Disinfectants – bactericidal, fungicidal or viricidal?

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Introduction

The hottest topics since the novel Corona virus (COVID-19) started affecting the globe are disinfectants, sanitizers, face masks and gloves. One of the main concerns to us, as microbiologists, is the interchangeable manner in which the terms bactericidal, fungicidal and viricidal are used. Another main concern is the assumption that disinfectants and sanitizers are capable of being bactericidal AND fungicidal AND viricidal by default and it is rarely stated on the label against which organisms these compounds have been tested. This is assuming a "one-size-fits-all" approach. There is, however, a considerable difference between a compound that is bactericidal, fungicidal and/or viricidal as indicated below:

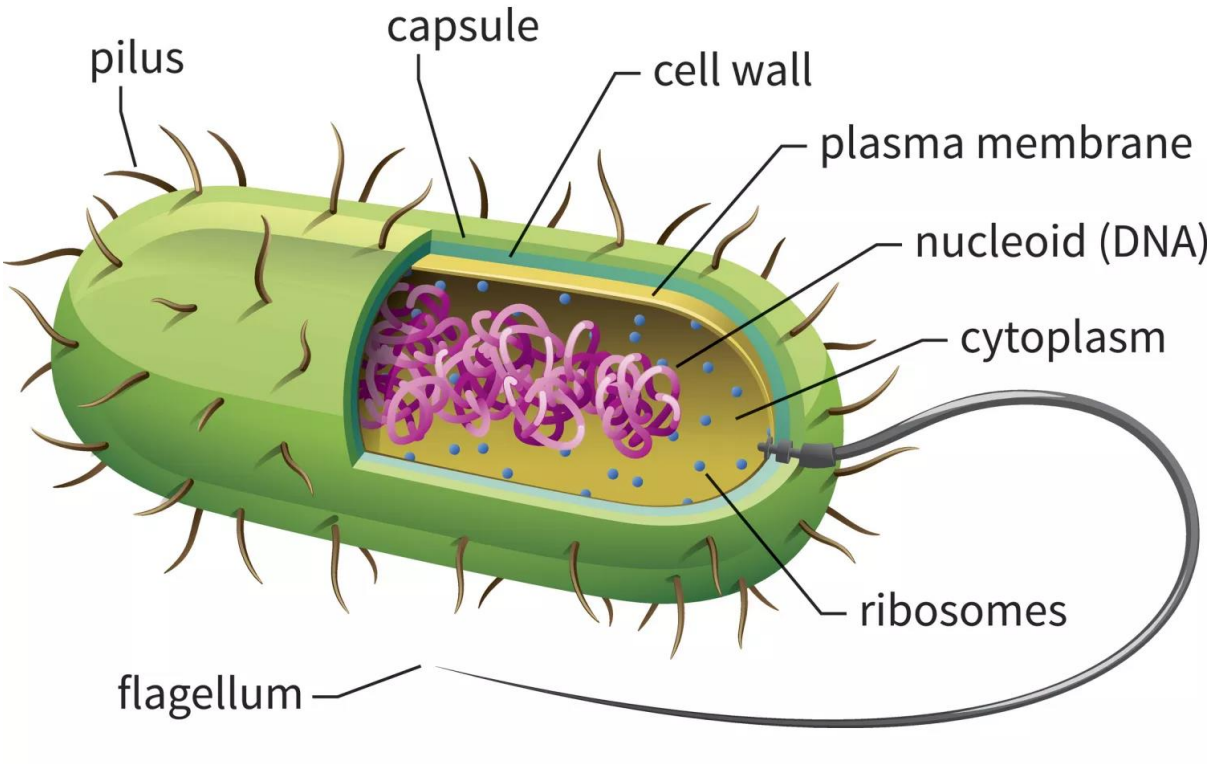
- Bactericidal: a compound or condition that destroys **bacteria**.
- Fungicidal: a compound or condition that destroys **fungi**.
- Viricidal: a compound or condition that destroys **viruses**.

"What is the difference between bacteria, fungi and viruses" you ask… germs are germs! Unfortunately, this is not the case. This would be like stating that all animals have the same characteristics, whether it be birds, fish or wild cats. It is the same with bacteria, fungi and viruses. They each have their own characteristics that, in most cases, differ vastly from each other.

Bacteria

These microscopic organisms are single-celled and are found in mostly every environment you can think of, e.g. soil, water, plant roots and the human gut. Bacterial cells differ from plant and animal cells in that they do not have a nucleus (prokaryotes). The structure of bacterial cells contains the following:

- Capsule: some bacteria have a layer on the outside of their cell wall.
- Cell wall: a layer of peptidoglycan (a polymer) that gives the bacterial cell its shape. The layer varies in thickness between different types of bacteria.
- Plasma membrane: a permeable layer found within the cell wall. It is capable of generating energy and transporting chemicals.
- Cytoplasm: a gel-like substance surrounded by the plasma membrane that contains the organelles and genetic material of the bacteria.
- DNA: this contains the genetic instructions that the bacterium needs to develop and function.
- Ribosomes: responsible for the synthesis of proteins and consists of RNA-rich granules.
- Flagellum: used to propel mobile bacteria.
- Pili: hair-like protrusions that allows the bacterium to stick to surfaces and/or transfer genetic material to other cells.

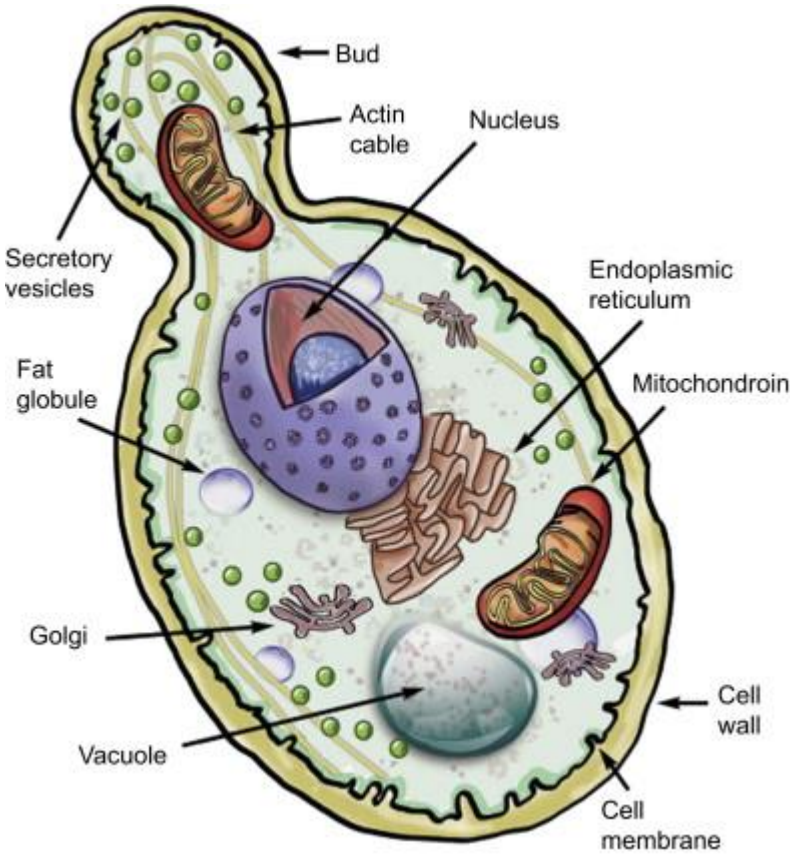


Bacterial Cell Structure (Taken from Bacterial Cell Anatomy and Internal Structure. Jacom/Getty Images. Thoughtco. What are prokaryotic cells? Structure, Function and Definition. By: Regina Bailey, October 2019. https://www.thoughtco.com/prokaryotes-meaning-373369).

Fungi

Fungi are eukaryotic, microscopic organisms that include yeasts, moulds and mushrooms. They are grouped in their own kingdom, apart from plants and animals (although they have similarities to both). They are generally larger than bacteria and contain chitin in their cell walls. In general yeasts and moulds are opportunistic pathogens that infects only those with a weakened immune system (e.g. *Candida albicans*). Moulds are often responsible for secreting mycotoxins that can be harmful to humans. The structure of a yeast will be used as an example to indicate the manner in which it differs from bacteria and viruses. The structure of yeasts mainly contains the following:

- Cell wall: consists of carbohydrates and acts as a barrier to protect the content of the cell.
- Plasma membrane: semi-permeable lipid bilayer that regulates diffusion of molecules in and out of the cell.
- Cytoplasm: gel-like substance enclosed by the plasma membrane and contains the cell organelles.
- Mitochondria: responsible for energy production.
- Vacuole: an organelle used for storing nutrients.
- Endoplasmic reticulum: a network of membranes used for the synthesis of proteins, lipids and carbohydrates.

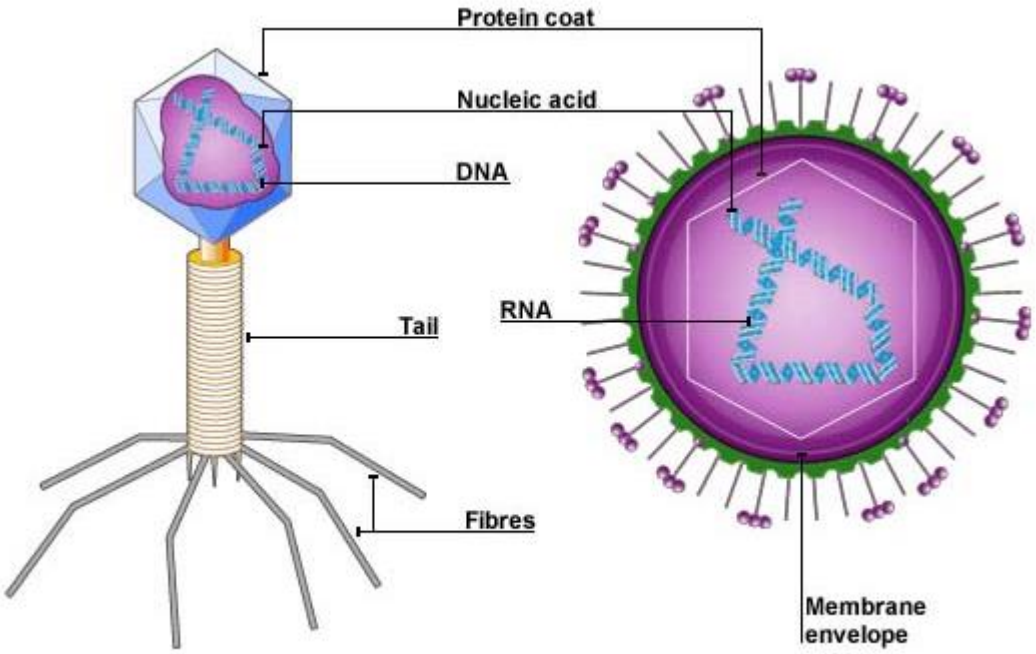


Yeast Cell Structure (Taken from Brewing Microbiology. Managing Microbes, Ensuring Quality and Valorising Waste. Yeast: An Overview. A. Speers and J. Forbes. Woodhead Publishing Series in Food Science, Technology and Nutrition, May 2015, pp. 3 – 9. https://doi.org/10.1016/B978-1-78242-331-7.00001-0).

Viruses

Viruses are microscopic obligate parasites and are much smaller than fungi and even bacteria. Viruses are often not considered as being alive, since they lack the ability to thrive, grow and reproduce outside of a host body. Viruses have a reputation of causing widespread events of disease and death for example Ebola, Swine Flu and even the current COVID-19 pandemic. The structure of a virus contains the following:

- Protein coat (capsid): protects the genetic material of the virus.
- Genetic material: RNA or DNA genome.
- Tail and Fibres: used to infect the host.
- Envelope: some viruses have a lipid envelope obtained when leaving the host cell.



Virus Cell Structure (Libretexts. Viral structure and reproduction, September 2019. Powered by MindTouch® and supported by the Department of Education Open Textbook Pilot Project, the UC Davis Office of the Provost, the UC Davis Library, the California State University Affordable Learning Solutions Program and Merlot. Unless otherwise noted, LibreTexts content is licenced by CC BY-NC-SA 3.0. https://chem.libretexts.org/Courses/Remixer_University/iLearn_Collaborative/Copy_of_DCW-Biology-Semester-2_Curated.imscc/01%3A_Course_Content/00%3A_Unit_6%3A_Classification/00%3A_Week_1%3A_Classification%2C_Viruses%2C_Bacteria%2C/08%3A_Viral_Structure_and_Reproduction).

Disinfectants and Sanitizers

Disinfectants are anti-microbial agents that are designed to inactivate or destroy microbes on inert surfaces. It does not necessarily kill all microbes, especially resistant bacterial spores. Disinfectants work by destroying the cell wall of microbes or interfering with their metabolism, although the exact modes of action are not always known. In addition, considerable progress has been made in understanding the mode of action of disinfectants against bacteria, however very few studies have been conducted to determine the mode of action against fungi, viruses and protozoa. Sanitizers are substances that simultaneously clean and disinfect. Sanitizers are less effective at killing microbes than disinfectants.

Chemical Efficacy Testing

Companies that wish to state certain claims about the ability of their products to destroy bacteria, fungi or viruses have to present proof that the products do indeed have the ability to be bactericidal, fungicidal and/or viricidal. In order to prove such claims chemical efficacy testing should be

performed. There are various standards that can be used for each category (bactericidal, fungicidal, viricidal) to determine the effectiveness of a chemical substance against various microbes. Some of these standards include:

- EN 1276: Chemical disinfectants and antiseptics – Quantitative suspension test for the evaluation of **bactericidal activity** of chemical disinfectants and antiseptics used in food, industrial, domestic and institutional areas – Test method and requirements (Phase 2, step 1).

- EN 13697: Chemical disinfectants and antiseptics – Quantitative non-porous surface test for the evaluation of **bactericidal and/or fungicidal activity** of chemical disinfectants used in food, industrial, domestic and institutional areas – Test method and requirements without mechanical action (Phase 2, step 2).

- EN 14675: Chemical disinfectants and antiseptics – Quantitative suspension test for the evaluation of **viricidal activity** of chemical disinfectants and antiseptics used in the veterinary area – Test method and requirements (Phase 2, step 1).

- EN 14476: Chemical disinfectants and antiseptics – Quantitative suspension test for the evaluation of **viricidal activity** in the medical area – Test method and requirements (Phase 2, step 1).

Note that each of these standards refer to a specific organism, e.g. bacteria, fungi and viruses. Therefore, one cannot assume that a disinfectant or sanitizer that passes EN 1276 or EN 13697 will, by default, pass EN 14675 or EN 14476. A compound that is effective against bacteria and/or fungi, might not be effective against viruses.

Where does this leave us during COVID-19 in South Africa?

The current pandemic caused by the novel Corona virus (COVID-19) has created a huge opportunity for companies to develop and promote disinfectants and hand sanitizers. Unfortunately, to have an advantage in the market, certain claims would be beneficial to make. However, to make such claims and obtain, for example, EPA or NCRS approval, these claims must be substantiated with proof. It is exactly here where South African companies are running into complications. Although there are a few accredited laboratories in South Africa capable of testing chemical efficacy, these are all aimed at bactericidal and/or fungicidal activity (EN 1276 and EN 13697).

Due to the difficulty of working with viruses in a laboratory, accredited chemical efficacy testing laboratories for viricidal compounds are scarce, especially in South Africa. There are no accredited laboratories in South Africa (according to our knowledge) capable of testing compounds for viricidal activity. This leaves companies with only one other option and that is to send their disinfectants and sanitizers abroad to be tested. There are a number of complications linked to this option, including (1) the travel ban and limitation of air traffic, (2) the cost involved and (3) the turn-around time it will take to obtain results (which could be two to three months). Unfortunately, companies are now desperate to secure a place in the market and are therefore looking for laboratory approval letters stating that

products that passed EN 1276 and/or EN 13697 can be used to combat COVID-19. Although it might be possible that the specific compound is viricidal as well as bactericidal and fungicidal, it cannot be assumed without proof. There is little to no literature concretely stating that bacteria (or a specific bacterium) can be used as a model to simulate viruses. Due to the vast differences between bacteria, fungi and viruses (as explained above), there is no evidence that a chemical compound will have a similar mode of action against all microbes.

What do we do now?

Given the current situation, there is an obvious need to disinfect and sanitize in order to keep the COVID-19 at bay and ensure the safety of our people, especially in the workplace. Companies are encouraged to use chemical products to disinfect surfaces and have hand sanitizers available. What do we do then, when we are not in the position to have these compounds tested locally for efficacy against viruses (let alone this specific Corona virus)? One suggestion would be to use products that are already EPA or NCRS approved for viricidal activity and clearly states this on the label/instruction sheet (there should be proof of such claims available on request). The other would be to take the longer, yet ethical route, to get your chemical products tested for viricidal activity. Let us remain rational and ethical as we strive to keep our employees and all South Africans safe.

Disclaimer

The content of this document is the **opinion** of SMT LABS. The images of the structure of bacteria, yeast and a virus do not belong to SMT LABS and has been fully referenced under each image.