Biology: uniformity and diversity

Phytoplankton in the sea

Narrator:
Paul Tett is an ecologist who uses models from physics to shed light on the behaviour of oceanic plankton.

Prof. Paul Tett, Napier University, Edinburgh
Understanding about the very small requires us to understand first of all the biology of the organisms. But also something about the physical nature of the environment, in which they find themselves because we're dealing with a very different world at the level of the very small.

The creatures that I am studying are called 'Plankton'. And in particular the plant members of the plankton. The floating microscopic plants called 'phytoplankton'. And you can see some of them here. These little plants are really microscopic single cells. Each of them has some green chlorophyll and some red pigment. These colours are distinctive of different types of phytoplanktonic algae. So you would expect to find different coloured phytoplankton at different depths in the sea, depending on the colours of the light that reaches them. They need light because they're plants, and they need light to grow. But in addition, they need things that I call 'nutrients'. Mineral nutrients. And these are sorts of phosphate and nitrate. The sort of thing that you'd find if you used grow more fertiliser in the garden.

The problem with phytoplankton is that they can very rarely get light and nutrients at the same time because light is at the surface of the sea and the nutrients are found deep down, where organic matter decays in this cold water at the bottom of the sea.

Narrator
Being small does bring its compensations.

Paul Tett
The advantages of being small for phytoplankton is that it helps them to get nutrients and it helps them to stay in the light. It helps them to get nutrients, because a small creature has got a high ratio of surface area to volume. And it's the surface that governs the rate in which nutrient can be taken up. It helps them to get light because small creatures sink very slowly in seawater and therefore they can stay close to the surface of the sea and the surface of the sea is where light is.

Narrator
These cultured phytoplankton are kept in the lab. They get optimal lighting and the ideal balance of nutrients.

The sea is the dominant force in the life of the plankton. Their movement is dictated by motions of the water around them.

Paul has modelled the forces that plankton experience. These vary from the smallest to the largest scale.

PT:
Plankton are carried around the ocean basins by currents. One of the characteristic features of currents is that they form eddies. Their motions become irregular and I can demonstrate that by pouring a little cream into my coffee cup. So first of all I'll stir the coffee round, to simulate the motion of water around the north Atlantic. And then I'll add the cream. And there it is forming swirls. And that is a characteristic of the largest scale of motion in the sea.

On the smallest scale the behaviour of water is dominated by the attraction between all the water molecules. This is called ‘viscosity’. It makes the water very sticky, to small animals. It’s as if they’re living in honey rather than water. A consequence of the high viscosity at small scales is that microorganisms find it very difficult to get hold of particles in the water. As perhaps will become apparent when I’ve buttered my toast and put some honey on it.

Oh dear, as is often the case. I’ve left a little smear of butter in the honey. So I’ve got to get that out. But it doesn’t really want to come does it. Let’s try again. So for small organisms, it’s as if they’re wrapped in a jelly like coat of this thick and viscous liquid. It’s very hard to them to come into contact with other organisms or with their food.

This is glycerine, a liquid which is much more viscous and water and I’m using it to demonstrate the properties of water on the scale of small organisms. Now what is remarkable about what I’ll demonstrate is that I can reverse the effects of stirring in this liquid. You can’t do that with water. When you stirred your sugar into your teacup, you can’t reassemble the sugar cube afterwards. So let’s make this demonstration. Beginning by adding a few drops of this green glycerine. Now I’m going to stir these drops. So as I go round the drops elongate. But when I come back, they return amazingly enough to the original round shapes. There are strong implications of this for locomotion. Movement is completely reversible. The forward stroke which drives the organism forward is reversed by the backward stroke which sucks the organism backwards so these little creatures can’t swim by moving their fejelly up and down, or forwards and backwards. Instead they have to use a corkscrew like motion.