
The Collee article

This article on food poisoning is referred to in various chapters of the book and is used to illustrate a number of important study skills. It's a shortened version of an article originally published in *New Scientist*, and I've numbered the paragraphs to make it easier to refer to specific parts of the text.

Of course, not all the texts you'll come across studying MST subjects will be like this article. Some will be harder to follow, and most will deal with topics far removed from this one. So, why choose just one article? Well, a single text can be looked at from a variety of angles and the study skills practised using the Collee article can be applied to many other types of text.

Why did I choose this particular article? First, it has lots of the features that the book highlights – diagrams, written text and a few numbers – like many of the texts you'll be working with as a beginning student. Second, it's got many features that I like and a few that I don't, so it's possible for me to take a critical approach. Third, it's written in a technical style, but is reasonably approachable. Don't be concerned if you don't understand all of the article at once. And don't be put off by some of the vocabulary it uses – for example, you'll find bacteria referred to by their Latin names, which have to be written in italics: *Clostridium botulinum*.

It'll help if you make at least one photocopy of the article. Perhaps you'll want to annotate it, writing notes or highlighting key points. Keep it to hand – you'll work with the article at several points in the book. You'll need a copy when you read Chapter 2, for example.

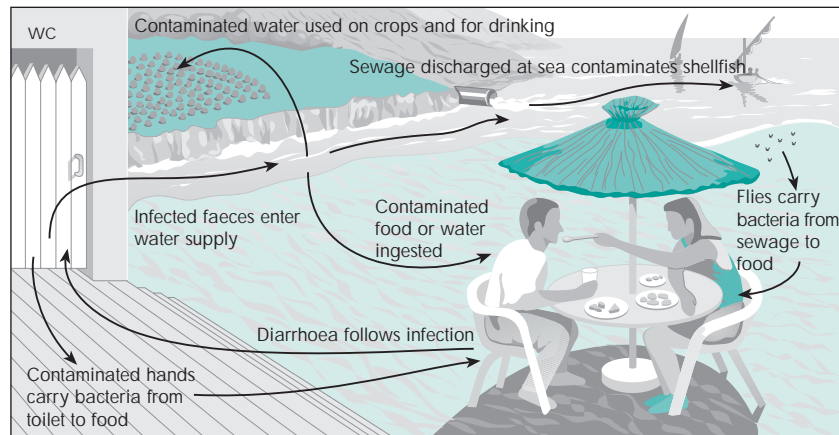
New Scientist, 21 October 1989

We need food to stay alive, but sometimes it makes us ill. Understanding the reasons why bacteria and other microbes may contaminate our food can help us to reduce the risk of food-borne disease

Food Poisoning

Gerald Collee

- 1 Most people have experienced an attack of food poisoning: an episode of diarrhoea, often associated with vomiting. Sufferers frequently assume that the cause was something that they ate or drank that was wrongly prepared, badly cooked or simply 'off'.
- 2 The cause of such an attack may be difficult to determine, often because none of the food eaten remains. Only when many people fall ill at the same time, having eaten the same food, does it become possible to say with any certainty that food was the source of the outbreak. This is why it is so important to report cases of food poisoning to general practitioners, who in turn inform the local environmental health department.
- 3 The term 'food poisoning' is a misnomer. A range of micro-organisms, including viruses, bacteria, fungi and protozoa, can cause such infections. The diseases that these organisms cause may arise as a result of two possible mechanisms. They may be true infections, in which the microbe gains access to the human body and multiplies within it; or they may occur when a microbe multiplies in the food, producing a **toxin**, which poisons the person who eats the food. So a better term is 'food-borne infections and intoxications'.
- 4 This article will concentrate mainly on *bacterial* infections and poisonings spread by food and water. For the sake of simplicity, I will use the term 'food poisoning' in its established sense.
- 5 As with almost any kind of infection, contact with disease-causing microbes does not inevitably result in a case of disease. We routinely cope with a low level of bacterial contamination in much of the food we eat, without coming to any harm. Natural defences such as acid in the stomach and other protective mechanisms in the gut are often enough to kill bacteria eaten in food. Those microbes that survive processing in the stomach have to contend with the immune system, which may be able to eliminate them, particularly if the person has encountered the microbe before and has some immunity to it.



Some of the ways in which food-borne or water-borne diseases such typhoid and cholera can spread

- 6 Yet several factors may tip the balance in favour of the microbe being able to attack its new host. With some species of microbe, relatively few can cause disease. In other instances, diarrhoea and vomiting occurs only after someone has eaten huge numbers of them. These may have originally contaminated the food in minute quantities, which would have been harmless if the food had been eaten straight away.
- 7 Depending on the species of bacterium, someone who has ingested a large dose of microbes is more likely to fall ill than someone who took in relatively few microbes. If the infecting bacteria or viruses are particularly virulent, they will be more likely to cause disease. So someone may be more likely to fall ill following a smaller dose of a more virulent organism than after a bigger dose of a milder one. Usually, however, in bacterial food poisoning, the food has been mishandled in such a way as to boost the growth of bacteria in it.
- 8 To avoid the problem of taking in a high dose of organisms, food must be stored at temperatures too low or too high to permit bacteria to grow: either below 5 °C or above 55 °C. Storing or holding food at temperatures in between these limits allows bacteria to multiply rapidly, and often with devastating consequences.
- 9 Differences between individuals may also account for why some people fall ill while others do not, even though they have eaten the same food. *Listeria* bacteria, for example, do not usually attack normal healthy people, but those whose immune systems are impaired (such as may happen with pregnant women, very young babies, the elderly, and those patients taking drugs to suppress their immune systems) are much more susceptible.
- 10 Some bacteria produce toxins when they grow in food. The most serious example of this type of food poisoning is **botulism**, caused by the bacterium *Clostridium botulinum*. This microbe grows only in the absence of oxygen, producing a poison called **botulinal toxin**.

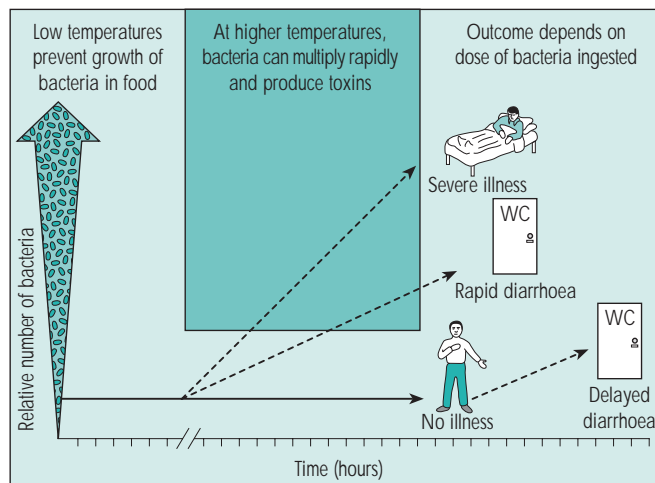
- 11 When someone eats food containing botulinal toxin, the toxin is absorbed into the blood stream and affects the nerves. Although the person remains conscious, many muscles become paralysed. Death may occur when the toxin reaches the nerves supplying the heart or respiratory muscles. Botulinal toxin is probably the most potent natural poison known. Pathologists estimate that one gram of crude botulinal toxin could kill between 100 000 and 10 million people, depending on how it is given.
- 12 A more common form of food poisoning due to a bacterial toxin is that caused by *Staphylococcus aureus*. This organism is frequently found in septic spots, sties, boils and infected wounds. It also occurs in the nose and elsewhere on humans who are perfectly healthy, where it may persist without harming its host.
- 13 When this organism gets into food under conditions in which it can grow, it may produce a toxin that can cause acute vomiting, often accompanied by dizziness and subsequent diarrhoea in the person who eats the food. The sufferer may become severely dehydrated and, as a result, mentally confused.

The longer food is left in conditions that allow bacteria to multiply, the more likely it is that someone who eats the food will fall ill. Sometimes bacteria ingested multiply inside the host, and may cause delayed disease

- 14 *S. aureus* can grow on salted and cooked meat. It is also associated with milk foods, custards and processed foods that have been kept in warm or inadequately refrigerated conditions.
- 15 Some bacteria cause disease by producing toxins not in food before it is eaten, but in the body of the host. The organism that causes cholera, for example, multiplies in non-chlorinated water. When someone drinks the water, many cholera organisms enter the gut, where they release a toxin. This has the effect of reversing the normal flow of water and salts across the membranes of the cells lining the gut. The result is a massive outpouring of fluid, causing the copious watery diarrhoea that rapidly dehydrates someone with cholera. Without adequate replacement of these lost fluids and salts, cholera can be rapidly fatal.

Warm stew Canteen culture

- 16 A relative of *C. botulinum*, called *Clostridium perfringens*, causes food poisoning by producing a toxin when it multiplies inside the host.



C. perfringens occurs very widely in nature. It is easy to isolate from the faeces of humans and animals and from soil and vegetation. It can also infect wounds.

- 17 One subgroup of this species of bacterium produces spores that are very resistant to heat. If these contaminate food, particularly meat dishes, they may survive cooking. If the dish is then kept warm, as in canteens serving large institutions, such as schools and hospitals, the spores may germinate and multiply.
- 18 Once eaten, these bacteria form spores in the gut. During this process, they produce a toxin which affects the intestine: cramping abdominal pains and diarrhoea occur about 9 to 12 hours after eating the meal, and last for a day or two. The illness is self-limiting and not usually severe, except in the very old or the very young, or in pregnant women.
- 19 Perhaps the most notorious food-poisoning agents are the **salmonella bacteria**. *Salmonella typhi* is the cause of typhoid fever, transmitted by contaminated drinking water. It is quite separate, however, from the large group of salmonellae that also belong to this genus and are linked with food-borne infections.
- 20 While the typhoid bacillus causes disease only in humans, the salmonellae associated with food poisoning occur in many animal species as well as humans. They infect many animals that we consume for food, including poultry and their eggs, cattle, sheep and pigs. Rats, mice and other rodents that can contaminate our food supplies are also often infected.
- 21 There were more than 27 000 cases of salmonella infection reported in England and Wales in 1988, and no doubt many more that were not reported. Most cases were unrelated and it was not possible to identify the source of the infection. Of 505 outbreaks of related cases, however, 60 of them were associated with eggs. Out of these 60 outbreaks, just over half were associated with a particular type of salmonella known as *Salmonella enteritidis phage type 4*.

Infected hens Contaminated eggs

- 22 This strain used to be rare, but now accounts for most salmonella infections in England and Wales. Studies have shown that infected chickens are the source of this type of infection. Not only the carcasses and the outer shells of the eggs (which may be contaminated with faeces) may carry the infection. The bacterium can infect the ovaries and oviducts of the hens and thus the contents of intact eggs. So, eating raw or lightly cooked contaminated eggs, in mayonnaise, home-made ice cream or as soft-boiled eggs, for example, can cause salmonella infection.
- 23 Although only a small proportion of eggs is infected, because people eat so many, the total numbers of salmonella infections that result throughout the country as a result of eating eggs may be considerable. Cooking eggs until the yolk sets should destroy any bacteria that are present. The government has introduced new regulations for farmers aimed at reducing the number of infected birds.
- 24 *Salmonella typhimurium* is another very common type that causes disease in humans. Its name means that it causes a typhoid-like disease in mice, but it can also infect a wide range of animals, including humans.

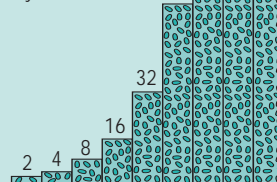
How to stop microbes making a meal of your food

512 in 3 hours

- 25 The organisms that can cause disease in humans are quite different from those that colonise and spoil food that has started to decay. The circumstances in which **spoilage** occurs are also distinct from those that help food-poisoning bacteria to multiply. Most significantly, food that is dangerously contaminated with bacteria capable of causing disease (**pathogens**) may appear, to the naked eye, to be entirely wholesome.
- 26 Bacteria can grow very rapidly. If you supply a bacterial cell with all it needs to grow and multiply, it grows a little and then promptly divides to make two cells. These cells, likewise, grow and divide. A population of bacteria can multiply in this way until it runs out of an essential nutrient, or the temperature changes, or there is an accumulation of acid that halts the process.
- 27 The rate of increase can be formidable. The average time needed for one of the common disease-causing bacteria to divide and create a new generation, when growing under ideal conditions in a test tube at 37 °C, may be 20 minutes or less. Within less than 12 hours, a few bacteria in a millilitre of nutrient broth can multiply to hundreds of millions. If a teaspoon holds five millilitres of fluid, imagine the dose of bacteria that someone could ingest from an average helping of stew that had been contaminated and then left for some time in a warm kitchen.
- 28 Bacteria such as salmonellae and staphylococci grow best at a relatively warm temperature, but bacteria can grow over a very wide range of temperatures. Some bacteria, such as listeriae and *Clostridium botulinum*, the cause of botulism, can grow at relatively low temperatures. In general, temperatures above that of **pasteurisation** (63 °C for 30 minutes) kill pathogenic bacteria, provided they are wet. Dry heat is much less effective.
- 29 A few of the disease-causing bacteria produce spores that resist heat. Others are protected from variations in temperature by the materials with which they are associated. Egg white and egg yolk, for example, are good at protecting bacteria within them.
- 30 Bacteria cannot grow without water. Many techniques of preserving food rely on this fact. Jam, for example, resists the attack of bacteria because the high concentration of sugar makes water unavailable to bacteria.
- 31 The bacterium's need for water explains why bacteriologists who want to reduce contamination in their laboratories like to keep all their equipment dry, and why doctors advise keeping wounds out of water.
- 32 Another factor that influences bacterial growth is the pH (acidity or alkalinity) of the medium in which the microbe is growing. This piece of information is not much help in reducing the risk of food poisoning, however: with the exception of foods such as pickles, the pH value of most of our food is close to neutral.
- 33 Antibiotics and other antibacterial agents can also retard bacterial growth, but the presence of antibiotics in food and water encourages the development of bacteria resistant to these drugs. In addition, if people consume antibiotics in food, they may develop serious allergic reactions.

Numbers of bacteria can increase dramatically in a short period, given the right conditions. Each bacterium contaminating food can give rise to 512 other bacteria within the space of just three hours

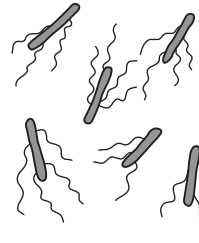
Number will double every 20 minutes



Some infections spread by food or water*

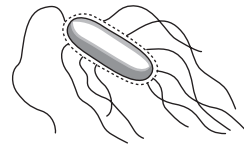
Listeria infections

- 34 *Listeria* organisms occur widely in soil, animals, vegetation, silage and water. They do not usually attack healthy people, but can cause serious illness in those whose immune defences are impaired. The infection usually causes an illness similar to influenza, sometimes with diarrhoea. In some cases, meningitis may result. In pregnant women, infection with *Listeria monocytogenes* can cause death of the fetus, a miscarriage, or serious infection in a newborn baby. For this reason, health officials have warned pregnant women and those with impaired immune systems not to eat food in which *Listeria* is common, such as soft cheeses and pâté, and to reheat thoroughly cooked and chilled meals and ready-to-eat poultry.



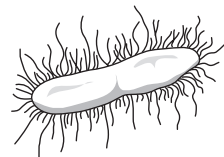
Salmonella infections

- 35 The typical symptoms of this type of food poisoning, which develop from 12 to 36 hours after the offending meal, are vomiting, diarrhoea and abdominal pain. The person may run a high temperature. Usually the symptoms pass off in two or three days, but the illness can sometimes be fatal especially in the very old and very young, and those who are already suffering from other diseases.



Escherichia coli

- 36 Most strains of this species are harmless bacteria inhabiting the human gut. Some strains, however, have a harmful effect on the gut, and are known as enteropathogenic strains. Enteropathogenic *E. coli* infections are a particular threat to young children, but they also account for some cases of travellers' diarrhoea. The symptoms may resemble those of cholera, dysentery or salmonella infection.



Most of the bacteria shown are, in life, between 1 and 5 μm (thousandths of a millimetre).

* The original article included descriptions of 10 infections. I have included only three examples to conserve space.