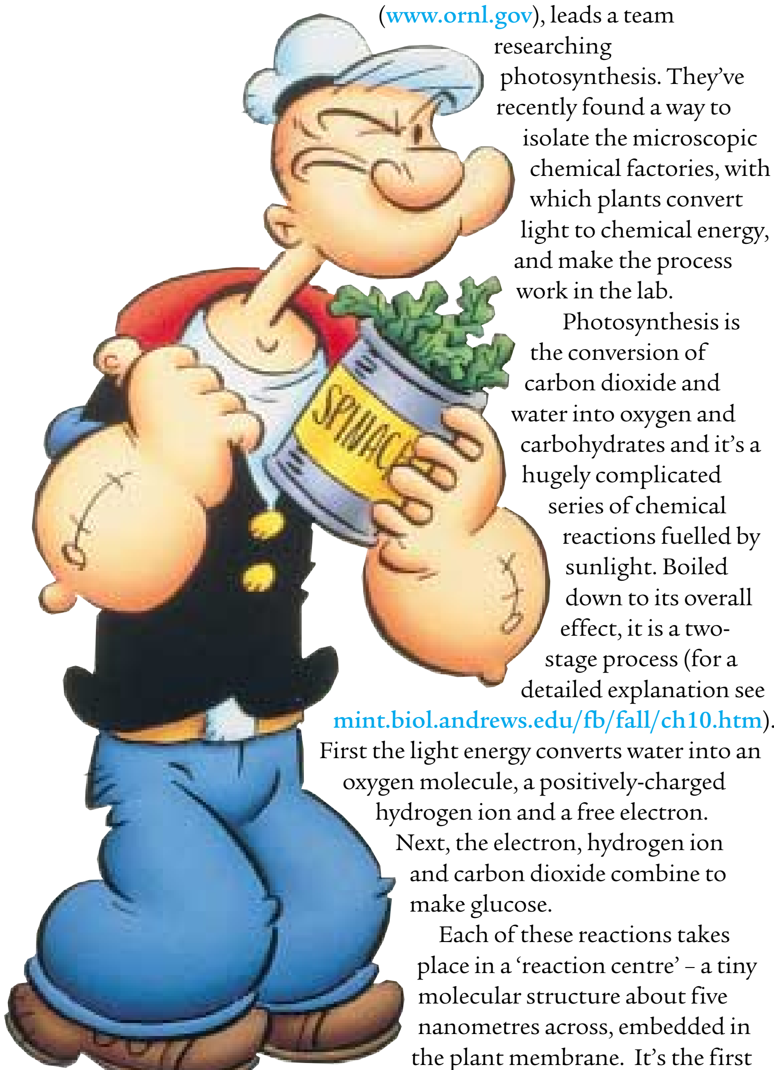
THE MINUTE MANUFACTURING PROCESSES OF PHOTOSYNTHESIS COULD POWER PCS.

Popeye computers

THIS MAY BE HARD TO SWALLOW, but researchers have found a new use for spinach – building computers.

No, it's not April Fool's Day. Elias Greenbaum, of the Energy and Environmental Biotechnology Research Group at Oak Ridge National Laboratory in Tennessee (www.ornl.gov), leads a team researching photosynthesis. They've recently found a way to isolate the microscopic chemical factories, with which plants convert light to chemical energy, and make the process work in the lab.



PHOTOGRAPH MOVIESTORE COLLECTION

Photosynthesis is the conversion of carbon dioxide and water into oxygen and carbohydrates and it's a hugely complicated series of chemical reactions fuelled by sunlight. Boiled down to its overall effect, it is a two-stage process (for a detailed explanation see mint.biol.andrews.edu/fb/fall/ch10.htm). First the light energy converts water into an oxygen molecule, a positively-charged hydrogen ion and a free electron. Next, the electron, hydrogen ion and carbon dioxide combine to make glucose.

Each of these reactions takes place in a 'reaction centre' – a tiny molecular structure about five nanometres across, embedded in the plant membrane. It's the first reaction centre – known as photosystem-1, in which the electron is liberated – that's of particular interest to Greenbaum's group.

In photosystem-1, two chlorophyll molecules are held inside a protein scaffold. When an incoming photon excites the system, a single electron is ejected from the chlorophyll molecules. The electron is then passed along by several other molecules, which ensure it can't immediately fall back into the now positively-charged chlorophyll. Finally, it exits the reaction centre, en route to take part in the second phase of the photosynthesis.

What Greenbaum has done is to find a way to isolate the photosystem-1 reaction centres from a plant. He uses spinach because it's so commonplace and has a long history of use in photosynthesis research. Getting the reaction centres out is no mean feat – the raw spinach is washed and liquidised, then rinsed with detergent and the reaction centres are separated using a centrifuge. Then they're deposited in a thin layer on a gold-plated substrate.

As for using photosystem-1 as a computer component, the key realisation was that each reaction centre behaves like a diode – it passes current in one direction, but not in the other. What makes these 'diodes' attractive for researchers is that they're 25 times smaller than conventional silicon diodes and operate faster.

And once you have a diode, you have the basics for constructing logic gates, the building blocks of computer processors. Greenbaum hopes that his group's research will lead to logic-packing densities as great as 1,000 times that of a Pentium chip. The biggest challenge is going to be connecting up reaction-centre diodes into functioning circuits. One possibility is to use carbon nanotubes – thin hollow carbon cylinders, just a few atoms in circumference – as connecting wires.

Greenbaum's work also raises the possibility of making a new kind of 'clean' fuel cell. He has developed a patented process for precipitating metallic platinum onto a sheet of deposited reaction centres. The metal catalyses the splitting of water into hydrogen and oxygen molecules. Shine a light on the device and it produces free hydrogen and oxygen, which you can subsequently allow to react and collect the heat. The only waste product is water. At the moment, Greenbaum's work is fundamental research, but he expects practical technology to appear in about five years' time.

Strangely enough, spinach has also recently been in the technology news for something quite different – its ability to neutralise dynamite. It turns out that some of the enzymes in spinach can digest TNT and turn it into carbon dioxide, water and nitrogen.

Oh, and it's good for you too.

TOBY HOWARD