How microbiology knowledge improves our well-being

Why am I happier after having a tasty meal?

Image provided by Ariel Benz

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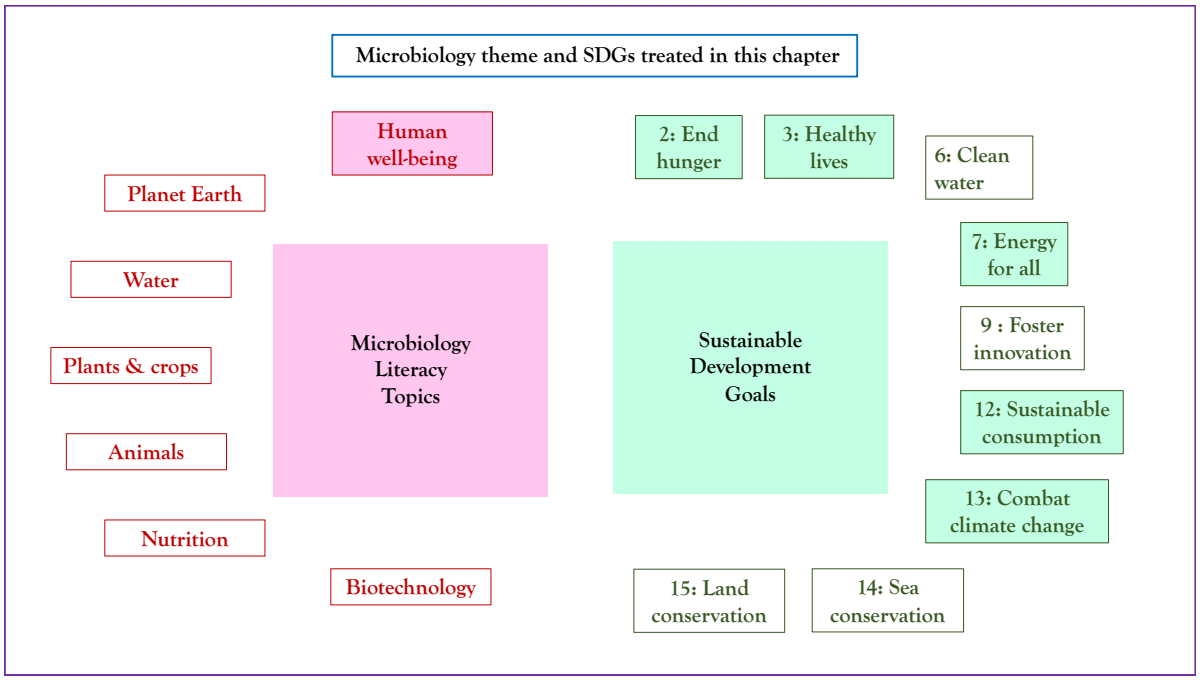
Storyline

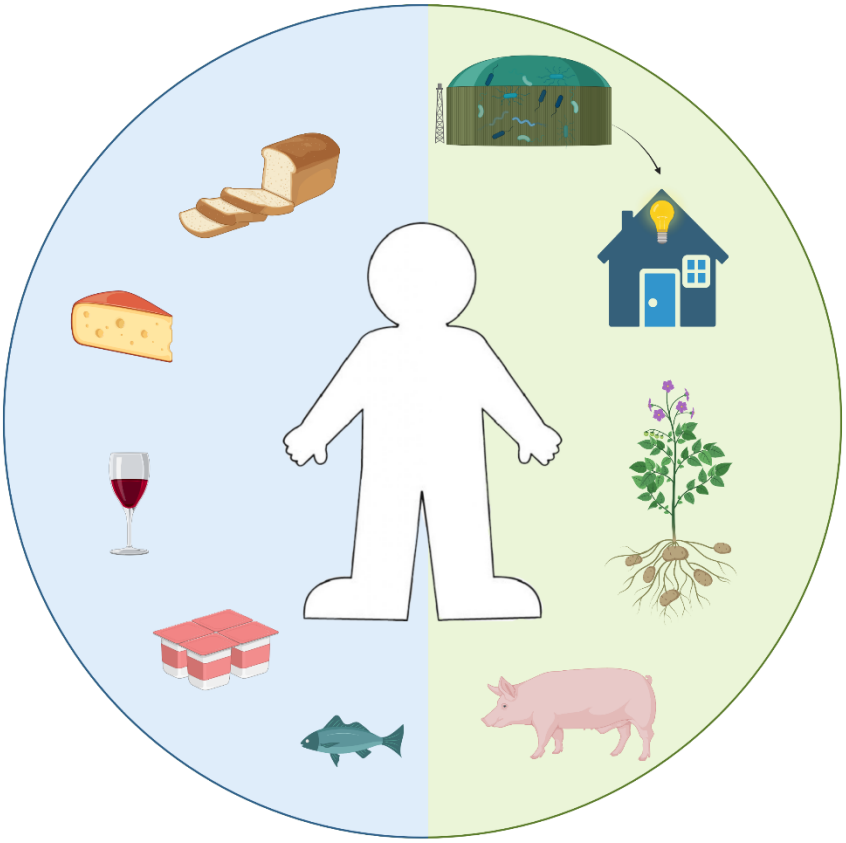
The term "well-being" generally means the state of being happy, healthy, or prosperous. Well-being is also a state of positive feelings and meeting your full potential in the world. Therefore, the concept of well-being surpasses the individual and also includes connections to the community and the environment. Because some microbes cause disease, we may initially connect them as being harmful. However, there are many more interactions we have with microbes that instead contribute positively to our well-being. From the time we wake up to the time we go to sleep again, microbes are deeply connected to our daily activities and the people and places around us. For many, the start of the day includes taking a shower, eating breakfast, putting on a clean outfit, and brushing our teeth. We then go about our activities, such as attending school or working at a job. Later on, we may continue the day doing hobbies, extra-curricular events, and socializing. At the end of the day, we will need to wash and clean up, all before going to sleep again. Although we don't tend to think about it, microbes are connected to all of these actions. Microbes in your digestive tract help with regularity when using the bathroom. You wash your hands with soap and water, changing the microbial communities your skin and hopefully removing unwanted pathogens. We are exposed to microbes at school and at our jobs and other activities. Rain causes pleasant odors made from microbes in the soil. Bad odors from rotting food or unsanitary environments similarly come from microbes. From changing clothes to avoiding microbially-caused smells, to affecting the tastes of the foods we eat, and influencing the types of fuels used to run cars, microbes are integral to our well-being.

The Microbiology and Societal Context



The microbiology: human well-being. *Sustainable development:* end hunger, healthy lives, energy for all, sustainable consumption, and combat climate change.

How microbiology knowledge improves our well-being: the Microbiology



Microbes are integral in our everyday lives. They contribute to well-being by directly helping regulate body processes and indirectly by creating foods we enjoy, contributing to energy security, and so much more.

1. Microbes are necessary for good health. Everyone will have had a "stomach bug" sometime in their lives. This is just one example of the myriad of ways microbes can make people and animals sick. Until the past 100 years, infectious disease was the top cause of death. Because of the discovery of antibiotics, the development of vaccines, and the use of governmental efforts to improve sanitation, infectious diseases have become less prominent in many places around the world. Yet, the lasting impact of pathogenic microbes on our well-being is still evident based on our very recent experiences during the SARS-CoV-2 pandemic.

On the other hand, trillions of friendly, or non-harmful, commensal microorganisms are found all over our bodies, including our skin, mouth, digestive tract, and nostrils. These microorganisms are so numerous that, if we add up their genetic contents, we are only 1%

human. Most of these microbes live in our large intestine, where they help to digest our food. The friendly microbes on our bodies serve as a shield to protect against unwanted potentially harmful microbes. New studies have also shown how our gut microbes contribute to our moods and behaviors.

2. ***Environmental microbes may help our immune system.*** Although improved sanitation has prevented rampant spread of infectious diseases, the friendly microbes can also be eliminated. It has been suggested that the dramatic rise in immunity-related diseases (for example, eczema and allergy) over the past 50 years is due to an absence of exposures to non-harmful microbes. The rise in contemporary chronic conditions like metabolic syndrome is also deeply intertwined with the loss of being around friendly microbes. Exposures to non-harmful microbes in the air, from pets, soil and dirt, and plants may stimulate our immune systems to recognize friend vs foe. This is a good case for the use of well-studied probiotics, or live microorganisms that when applied in sufficient amounts, confer health benefits. Probiotics have been investigated in thousands of human studies and shown to be efficacious in supporting gut health.

3. ***Microbes make good tasting foods we depend on.*** While microorganisms are frequently infamous for their capacity to cause foodborne illness or food spoilage, there also lies a significant beneficial role for them in foods as well. Our day may start with a bowl of yogurt or a drink of coffee and end with a tasty dinner with a cheese and pepperoni pizza and a chocolate brownie for dessert. Yogurt, coffee, pizza crust, cheese, pepperoni, and chocolate are all fermented foods. Fermented foods are foods and beverages made as a result of desired microbial growth and enzymatic conversion of food components. Foods like these have been prepared by hunter-gatherer societies, long before the development of settlements and cities. Fermented foods and beverages possess many desirable qualities including improved nutrition and reduced spoilage and safety risk. They are also some of the most beloved foods in our diets and eating them gives us a sense of happiness and well-being.

4. ***Microbes are needed for plants and crops.*** Our understanding of the importance of soil microorganisms for human and animal well-being developed long before microbes were first seen under a microscope. This is evident from ancient crop rotation methods practiced over the millennia which allowed the soil, and microbes it contains, to suppress plant pathogens. Today, many of our common food crops would not be as healthy without their microbial partners. For instance, legumes require nitrogen-fixing bacteria that make nitrogen available for plant growth. The bacteria in return live in nodules on the roots, a secure place which has nutrients they need to survive. Other microbes are also being applied to soils they reduce the risk for plant diseases. Microbes like *Agrobacterium* are also useful for improving crop breeding to yield more productive and climate tolerant crops.

5. ***Microbes contribute to energy security.*** Sustainable fuel sources create more energy security. This security is important for supporting our general well-being and alleviating or preventing the damaging effects of fossil fuels on the environment and planet. Despite their small size, microbes have a role in energy production. Microbes can produce biofuels by converting organic matter in plants to ethanol, a renewable fuel source. Microbes can also be used to turn

food waste into a biogas like methane in a process called anaerobic digestion. Biogas can be used in place of natural gas, a non-renewable gas, to heat homes. Other microbes can generate electricity in their cells to produce energy, thereby allowing them to serve as mini-motors. Applying these microbes is an important step towards transitioning to more sustainable fuel sources.

6. Animals and human well-being. Animals are essential for the health of the planet and human well-being. Just like people, animals, both on land and sea, require microbes to survive. This is even true for insects. It was shown that microbes influence insect behavior in order to protect the insects from potential threats such as predators or harmful environmental conditions. The same is true for coral in the ocean. Microbes develop symbiotic relationships with corals providing them with nutrients like oxygen, nitrogen, and carbon. Microbes are also important for farm animals like pigs, chickens, and cows. By providing adequate conditions for farm animals to develop a robust gut microbiome in early life, fewer antibiotics would be needed and this would help mitigate the spread of antimicrobial resistance.

Relevance for Sustainable Development Goals and Grand Challenges

- **Goal 2. Zero Hunger:** To achieve zero hunger with our growing population, advances in agricultural technologies and progress in sustainable agriculture will be necessary. Plant-microbe partnerships, soil microbes, and other microbe-based technologies will be crucial in setting up the infrastructure for these advancements.
- **Goal 3: Good Health & Well-being**: Microbes contribute directly to good health and wellbeing both directly through the regulation of the human body, and indirectly by providing necessities such as food and energy that contribute to well-being and comfort.
- **Goal 7: Affordable and Clean Energy:** Microbes assist in clean energy goals by playing an important role in the production of biofuels. This alternative fuel source contributes to energy security by providing a more sustainable alternative to petroleum.
- **Goal 12. Responsible Consumption and Production:** Fermentation is a relatively low-energy way of processing foods. Additionally, fermentation as a means of food preservation could help with limiting food waste due to spoilage.
- **Goal 13: Climate Action**: Microbes directly impact primary productivity and contribute to carbon cycling in the environment. Thus, any activity that impacts microbial populations can significantly impact carbon in our atmosphere and effect climate change. Many scientists are working towards harnessing the power of these microbes to sequester and/or modulate carbon in our atmosphere as a means for climate action.

Potential implications for decisions

1. Individual.

a. Easy to apply decisions for well-being. This framework helps us to understand microbes as important to our mental and physical well-being. With this known, people will be able to choose habits that promote well-being. In the long run, this will positively impact the health of individuals.

2. Community policies.

a. Communities that foster discussions around the importance of microbes for human well-being can lead to the use of practices that support hygiene, food, and environmental practices that are good for the planet.

b. Promotion of well-being can be a focus of community organizing. Well-being takes people and their environment into account. By encouraging well-being, the benefits of microorganisms to supporting positive outcomes can be understood.

3. National policies.

a. Countries develop policies on advertising of products which promote or hurt well-being.

a. Economic incentives created by national governments can lead to programs that promote well-being through health and environmental stewardship.

b. Legislators are responsible for creating laws that protect the public from harmful substances, including antimicrobials which damage human and animal health and the environment.

Pupil participation

1. Class discussion

a. Ask students to make a list with what they do on a typical day, including details like washing their face and cleaning up after dinner. Next to each activity, the students should write down how they think microbes are related to the activities. The class can then discuss which activities are directly impacted by microbes.

2. Exercises

a. Hygiene hypothesis activity. Have the students write a story or draw a picture describing what happens when friendly microbes are present. This story can focus on human health, food production, or the environment. Discuss how the situation would be different if the friendly microbes are removed or damaged.

The Evidence Base, Further Reading and Teaching Aids

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