Phytoplankton are now shown to be able to make use of extremely low levels of sunlight.

Researchers have discovered how algae that survive in very low levels of light are able to switch on and off a quantum chemical energy-saving phenomenon during photosynthesis.

It is thought it helps them harvest energy from the sun much more efficiently allowing them to live in regions otherwise believed to be too dark to support plant life. The discovery is likely to vastly expand the photosynthetic environment in the world’s oceans. Life seems to always finds a way. The research is published in the journal Proceedings of the National Academy of Sciences.

The work is part of an emerging field called quantum biology, in which evidence is growing that quantum phenomena are commonly operating in nature, not just the laboratory. Another observation is that it may explain how birds can navigate using the earth’s magnetic field.
“Once an algal cell has received sunlight, it needs to get the trapped energy in the light to the reaction centre in the cell as quickly and efficiently as possible. There the energy is converted via photosynthesis into chemical energy for the organism.

“It was assumed the energy gets to the reaction centre in a random fashion, like a drunk staggering home. But quantum coherence character of the cell allows the it to pre-test every possible pathway simultaneously before sending the light via the most efficient route.”

“We studied tiny single-celled algae called cryptophytes that thrive in the bottom of pools of water, or under thick ice, where very little light reaches them,” says senior author, Professor Paul Curmi, of the UNSW School of Physics.

Cryptophyte Light Capturing Molecule

“Most cryptophytes have a light-harvesting system where quantum coherence is present. But we have also found a class of cryptophytes where it is switched off because of a genetic mutation that alters the shape of a light-harvesting protein.

“The assumption is that this increases the efficiency of photosynthesis, allowing algae and bacteria to exist on almost no light,” says Professor Curmi.

In the new study, the team used x-ray crystallography to work out the crystal structure of the light-harvesting complexes from three different species of cryptophytes. They found that in two species a genetic mutation has led to the insertion of an extra amino acid that changes the structure of the protein complex, disrupting coherence.

“This shows cryptophytes have evolved an elegant but powerful genetic switch to control coherence and change the mechanisms used for light harvesting,” says Professor Curmi.

The next step will be to compare the biology of different cryptophytes, such as whether they inhabit different environmental niches, to work out whether the quantum coherence effect is assisting their survival. Understanding the mechanism may even help in the design of more efficient solar power cells.

Editors note: The authors obviously have not considered the other key factor that limits plankton photosynthesis, that is iron. Iron when in sufficient availability facilitates a dramatic improvement in plankton photosynthesis, when in short supply plankton switch into a ‘low gear’ or even
become dormant. This quantum coherence mechanism effectively allows more efficient photosynthesis using a pathway separate from the iron abundant path and it seems likely it might be used to sustain plankton during times of low iron ‘dust drought’.

The research was led by UNSW’s Dr Stephen Harrop and Dr Krystyna Wilk, and includes researchers from the University of Toronto, the University of Padua, the University of British Columbia, the University of Cologne and Macquarie University.