Microbiology
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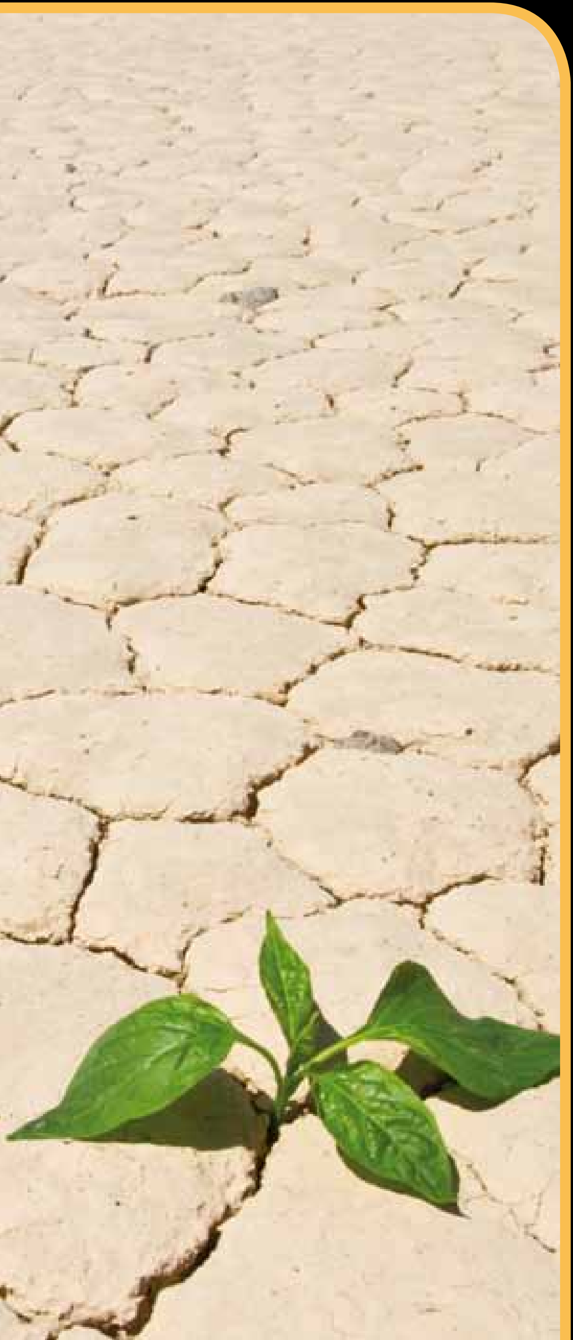
# Microbes and Climate Change



While humankind has only relatively recently started to alter the composition of the atmosphere and the energy balance of the planet, micro-organisms have been dictating global climate for billions of years.

Microbes play an important role as both users and producers of greenhouse gases. Both natural and human-induced fluxes of carbon dioxide, methane and nitrous oxide are dominated by microbiology.

> *The role of microbes in climate change cannot be ignored.*

# Gas cycling

Micro-organisms play a crucial role in the carbon and nitrogen cycles.

## Carbon

Photosynthetic algae and cyanobacteria draw carbon from the atmosphere, while decomposing fungi and soil bacteria break down organic matter and release carbon dioxide back into the atmosphere.

The respiration of all micro-organisms also contributes hugely to carbon dioxide emissions.

***The balance between primary production, respiration and decomposition by microbes results in the uptake of around 120 billion tonnes of carbon, and the loss of about 119 billion tonnes of carbon each year.***

Fungi growing on decomposing wood. *Michael P. Gadomski / SPL*

## Nitrogen

Nitrogen-fixing bacteria convert nitrogen in the atmosphere into biological nitrogen that can be used by plants.

Denitrifying bacteria break down nitrates in the soil and release nitrogen back into the atmosphere in the form of nitrogen gas and nitrous oxide.

Nitrous oxide is 300 times more effective at absorbing heat than carbon dioxide.

***For every tonne of reactive nitrogen that human activities add to the biosphere, between 10 and 50 kg end up being emitted into the atmosphere as nitrous oxide by denitrifying bacteria.***

*“‘Out of sight, out of mind’: the very fact that we cannot see micro-organisms and their products can make us ignorant of where and how important they are.”*

Nitrogen-fixing bacterium *Nitrosospira*. *Dr Kari Lounatmaa / SPL*

**Blue-green algae.** *Sinclair Stammers / SPL*

> *“Microbes will continue as climate engineers long after humans have burned that final barrel of oil. Whether they help us to avoid dangerous climate change in the 21st century or push us even faster towards it is dependent on just how well we understand them.”*

## Methane

Micro-organisms called methanogens produce 75% of natural sources of methane in the atmosphere. These microbes live primarily in wetlands, the guts of termites and ruminants and the oceans.

Human activity is increasing the amount of methane released by microbes; landfill sites, rice paddies and guts of ruminants provide ideal environments for methanogens, adding 150 million tonnes of methane to the atmosphere annually.

Methane has 23 times the global warming potential of carbon dioxide over 100 years.

> ***Around 20% of global methane production is from ruminants.***

**Rice paddy field.** *Digital Vision*

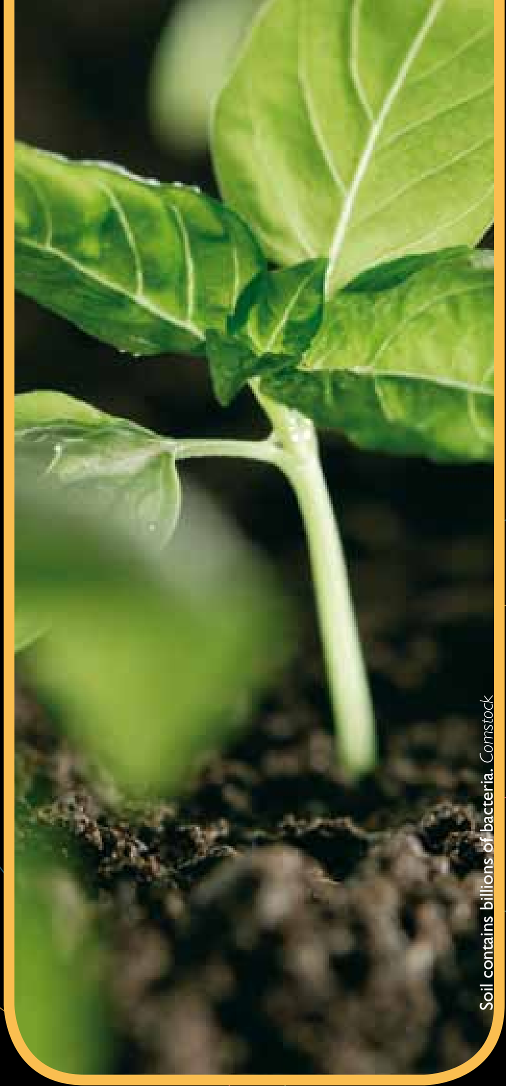
# Soil microbiology

Soil is not sterile. One single teaspoon of soil contains 1 billion bacteria, 120,000 fungi and 25,000 algae. Many of these microbes play a key role in cycling carbon and nitrogen.

Frequent use of fertilizers and increased growth of nitrogen-fixing crops in agriculture has resulted in higher soil concentrations of nitrogen-containing compounds. This has led to an increase in the growth and activity of nitrogen-cycling microbes.

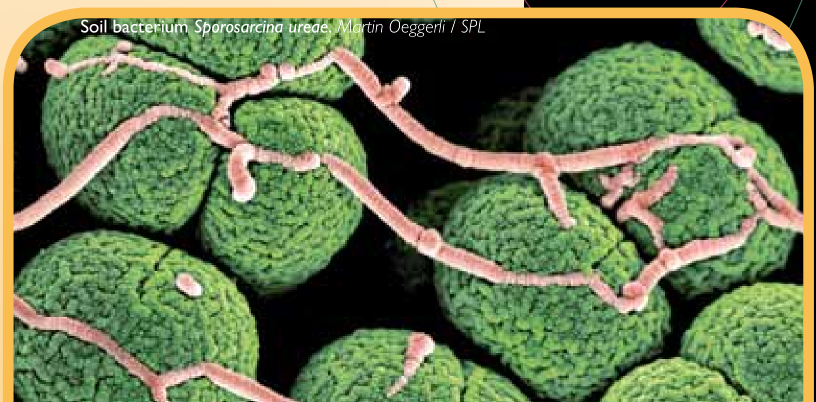
Microbial decomposers such as soil bacteria and fungi release carbon dioxide back into the atmosphere when they break down organic material. It is likely that their activity will speed up with increasing temperatures.

> *Soil respiration and carbon dioxide release have been shown to double with every 5–10°C increase in temperature, setting up a positive feedback loop – or vicious circle*



Soil contains billions of bacteria. *Comstock*

> *“We now know with some certainty ‘who’ is there in the surface ocean. The challenge is now to understand ‘who’ does ‘what’ and if this will alter at this time of rapid climate change.”*



Soil bacterium *Sporosarcina ureae. Martin Oeggerli / SPL*

# Microbial activity in the oceans

Marine microbes play a fundamental role in recycling nutrients and in the production of biogases that influence the atmosphere.

The number of microbial cells in the oceans is estimated to be one million times greater than the number of stars in the universe.

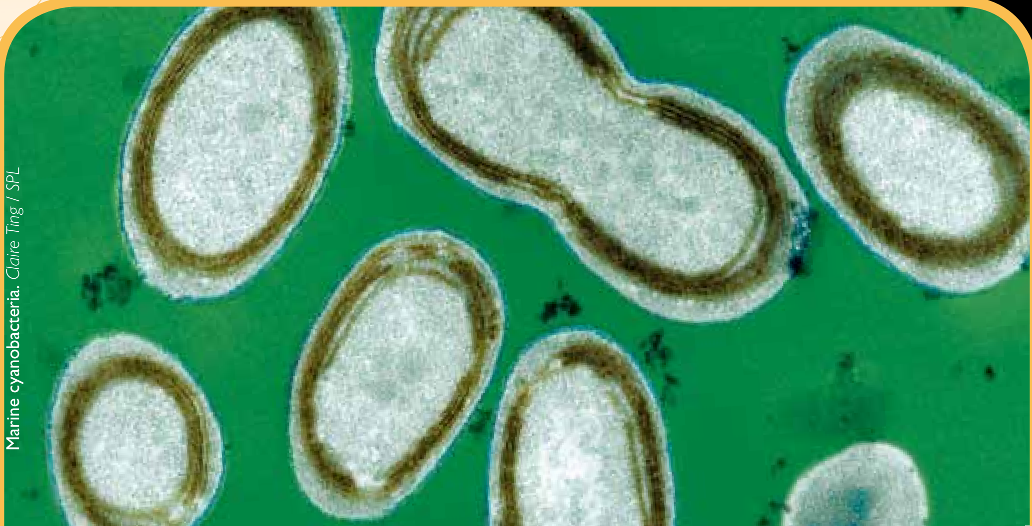
The majority of global carbon fixation is carried out by photosynthesizing marine microbes such as cyanobacteria and algae. These micro-organisms draw down 90 billion tonnes of atmospheric carbon annually. Microbial decomposition and respiration return much of this to the atmosphere.

At least half of the oxygen produced by photosynthesis each year is by marine micro-organisms.

Increasing levels of atmospheric carbon dioxide are causing oceans to become more acidic. Higher ocean acidity combined with warmer temperatures may have consequences for marine microbial populations. The impact on the complex feedback between the ocean and the atmosphere must be investigated further.

*Marine microbes are responsible for reabsorbing 30% of the carbon released from burning fossil fuels.*

“*Recent developments in DNA sequencing technologies mean that marine microbiologists are making very rapid progress in understanding this complex ecosystem.*”



**Marine cyanobacteria.** *Claire Ting / SPL*

# Microbes and health

The threat that climate change poses to the health of humans, other animals and plants cannot be ignored.

Higher rainfall and rising sea levels may lead to flooding, which increases the risk of water-borne diseases such as cholera.

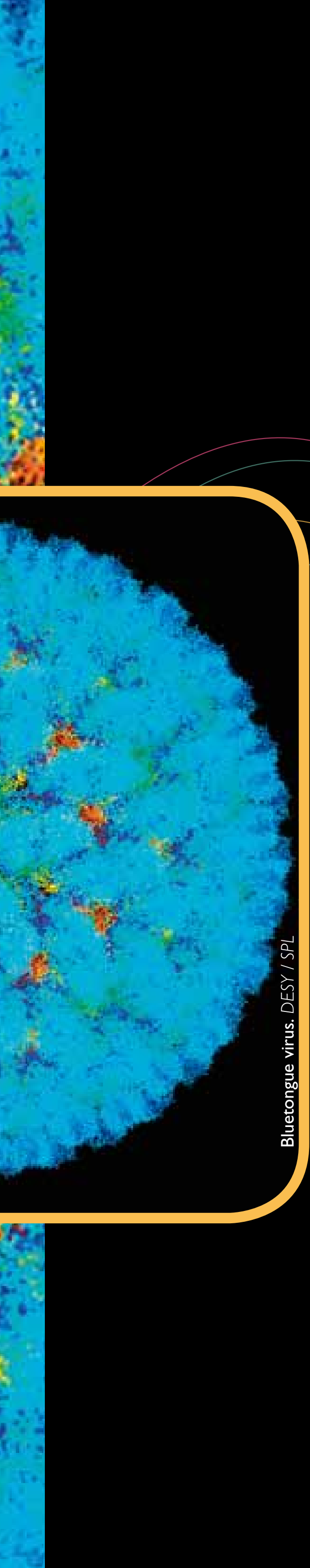
Lack of fresh water already affects 25% of the global population and is likely to get worse. This will compromise hygiene and health, leading to an increase in illnesses such as trachoma (that can cause blindness) and diarrhoea.

Certain disease vectors, including mosquitoes, thrive in floodwaters. Higher temperatures increase the rate of reproduction of these vectors, the frequency of bites and the length of their breeding season. These combined factors may increase the risk of malarial transmission.

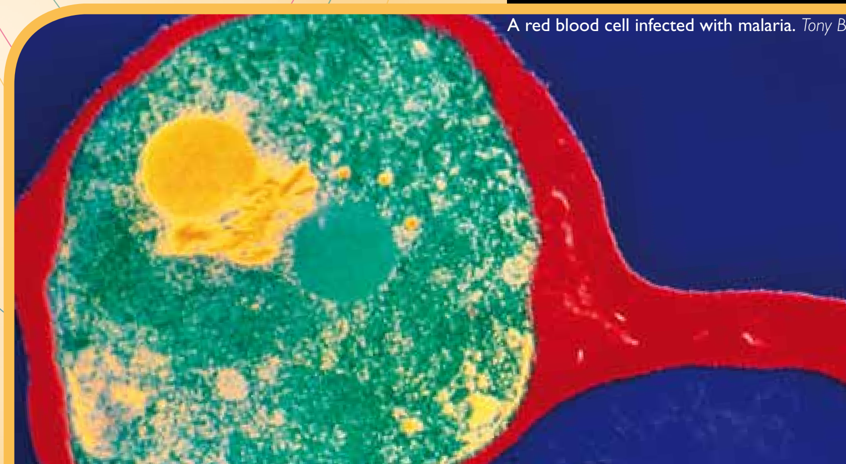
Bluetongue virus (BTV) is carried by a midge and causes bluetongue disease in domestic and wild ruminants, including sheep and cattle. Since the 1990s BTV has been spreading north, with the first outbreak in the UK in 1997. Some experts believe that global warming has caused an increase in the midge populations responsible for spreading the disease.

*Since 1998, BTV has spread 800 km further north across 12 European countries.*

Little work has been done to predict the effects of climate change on plant disease epidemics. If crops are affected this could have a major impact on food security.



Bluetongue virus. *DESY / SPL*



A red blood cell infected with malaria. *Tony B*

Tick feeding on human blood. *Eye of Science / SPL*

*rain / SPL*

## Microbial management as a tool for climate control?

- More carbon dioxide could be sequestered from the atmosphere by inducing increased photosynthesis in the oceans by adding iron or reactive nitrogen.
- Microbially produced methane could be liberated from reservoirs in a controlled way using underwater membranes, then piped and used to produce electricity.
- Methane emissions from ruminants could be reduced through the use of food additives or vaccines.
- Encouraging growth of sulfur-eating bacteria in areas such as rice paddies could allow these species to outcompete methanogens, thus reducing methane production.
- Biofuels could be efficiently produced through the microbial breakdown of waste products from agriculture and other human activities.
- Microbes could be engineered to produce high yields of clean fuels such as hydrogen.

A healthy environment. *Hemera*

# Society for General Microbiology

The Society for General Microbiology (SGM) is a professional body for scientists who work in all areas of microbiology. It is the largest microbiology society in Europe, and has over 5,000 members worldwide. The Society provides a common meeting ground for scientists working in research and in fields with applications in microbiology including medicine, veterinary medicine, pharmaceuticals, industry, agriculture, food, the environment and education.

An important function of the Society is promoting the understanding of microbiology to key stakeholders including members of Parliament and the House of Lords.

To be put in touch with SGM experts or to request copies of written resources, please send your enquiry to the address below.

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*Background – Hemera*

Struggling to survive in a parched land. *iStockphoto*

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