sediment and contaminate meats, vegetables, and fish. Because the spores are relatively heat resistant, they survive food processing and canning when the temperatures are insufficiently high. Under anaerobic conditions but in the presence of nutrients, such as the ones found in canned foods, the bacteria start growing and producing the toxin. In many cases the food has a normal appearance and taste. Foodborne botulism can be especially dangerous because many people can be poisoned by eating the same contaminated food. All forms of botulism can be fatal and are considered medical emergencies.

How common is botulism?

In 2012, the US had 160 laboratory-confirmed cases of botulism. Of these, approximately 16% were foodborne, 76% were infant botulism, 5% were wound, and additional 3% were of unknown or other origin. Foodborne illness is usually the result of homemade improperly preserved food. Infants can ingest the spores from the environment since the bacteria are common soil dwellers. Infants who live near a construction site are more likely to get sick. Certain foods such as honey can also contain the spores. This is why honey should not be given to infants. Wound botulism is mostly found among people who inject drugs such as heroin. Injuries are an additional source of wound botulism.

What are the symptoms of *Clostridium botulinum* infection?

The symptoms of botulism include double vision, blurred vision, drooping eyelids, slurred speech, difficulty

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5. Complications from botulism can lead to
   a. death resulting to respiratory failure.
   b. a breathing machine as well as intensive medical and nursing care for several months.
   c. fatigue and shortness of breath for years.
   d. long-term therapy.
   e. all of the above
swallowing, dry mouth, and muscle weakness. Infants with botulism appear lethargic, feed poorly, are constipated (a symptom that is usually overlooked), and have a weak cry and poor muscle tone. These are all symptoms of the muscle paralysis caused by the bacterial toxin. If untreated, these symptoms may progress to cause paralysis of the arms, legs, trunk and respiratory muscles. However, with proper treatment the majority of patients will recover. In foodborne botulism, symptoms generally begin 18 to 36 hours after eating a contaminated food but they can occur as early as 6 hours or as late as 10 days.

**How can botulism be treated?**

If diagnosed early, foodborne and wound botulism can be treated with an antitoxin, which blocks the action of toxin circulating in the blood. This can prevent patients from worsening but recovery still takes many weeks. Physicians may try to remove contaminated food still in the gut by inducing vomiting. Wounds are treated, usually surgically, to remove the source of the toxin-producing bacteria followed by administration of appropriate antibiotics. The respiratory failure and paralysis that occur with severe botulism may require a patient to be on a breathing machine for weeks, plus intensive medical and nursing care. After several weeks, the paralysis slowly improves - good supportive care in a hospital is the mainstay of therapy for all forms of botulism.

**Are there complications from botulism?**

Botulism can result in death due to respiratory failure. However, in the past 50 years the proportion of patients with botulism who die has fallen from about 50% to 5–10%. A patient with severe botulism may require a breathing machine as well as intensive medical and nursing care for several months. Patients who survive an episode of botulism poisoning may have fatigue and shortness of breath for years and long-term therapy may be needed to aid recovery.
**Definitions of Terms**

- **Diplococcus** — cocci (round) cells that stay together in pairs.
- **Meningitis** — inflammation of the membranes covering the brain and the spinal cord.

For a complete list of defined terms, see the [Glossary](#).

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**Neisseria meningitidis**

What is *Neisseria meningitidis*?

*N. meningitidis* (*meningococcus*) is a Gram-negative **diplococcus** that can colonize mucous membranes, such as in the nose, without causing symptoms. It is estimated that in endemic areas, 5 to 10% of the population are meningococcal carriers. While isolated cases, case clusters, or large epidemics of meningococcal disease can occur, the more usual outcome of exposure to the meningococcus is colonization of the nose with no local symptoms or systemic consequences. In contrast, meningococcal infection of the bloodstream is a life-threatening disease, and *Neisseria meningitidis* is one of the leading causes of bacterial **meningitis**. In the United States, bacterial meningitis is relatively rare and usually occurs in isolated cases. Clusters of more than a few cases are uncommon.

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In contrast, in parts of Africa, widespread epidemics of meningococcal meningitis occurred regularly causing a tremendous burden on the countries and hindering development. **In 2010, a new meningococcal vaccine specifically targeting the strain found in that area, and as of January 2015, there have been no new cases among the immunized population, and transmission has stopped!**

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**How is the infection spread?**

The bacteria are spread by direct close contact with the discharges from the nose or throat of an infected person. Fortunately, none of the bacteria that cause meningitis are very contagious, and they are not spread by casual contact or through the air. The cascade of events leading to disease are attachment of the bacteria to the cells of the mucous membrane, resulting in death of the ciliated cells that normally sweep bacteria out of the nose. If meningococci can then enter into the bloodstream where they cause devastating systemic disease including small blood clots in the skin, meningitis, shock, and death.
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One of the most amazing aspects of a meningococcal infection is the high numbers they can reach in the bloodstream. Then when they die, they release an endotoxin, which breaks down red blood cells, quickly causing bruises under the skin. The bacterium also makes a capsule, which allows it to hide from the immune system and plays an important role in its pathogenicity. In fact, patients most susceptible to the infection often have immune systems that cannot recognize the capsule as a foreign invader. In these cases, the bacteria are not killed by phagocytic cells of the immune system in the bloodstream, so the bacteria multiply rapidly!

What are the symptoms of Neisseria meningitidis infection?

Anyone can get bacterial meningitis, but it is most common in infants and children. In persons over age 2, common symptoms are high fever, headache, and stiff neck. These symptoms can develop over several hours, or they may take 1 to 2 days. Other symptoms can include nausea, vomiting, sensitivity to light, confusion, and sleepiness. In advanced disease, bruises develop under the skin and spread quickly. In newborns and infants, the typical symptoms of fever, headache, and neck stiffness may be hard to detect. Other signs in babies might be inactivity, irritability, vomiting, and poor feeding. As the disease progresses, patients of any age may experience seizures.

What complications can result from bacterial meningitis?

Advanced bacterial meningitis can lead to brain damage, coma, and death. Survivors can suffer long-term complications, including hearing loss, mental retardation and paralysis.

How is bacterial meningitis diagnosed?

The diagnosis is usually made by growing bacteria from a sample of spinal fluid. The spinal fluid is obtained by a spinal tap. A doctor inserts a needle into the lower back and removes some fluid from the spinal canal. The cultures are then used to identify the correct antibiotic treatment.

Figure 16: Bruises under the skin, a symptom of advanced meningitis.

Figure 17: Spinal fluid is obtained via spinal tap and examined for the presence of meningococci.
How is an infection treated and prevented?

Bacterial meningitis can be treated with a number of different antibiotics but in order to have an effective treatment, it is important to start it as soon as possible. There are also vaccines against some strains of Neisseria meningitides. Since there are numerous strains of the bacteria, the development of one universal vaccine has not been achieved yet (as of spring 2015). In 2012, the FDA approved the first vaccine for infants and children between the age of 6 weeks and 18 months — a high-risk age group. Since the occurrence of meningococcal disease increases again during adolescence, the CDC also recommends vaccinating previously unvaccinated pre-teens and teens 11–18 years of age.

College freshmen living in shared spaces like dormitories are at an increased risk for meningococcal disease. For this reason, vaccination is also recommended for students before starting college. The risk for meningococcal disease among non-freshmen college students is similar to that for the general population of similar age (18–24 years). However, the vaccines are safe and produce robust immunity, so non-freshmen college students who want to further reduce their risk for meningococcal disease may elect to be vaccinated.

Clostridium tetani

What is Clostridium tetani?

Clostridium tetani is the name of a bacterial species commonly found in the gastrointestinal tract of humans and animals, and in soil. It belongs to the same genus as Clostridium botulinum. As any relatives, the two species have many features in common. The cells of C. tetani are also rod-shaped and grow best under anaerobic conditions. Another similarity between the two pathogens is the formation of hardy spores. The spores are found in manure-treated soils and can also be found on human skin, and in contaminated heroin.

So, why do we care about C. tetani? Mainly because it causes tetanus, a tragic disease, that is preventable. Experience with tetanus in the two World wars of the 20th century demonstrated beyond doubt the benefits of the tetanus vaccine. Universal immunization of the American forces in World War II, virtually eliminated the disease as a complication of traumatic injuries in soldiers. In developing countries,
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where immunization is not widely practiced, tetanus remains a serious public health problem.

How does one get infected?

*Clostridium tetani* is commonly found in the environment. Most cases of tetanus are associated with a traumatic wound. Neonatal tetanus results from contamination of the umbilical cord at the time of delivery, either through unsanitary procedures or local customs in some places of wrapping the cord in dung or mud. The spores of *Clostridium tetani* enter the damaged tissue, germinate into bacteria which produce an exotoxin (also known as *tetanus toxin*). The then toxin blocks neurotransmission producing the symptoms of the disease.

What are the symptoms of *Clostridium tetani* infection?

Generalized tetanus is the most common type of tetanus, representing about 80% of cases. The first sign is lockjaw, and the facial spasms followed by stiffness of the neck, difficulty in swallowing, and rigidity of chest and calf muscles. Other symptoms include elevated temperature, sweating, elevated blood pressure, and even a rapid heart rate. Spasms may occur frequently and last for several minutes causing the body to arch as shown in the image to the right. Spasms can continue for up to 4 weeks leading to respiratory failure caused by paralysis of chest muscles. Complete recovery may take months!

The *incubation period* of tetanus can take several months but is usually about 8 days. In general, the further the injury site is from the central nervous system, the longer the incubation period. In neonatal tetanus, symptoms usually appear from 4 to 14 days after birth, averaging about 7 days.

*Reported mortality rates vary from 40% to 78%. In recent years, approximately 11% of reported tetanus cases have been fatal. The highest mortality rates are in unvaccinated people, newborns, and the elderly.*
How can tetanus be treated and prevented?

The treatment of tetanus mainly aims to prevent complications from the aberrant muscle contraction. Although antitoxin should be given at the earliest possible moment, it is often not productive because the toxin has already bound to the nerve cells, so the antitoxin is more of a preventative than a treatment in this case. Antibiotic treatment might also be given along with surgical cleaning of the wound.

Prevention of tetanus can be achieved through immunization. The vaccine consists of inactivated tetanus toxin that cannot cause tissue damage but still activates the immune system. It is the ‘Ta’ portion of the DTaP vaccine given to infants and children. Unfortunately, immune memories to the toxin can diminish over time so tetanus vaccine booster are needed periodically.
What happens when meningococci survive and multiply in the bloodstream?
<table>
<thead>
<tr>
<th>TERM</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>Acetylcholin</td>
<td>A molecule that transmits signals between nerve cells in the body.</td>
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<tr>
<td>Acute renal failure</td>
<td>Sudden loss of normal kidney function.</td>
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<tr>
<td>Anaerobic</td>
<td>In the absence of oxygen.</td>
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<tr>
<td>Antibiotics</td>
<td>Molecules, produced usually by bacteria and fungi, that have the ability to suppress the growth of microbes or kill them.</td>
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<tr>
<td>Biological weapons</td>
<td>Infectious agents or toxins that can be used as weapons.</td>
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<tr>
<td>Complete blood count (CBC)</td>
<td>A blood test used to measure the number and type of blood cells, white, red, and platelets as well as a few other parameters.</td>
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<td>Community-associated MRSA</td>
<td>More recent strain of MRSA that is unrelated to previous antibiotic use and spreads in the community among healthy people.</td>
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<tr>
<td>Dialysis</td>
<td>A process used to remove waste from the blood usually when the kidneys are not functioning properly.</td>
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<td>Diplococcus</td>
<td>Cocci cells that stay together in pairs.</td>
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<td>Electrolytes</td>
<td>Minerals in one's body such as K⁺, Na⁺.</td>
</tr>
<tr>
<td>Endotoxin</td>
<td>Permanent components of bacterial cells but when the cells are lysed they get released, and act like toxins to the host.</td>
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<td>Hemorrhagic colitis</td>
<td>Acute inflammation of the colon which results in watery diarrhea and possibly bloody stools.</td>
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<td>Incubation period</td>
<td>The time period from first exposure to a pathogen to the appearance of the first symptoms of a disease.</td>
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<td>Phagocyte</td>
<td>Scavenger cell that engulfs and samples foreign bodies.</td>
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