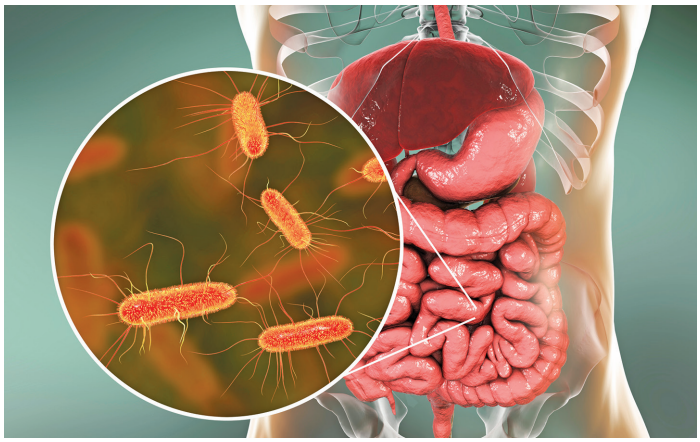
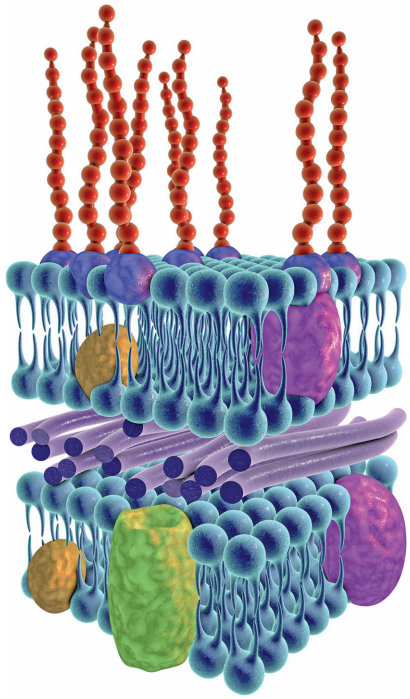
Gut Feelings: *E. coli* in the Gut

Jordan went to a picnic on Saturday with some of their friends. Everyone brought food to share and passed everything around for everyone to taste. On Sunday, Jordan woke up with a bad case of diarrhea. When they texted their friends to tell them, three friends said they had the same symptoms. They wondered whether they had gotten sick from being at the picnic together. Was it something they ate? Was it something they shared with each other while they were together?



E. coli, rod-shaped bacteria with flagella, are common in the gut.

Within our intestines, each of us has several hundred different types of bacteria. Most of these bacteria are harmless and are an important part of a healthy intestinal tract. *Escherichia coli* or *E. coli* is one such bacteria. It is an inhabitant of over 90% of human intestinal tracts. Although it represents less than 1% of the intestinal tract microbiota (community of microorganisms), *E. coli* is the predominant aerobic (oxygen-using) organism in our gut. Almost all *E. coli* consume glucose (a simple sugar) that is present in the gut, to fuel growth and reproduction. It is among the first species to colonize the intestines, establishing itself in the gut early after birth, and remains a resident throughout the life of the host. If it is so common, why do we keep hearing about all the problems it can cause?



A microscopic view of the cell membrane with long chains of sugar molecules protruding from the surface.

Scientists identify *E. coli* by the sugar coat of molecules they display on their cell surface. These sugars help the bacteria stick to surfaces and reveal their identities to your immune system. The sugars *E. coli* bacteria display differ from strain to strain. Differences in the sugar coat on *E. coli* cell surfaces help to classify the different strains into those that don't harm us or that help us (the good) and those that cause problems (the bad).

The good

The truth is, most strains of *E. coli* coexist with their hosts (us and other mammals) in harmony. For example, several strains of *E. coli* aid in digestion, defend their host against harmful microbes, and produce necessary vitamins, including vitamins K and B. Recent research has also found that *E. coli* is a vital part of our gut microbial community because it helps cells absorb iron.

The bad

Some strains of *E. coli* are pathogenic (harmful to their hosts) and carry a combination of genes that allow them to cause intestinal infections. The most common symptom of an intestinal *E. coli* infection is diarrhea. The severity and characteristics of the symptoms can help classify which type of *E. coli* is present. Intestinal *E. coli* infections are typically classified into five categories:

1. Enterotoxigenic (ETEC)
2. Enteropathogenic (EPEC)
3. Enteroinvasive (EIEC)
4. Enterohemorrhagic (EHEC)
5. Enteroaggregative (EAEC)

E. coli bacterial cells.

The table on the next page highlights the differences between the strains and the symptoms experienced. In general, strains of *E. coli* typically enter into the intestinal tract when a person eats something that is contaminated with a pathogenic strain of bacteria, such as undercooked ground beef, soft cheeses made from raw milk, fresh produce, or contaminated beverages including water, unpasteurized milk, and fruit juices. Humans can unknowingly ingest *E. coli* after not carefully washing hands that have come in contact with animals, people, or surfaces that have *E. coli* on them. Swimming in water contaminated with *E. coli* may also lead to an infection, especially if any water was swallowed.

Once the bacteria are ingested, the bacterial cells travel to the gut and communicate with intestinal cells, telling them to produce tiny structures, called pedestals, that anchor the bacterial colonies in place and help them grow and reproduce. As the bacterial colony continues to grow, some strains of bacterial cells produce toxins (called enterotoxins) that poke holes in intestinal cell walls, causing the intestinal cells to die. When cells die, water may be released into the intestines. Sometimes, ulcers (open bloody sores) form in the intestines. Both of these types of damage can result in diarrhea or more serious symptoms.

	ETEC	EPEC	EIEC	EHEC	EAEC
Where are they found and how do they get in us?	Contaminated food and water is ingested; always comes from humans, not found in animals	Feces and contaminated water sources; feces accidentally ingested (fecal-oral transmission)	Contaminated food and water are ingested; always comes from humans	Contaminated meat or unpasteurized beverages are ingested	Unknown
How much do you need to ingest to be infected?	Large amounts need to be ingested to cause an infection	Unknown	Large amounts need to be ingested to cause an infection	Small amounts need to be ingested to cause an infection	Unknown
What symptoms do people experience?	Watery diarrhea	Watery diarrhea	Dysentery (blood- and mucus-filled diarrhea)	Watery diarrhea followed by bloody diarrhea	Watery, mucus-filled diarrhea
What happens when they get in our gut?	Adhere to intestinal cells and produce toxins	Adhere to intestinal walls and form a microcolony altering intestinal cells	Enter intestinal cells and multiply, eventually causing cell death	Adhere to intestinal cells and produce Shiga toxins that enter and kill intestinal cells	Adhere to intestinal walls and form highly specialized colonies (biofilms)
Why do we get symptoms?	The toxins cause a release of water from the intestinal cells; that water enters the intestines, which leads to watery diarrhea	Unknown	When enough intestinal cells die, ulcers (open bloody sores) form inside the intestines	When enough intestinal cells die, ulcers (open bloody sores) form; kidneys can become clogged with red blood cells and this can cause kidney failure	Unknown

The complicated

Not only do the pathogenic bacteria communicate with their human host's cells, they also communicate with each other. This communication between bacterial cells may be the key in understanding why some people get so sick when they ingest harmful *E. coli* and others seem to be fine.

In a 4-year study, researchers co-cultured (grown together) a pathogenic *E. coli* strain (*E. coli* 0157:H7) with a nonpathogenic *E. coli* strain (*E. coli* C600) and injected the strains into one group of mice. In another group of mice, they injected the pathogenic *E. coli* strain alone. The mice injected with both strains got much sicker than the mice infected with the pathogenic strain alone. Because most humans have multiple strains of *E. coli* in their intestines, these findings are important. The results of the study may be particularly helpful in predicting how an *E. coli*-infected patient will fare by evaluating a stool sample for the absence or presence of certain nonpathogenic *E. coli* bacteria.

Results from this study illustrate the complexity of the gut microbiome. The study highlights how important it is to consider not only the pathogenic bacteria themselves, but all the organisms they come in contact with in their environment.

So how do we get rid of these little creatures?

Because many *E. coli* infections start when someone eats or drinks contaminated substances, it is important to take precautions when you eat. The best line of defense is avoiding ingesting them in the first place. Make sure you wash your hands and any raw foods before you eat. Cooking kills *E. coli*, so cook meats thoroughly and avoid using the same surfaces and cooking utensils for raw meat and uncooked fruits and vegetables. Avoid unpasteurized drinks like raw milk and unpasteurized juices and be sure to close your mouth when you are swimming in lakes, ponds, and swimming pools.

Sources:

American Society for Microbiology. "*E. coli*'s Secret Weapon in Launching Infections." ScienceDaily. August 20, 2019. www.sciencedaily.com/releases/2019/08/190820081857.htm

Evans, Doyle J. Jr., and Dolores G. Evans. "*Escherichia coli* in Diarrheal Disease." In *Medical Microbiology*. 4th ed., edited by Samuel Baron. Galveston, TX: University of Texas Medical Branch at Galveston, 1996, chap. 25. https://www.ncbi.nlm.nih.gov/books/NBK7710

Delmas, Julien, Guillaume Dalmasso, and Richard Bonnet. "*Escherichia coli*: The Good, the Bad and the Ugly." *Clinical Microbiology: Open Access* 4, no. 2 (2015): 1–3.

Goswami, Kakolie, Chun Chen, Lingzi Xiaoli, Kathryn A. Eaton, and Edward G. Dudley. "Coculture of *Escherichia coli* O157:H7 With a Nonpathogenic *E. coli* Strain Increases Toxin Production and Virulence in a Germfree Mouse Model." *Infection and Immunity* 83, no. 11 (2015): 4185-4193.

Hedlund, Kelly. "The Who's Who of *E. coli* Strains." Microbiologics. October 20, 2016. https://blog.microbiologics.com/the-whos-who-of-e-coli-strains

Taylor, Erika. "Why Are Some *E. coli* Strains Deadly While Others Live Peacefully in Our Bodies?" Scientific American. April 24, 2018. https://www.scientificamerican.com/article/why-are-some-e-coli-strains-deadly-while-others-live-peacefully-in-our-bodies