

Answer key, study questions part 2

1. The structure of the cell wall differs between Gram positive and Gram negative bacteria. For example, the peptidoglycan layer is much thicker in Gram positives. It is important to note that Gram negative bacteria have two cell membranes whereas Gram positives have one. The structure and composition of the cell wall influences which antibiotics that can be used to effectively target the bacteria.
2. Gram negatives: *Escherichia coli* (can for example cause urinary tract infections) and *Neisseria gonorrhoeae* (gonorrhoea).

Gram positives: *Streptococcus pneumoniae* (for example pneumonia and meningitis) and *Staphylococcus aureus* (wound infections).

Please refer to the section "Bacteria basics" for more examples.

3. Although antibiotic resistance is a natural phenomenon, it has probably never before been such a great evolutionary advantage for the general population of bacteria to be resistant. As antibiotics started to be used in medicine and in agriculture, the selection pressure for antibiotic resistance increased dramatically. In the presence of antibiotics, it is advantageous for bacteria to be antibiotic resistant since they thereby can avoid the action of these substances and thus continue to proliferate.
4. (Some) antibiotics can be produced by microorganism, including some bacterial species. The organisms are not themselves affected by the antibiotics they produce, and can therefore use them to outcompete other bacteria in the surroundings. If, by chance, a few of the targeted bacteria would become resistant to the relevant antibiotic (through mutation or acquisition of antibiotic resistance genes), they would survive and would be able to proliferate whereas the others would die off or stop growing. Hence, in any environment where antibiotics are present, it can be an evolutionary advantage for bacteria to be antibiotic resistant.
5.
 - The bacteria may alter the target site that the antibiotic binds to.
 - The bacteria may produce enzymes that inactivate the antibiotics.
 - The cell membrane of the bacteria may be altered which may lead to decreased permeability.
 - The antibiotic may produce efflux pumps that pump the antibiotics out of the cell.
 - The bacteria may use alternative metabolic pathways and thereby compensate for the action imposed by the antibiotic.

6. Via for example international travel and trade. Additionally, animal migration may contribute to international spread of resistant bacteria, but the impact on human health is probably limited.
7. Spread of resistant bacteria is, for example, facilitated by poor sanitation and hygiene, both in hospitals and in communities. Crowding facilitates spread. Resistant bacteria may also spread via animals and contaminated food products, dirty water and through direct and indirect contact with colonized and/or infected individuals.
8. She should for example wear proper gowns, use disposable gloves and apron and wash her hands carefully with soap, water and hand disinfectant.
9. Ideally, the hygienic routines for medical personnel should be designed in such a way that it should not matter whether patients are colonized by susceptible or resistant pathogens. Every patient should be treated as if they were colonized by resistant bacteria and proper infection prevention and control measures should thus be part of the everyday routines.
10. Chang et al, authors of the article "Antibiotics in agriculture and the risk to human health: how worried should we be?" (Evolutionary applications, 2015, 8.3: 240-247.), describe three risks that agricultural use of antibiotics may pose on human health:
 - Humans might get infected with a resistant bacterium originating from an animal, but no substantial transmission in the human population follows. The bacterial spread from animal to human could for example be facilitated through direct contact or via consumption of contaminated meat or water.
 - Humans could get infected by bacteria originating from animals and human-to-human transmission might follow thereafter.
 - Antibiotic resistance genes could be transferred from bacteria of an animal origin to human pathogens.

As described in the article, the exact impact of these three mechanisms on human health are more or less difficult to prove and quantify. The authors reason that identifying and correctly quantifying zoonotic spread of resistance genes is particularly difficult, albeit this risk probably is the most important of the three.