Ants in space

(Intro)

Ants are awesome! If I don't convince you of this in the next 10 minutes, then do not *ever* listen to another episode of SISS. The next episode might be about why your fingernail clippings are awesome.

Anyway, if you are still listening, here is the case for ants. Ant colonies operate without any central control. Sure, the queen produces the next generation, but it's not like she sends out orders telling the rest of the colony what to do on a daily basis. She does her job – laying eggs – and that's about it. In reality, the daily activities of the colony are entirely leaderless, but at the same time, they are not entirely random.

Theorists suggest that an ant colony is governed by parallelism and a high degree of fault tolerance. If you put a large collection of individuals together and they all end up doing the same thing, that's parallelism. A high degree of fault tolerance means that the success of the colony is never dependent upon the actions of single individuals. After all, in a colony of parallel individuals, one individual just does whatever the individual next to them is doing. So, if a few ants are lost during a wide search for food, well that's no great loss. As long as at least one member of the colony finds food and can bring others to it, the colony survives.

A colony of such parallel, fault-tolerant individuals may give the *appearance* of being organised – and, in some respects, they are organised. In the case of ants there are a number of signals that individual ants are genetically-programmed to respond to. Such a signal might be the scent of a food source. This is not a signal that carries very far, but an ant returning to the nest with a sample of that food source leaves a pheromone trail behind that others can follow and as more ants begin to follow that same path, the pheromone signal becomes amplified by the amount of ant-traffic it is carrying. Pretty soon, there is a whole stream of ants heading that way.

If you introduce a collection of ants to a new environment, individual ants do at first seem to move in random directions, until a definite objective, like a food source, has been established. But here we should stop and question whether the ants ever really just move in random directions. For example, although one ant could never hope to gather sufficient information about a large macro-environment – like a kitchen – a colony of ants can collectively gather all the information they need to know about that macro-environment. And they can do it quickly and efficiently, without the human owner of that kitchen ever realising what is going on.

Faced with the huge expanse of a human kitchen to search, no leader ant whispers 'spread out', the ants' genetic programming seems to make them adopt a wide and non-random search pattern automatically. The totality of information that is captured by the many different ants involved in such a wide search is never drawn together to be contemplated by one individual ant. But when the ants to the south-west find nothing, while the ants to the north find crumbs and the ants to the east find crumbs, the whole swarm of ants ends up heading north-east and finds the cookie that fell under the fridge. This is what is known as *swarm intelligence*.

But, as we often say at about this point in a Science on the ISS episode, what the heck has all this got to do with Science on the ISS? And the answer is – as it often is – *robotics*. For your information, one quarter of all the SISS podcasts that there have ever been – have been about robotics. But this time, it's got nothing to do with the SPHERES program or with Robonaut 2, this episode is about robotics *theory*. There really is a major area of robotics research that is called *ant robotics* – although, it's not really about ants, nor is it about robot ants, it's all about swarm intelligence.

When robotics people watch what ants can do, they start thinking that rather building one big Robbie the Robot, with lots of complex sensors and servomotors, all overseen by a positronic brain that would cost several billion dollars to develop, they could instead just built lots of cheap, matchbox-sized microbots on wheels. A large collection of such microbots could turn out to be just as functionally useful as one big, complex macrobot.

For example, just as a colony of ants can find a cookie under your fridge, with the right swarm intelligence software a collection of cheap, matchbox-size robots on wheels could find a crate of cookies in a warehouse. They could also find other things like a bomb, a dangerous pathogen or even a human survivor trapped in a collapsed building.

The software that you need to operate a microbot swarm is called a distributed algorithm. This algorithm will tell each microbot how to interact with its environment, what to pay attention to, what to ignore, what to communicate to its neighbours and what to listen out for from those neighbours. Most importantly, a distributed algorithm is *scalable* – so that it can coordinate ten microbots, or a hundred or a thousand. Its scalability comes from the fact that the behaviour of a whole collection of individual units is largely determined by local interactions between neighbouring units.

There might be some underlying instructions that tell each individual to search an area using a certain search pattern and to leave a marker if they find something – but overriding all those instructions will be a compulsion for parallelism. So, regardless of what each unit may find in its own search pattern, if it suddenly notices all its neighbours are heading north-east, it will drop everything and head north-east. After all… everything is awesome, when you're part of a team.

The goal of ant robotics is to develop distributed algorithms that enable swarm intelligence to achieve different objectives under different conditions. To first develop and then test such algorithms you might need to build yourself hundreds tiny microbots and run them through mazes, adding and subtracting various obstacles along the way. But that is actually a lot of work and it requires a lot of technical know-how. So, most experts in the field just watch ants.

NASA has sent number of ant farms into space already. An ant farm is just right for a space experiment – its light-weight and low-maintenance. You can launch a small ant farm with enough nutrients inside it to keep the ants going for months, even years – so the astronauts don't end up having much to do, apart from switching on the video camera.

The latest ant farm to go into space is the Commercial Generic Bioprocessing Apparatus Science Insert - but even NASA couldn't pull a usable acronym out of that, so everyone just calls it *Ants in Space*.

The point of flying *Ants in Space* into space is to investigate how ants apply their swarm intelligence to solve the task of searching a new area when they are faced with the additional challenge of doing it in microgravity. The video feed that comes from *Ants in Space* is sent back to Earth and compared with video feeds from identical ant farms back on Earth, where the same system set up in normal Earth G provides an experimental control. Furthermore, school students are being invited to set up their own *Ants in Space* experiments using whatever local ant species they can find, so that they can collect their own citizen science data that may add yet more value to the *Ants in Space* experiment.

As for the particular ants that are in space, they are 70 individuals of the species *Tetramorium caespitum*, also known as *pavement ants*. In other words they are just everyday ants that you might well find crawling about on your pavement – or your footpath or your sidewalk. Those 70 astro-ants will live out the remainder of their days on the ISS and the human crew never need fear being over-run by a spread of new colonies as only sterile worker ants were sent on the mission. Nonetheless, the experiment could run for a quite long time – pavement ant workers can live for around five years.

(Outro)