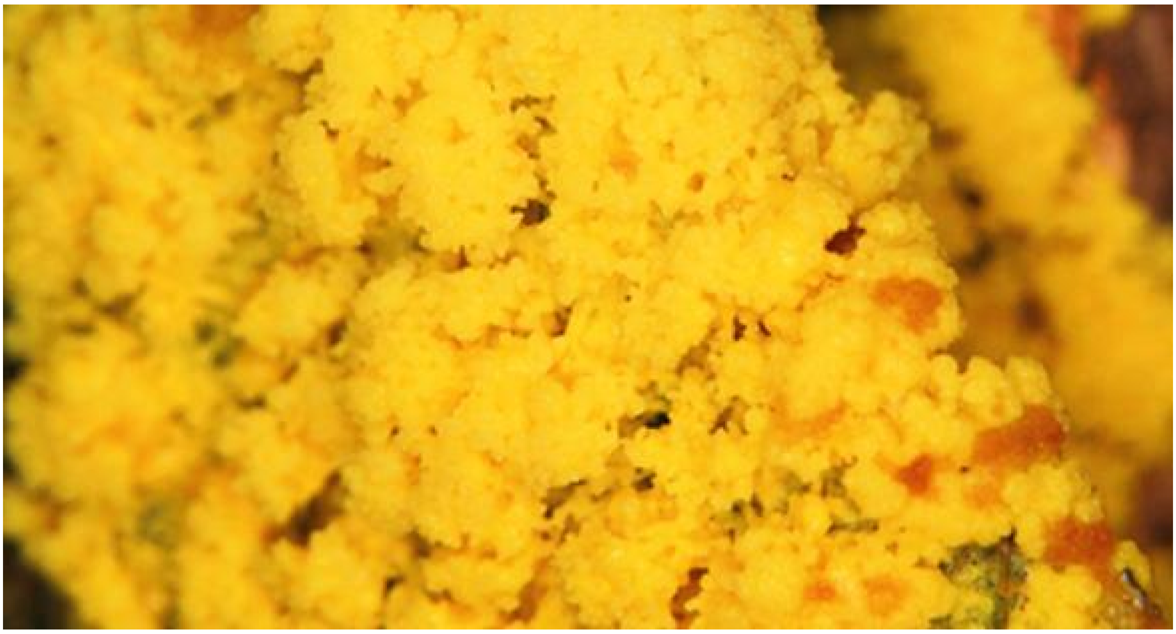

Growing computer chips from slime mould and bacteria

Scientists are developing computing devices built from living organisms such as slime mould and bacteria, in order to harness their problem-solving and programmable properties.

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One organism of interest is the many-headed slime mould, Physarum polycephalum. In its vegetative state, slime mould is one large cell consisting of a mass of protoplasm, the living material found inside the cell wall. It finds food by sending out a series of protoplasmic tubes that act as a transport network for nutrients.

The clever thing is that the slime mould is able to map the optimal route between different pieces of food, such as oat flakes, in order to create the most efficient way of transporting nutrients throughout the organism.

This is important because, while conventional semiconductor computers are extraordinarily efficient at performing repetitive tasks, problems such as optimisation of transport networks do not readily lend themselves to this kind of processing. Slime mould could therefore provide a solution.

'Combined with conventional electronic components in a hybrid chip, Physarum networks could radically improve the performance of digital and analogue circuits,' said Professor Andy Adamatzky, Director of the Unconventional Computing Centre at the University of the West of England in Bristol, UK, who is scientific coordinator of the EU-funded PhyChip project.

This remarkable organism has already been used to navigate through mazes, calculate efficient networks, construct logical gates, and even in robot control.

Inspired by nature, made by nature

The project is working to develop a Physarum chip, which comprises a network of slime mould tubes coated with conductive substances. Inputs could include chemicals, light or electrical signals and the results would be assessed electrically or optically.

In principle, such devices could be hooked up to humans either directly or via interfaces, to become wearable or prosthetic self-growing computing devices that enhance humans' cognitive abilities.

'Growing protoplasmic tubes of slime mould could be used as the architectural skeleton to build bio-electronic circuits, to provide connections between living tissue and computers, such as brain-machine interfaces,' Prof. Adamatzky said. 'Such interfaces might, for instance, allow an amputee to control a prosthetic limb the same way he would control his real limb – with just a thought.'

This video from the PhyChip consortium shows timelapse of Physarum polycephalum growing towards a food source.

Other living organisms whose computing potential scientists are trying to exploit are bacteria. Researchers in the EU-funded PLASWIRES project are using bacteria to try to produce a living computer that runs different genetic programs in parallel.

Currently, genetic engineers are able to reprogramme bacteria such as E. coli to produce different chemicals and molecules, such as proteins, by introducing new genetic programs into their cells. But E. coli will only tolerate a few added genes or small genetic circuits.

To produce more complex biomolecules for diagnostics, the biologists, physicists and computer scientists in the PLASWIRES project aim to hook up many cells as 'processors' running more complex programs.

'We think we could programme a whole bacterial colony to run in parallel different genetic programs,' said Dr Alfonso Rodríguez-Patón, associate professor of computing at the Technical University of Madrid, who is scientific coordinator of PLASWIRES.

That demands control of the communication between cells to get them to work in concert, using small pieces of DNA called plasmids.

'This is what we need to program a bacterial internet, or a living parallel computer, where each bacterium is a live processor executing a genetic program and sharing the results with neighbouring bacteria,' Dr Rodríguez-Patón said. 'In this way, our programmed bacteria colony behaves as a powerful live parallel computer where the plasmids are the wires.'

By mastering this process, the system could potentially diagnose pathogens or the plasmids could even be 'programmed' as antibiotics, where they are able to detect virulent bacteria and trigger a response to kill them.

Bio-hybrid devices

Unconventional computing holds out the prospect of new areas of exploration, partnering the digital world of conventional computing with the analogue systems found in nature.

'Bio-hybrid devices will be the way forward for feasible, unconventional computing in the short-to-near term,' said Professor Martyn Amos, scientific coordinator of the EU-funded TRUCE project, which is supporting and mapping out the state of play and future possibilities for unconventional computing, from quantum devices to PhyChip's slime moulds.

This hybrid approach could be along the lines of co-processors, such as the specialised chips in conventional computers that render graphics.

'We can anticipate maybe in the future having the equivalent in unconventional computing, where you have a slab of slime mould, or a colony of bacteria, or even a quantum chip, which takes over some of the work that can be done better by that device, that communicates with a traditional computer, and they can work in sympathy with one another,' said Prof. Amos, who is based at Manchester Metropolitan University, UK.

While there is great scope for unconventional computing in the coming decades, it is not intended to replace existing technology in the short term, said Prof. Amos. ‘The point is to expand the range of possibilities, in the sense that conventional computers have served us very well, and are good at doing specific things, but they are actually quite dumb.’

More info

PhyChip

TRUCE

PLASWIRES