Putting microbes to work

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Microbial activities can be harnessed for our benefit in a huge variety of ways. Kristien Mortelmans provides an overview which serves as an introduction to the theme of this issue of *Microbiology Today*.

This issue of *Microbiology Today* with its special features on 'Putting microbes to work' is a tribute to microbial diversity, the adaptability of microbes and the ingenuity of (micro)biologists.

It is believed that all of planet earth was anaerobic about 3 billion years ago. The first microbial forms of life that emerged at that time must have been anaerobic. They must have relied on anaerobic respiration for energy production with terminal electron acceptors such as nitrate, sulphate, sulphur, carbon dioxide and fumarate. With the emergence of photosynthetic blue-green algae and cyanobacteria (and later plants) molecular oxygen (O_2) gradually accumulated in the environment, O_2 being a by-product of photosynthesis. One can actually consider O_2 to be an early environmental pollutant that changed planet earth's atmosphere from a reduced form to an oxidized form. It is well known that O_2 is highly reactive, which made it a prime candidate for becoming the most efficient terminal electron acceptor. One can therefore speculate that some of the early anaerobic life forms must have eagerly accepted O_2 because of the higher energy yield (ATP) obtained per substrate in aerobic respiration compared with anaerobic respiration.

The different types of respiration must have contributed to the ability of microbes to colonize and populate diverse regions of the globe. In addition, some microbes, referred to as extremophiles, have adapted to live in harsh and extreme environments such as:

- the bottom of the ocean (depth of 10,000 m and pressures up to 1,035 atm)
- hot springs (temperature close to boiling)
- Arctic and Antarctic zones (temperature at or near freezing)
- salt and soda lakes (30 % sodium concentration)

Microbes have also adapted to live in close association with humans; this association is fortunately mostly harmonious. Indeed, more than 300 different microbial species, the majority being anaerobes, populate the human oral cavity and the human gut where they play, amongst other things, a protective role against invading microbes. In addition, our gut flora tirelessly work day in and day out to help digest our food and provide us with much needed nutrients. Unlike in humans, the gut of termites is colonized by cellulase-producing microbes that degrade cellulose to soluble sugars much needed by their host. This is a beautiful illustration of natural symbiosis: the termites, eat wood which they cannot digest (just like humans), but they have found the perfect working partner to do it for them. In return, the host provides a protective environment for the microbes to live in and thrive. This symbiosis between termites and anaerobes is, however, unfortunate for anyone living in houses built of wood!

Considering the diversity of the microbial world and the adaptability of microbes, it should come as no surprise that, since ancient times, microbes have been put to work by mankind to serve mankind. What comes to mind immediately are consumer products, such as wine, beer, cheese and fermented foods. What is so remarkable is that for a long time empirical means were used to exploit microbial activities. This in itself is a tribute to the experimentalists who made it an 'art', establishing and maintaining the optimum (growth) conditions for these microbes to do their work. It is also a tribute to the microbes in that they behaved as great team players in complete anonymity.

These days (micro)biologists are putting microbes to work usually with knowledge about the genus and species. In addition, it is now possible to genetically engineer desirable traits. The emergence of the '-omics' revolution, i.e. genomics and proteomics, as well as bioinformatics, will offer researchers additional tools to extend the arsenal of microbial products or processes, the listing of which is beyond the scope of any review article or even a book. However, in broad terms microbes today are put to work in fields as diverse as:

- the environment (e.g. bioremediation, horticulture, agriculture, oil drilling)
- medicine (e.g. antibiotics, insulin)
- food (e.g. food flavours and emulsifiers)
- energy production (e.g. ethanol, methane, hydrogen)
- solvent production (e.g. acetone, butanol)

The articles that follow are just a few concrete examples of how microbes are used to our benefit.

As a final note, no matter what tools are available to 'put microbes to work' it would be prudent for any researcher to abide by the following five laws of applied microbiology established by the late Dr D. Perlman:

- the micro-organism is always right, your friend and a sensitive partner
- there are no stupid micro-organisms
- micro-organisms can and will do anything
- micro-organisms are smarter, wiser and more energetic than chemists, engineers, etc.
- if you take care of your (microbial) friends they will take care of your future (and you will live happily ever after!)

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