Hi, this is Janet for Cheap Astronomy, www.cheapastro.com. This is SISS, Science on the ISS – and today's episode is *Organs-on-a-chip*.

Keen observers of the scientific endeavours on the ISS sometimes wonder if some ISS science projects just involve sending up the latest 'big thing' in science – without any clear reason as to *why* being in space might make it a better experiment. But hey, this is science – not knowing *why* is often a good reason to do something.

Anyway, organs-on-a-chip are one of those 'big things' in science at the moment and yes, there are plans afoot to put some up in space. After all, organs-on-a-chip could become a disruptive, world-changing technology – although the list of potentially-disruptive and world-changing technologies is a pretty long list these days. It's often hard to know which ones are *really* going to be world-changing until the world actually changes.

Since we are yet to send organs-on-chips up to the ISS, this episode is mainly about *how* things like organs-on- chips eventually get up there – a story that is not so much about rockets, payloads and docking procedures, but about grant applications, knowing who to know and a certain amount of luck.

But, just what exactly are organs-on-a-chip? An organ-on-a-chip mimics the functional unit of a human body organ and is created by culturing a few of that organ's specialised cells on a geometrically-organised scaffold, which is about the size of a microscope slide. A kidney-on-a-chip involves organising some nephron cells into a geometric structure that can concentrate urine. A liver-on-a-chip involves organising some Kupffer cells into a structure that can detoxify blood serum. There's even a lung-on-a-chip that can mimic the function of alveoli, the gas exchange units in your lung.

The chips, on which these scale-model organs are grown, are made of PDMS – that is, Polydimethylsiloxane – a transparent, flexible and biologically-friendly plastic – the same stuff that contact lenses are made of. Cells can be both cultured and organised into 3d structures on a PDMS scaffold –and onto that scaffold can be added sensors, fluid flow gates and even tiny pumps. Lungs-on-a-chip include little mechanically-expandable channels that can mimic the stretching and relaxing of alveoli inside a real, breathing lung. This is a good example of a biological microelectromechanical system – a BioMEMS – which represents the synthesis of artificial and biological structures within an integrated system – which isn't exactly alive, even though bits of it are.

But, despite all the clever infrastructure and micro-engineering, it is the alive bits of an organ-on-a-chip that do all the important work. The organ functions being replicated on these chips depend on living cell membranes. Most key bodily functions like urine concentration, blood detoxification and gas exchange are mediated by cell membranes, which are constantly working to filter, or extract or concentrate things.

So, it is the membranes of the cells cultured on the chips that define most of the separated compartments and it's the membranes that do most of the important work of the chip. For the most part, all the PDMS infrastructure and micro-engineering that are built into organs-on-a-chip are just there to support and to monitor those cell membrane functions.

Organs-on-a-chip can test how well drugs work and assess how dangerous different toxins are. They can also monitor cellular resilience to infection and compare the effect of various antibiotics. It is hoped that organs-on-a-chip may eventually put an end to all scientific testing on animals – which would be a good thing for the animals and a good thing for science too, since most of the animal testing we do now is to determine the effect of the drugs and the toxins and the antibiotics on *humans*.

Animals will often react in a very *similar* way to how humans would when exposed to different drugs, toxins or antibiotics. But *similar* is never quite *the same*. If we keep developing organs-on-a-chip into more sophisticated analogues of human organs – and then maybe join some of them together to form a virtual *body-on-a-chip*, then we really might be able set all the lab rats free.

Perhaps the best thing about growing a scale model an organ on a chip, is that you get a functional unit that is reproducible on a large scale. Imagine if you tried to publish a paper telling people how you'd put a few cells on a chip, added solution x and then saw effect y happen – everyone is just going to say *hmmm...* But if said you put a few cells on *a hundred* chips and *they all* showed effect y when solution x was added, then everyone is going to say *aahh…* Reproducibility is the hallmark of good science.

What benefit we might gain from putting organs-on-a-chip in space remains to be fully explored. In microgravity it might be possible to construct more elaborate 3d tissue structures that would otherwise collapse under the own weight back on Earth. Perhaps this will help us create things like a brain-on-a-chip. And yes, we did say a brain-on-a-chip. It will probably just be a few neurons arranged to mimic a tiny neural network, along with a few firing synapses. No-one is expecting it achieve self-awareness – at least, not straight away.

Apart from that, we'll be able to do the usual business of investigating how microgravity affects biological tissues – and we'll be able to investigate that down to the cellular level. So, on the ISS, we might start seeing muscles-on-a-chip, bones-on-a-chip and even cartilage-on-a-chip. At this stage the only limit is our imagination.

How organs-on-a-chip will eventually get launched to the ISS is an easier story to tell. First, you need to understand who CASIS are. CASIS – the Center for the Advancement of Science in Space – was chosen by NASA in 2011 to *maximise use of the station through accelerating innovations and new discoveries*.

CASIS have put out a call for proposals for organs-on-a-chip projects. Submitted proposals will presumably be assessed on their potential to advance our current scientific know-how; on their potential to deliver an outcome of relevance to health care and to deliver a return on the investment needed put them up into space.

And that last bit is important. CASIS will be looking for proposals with an understanding of how your proposed project is going to work *in space*. That means explaining where it is going to be placed on the ISS, how it will connect with the ISS power supply and how it will interface with ISS data systems. However, you could make it all a whole lot easier for both you and for the proposal assessors by just informing them that your organs-on-a-chip experiment is compatible with *Nanoracks*.

Nanoracks provide *payload integration solutions* – that is, you tell them what you want to put up there and they'll make sure it fits in the right place, plugs into the right sockets and sends you back the data you want in the format that you want.

Needless to say, *Nanoracks* can get your experiment housed in a very small rack inside a crewed module of the ISS. Or you can arrange for your experiment to be mounted on an external platform of the ISS, exposing it to the cold vacuum of space. The *Nanoracks* people can even turn your experiment into a *small sat* – that is, a small satellite – which means it will be strategically-deployed… in other words, it will be dropped out the back of the ISS.

It's not likely that we'll be seeing organs-on-a-chip dropped out the back of the ISS or see them exposed to the cold vacuum of space. But *Nanoracks* will make sure that any organ-on-a-chip experiment fully-conforms with ISS operational requirements so that those experiments can do their thing – whatever their particular thing may be.

Nanoracks is a genuine space business and pulls a decent profit, only a quarter of which has come from NASA in recent years. The money doesn't come directly from scientists, since scientists don't usually fund their own research projects. Instead, scientists – and science in general – depend on *venture capital*, which might come in the form of a government grant or it might come in the form of private investment. A good example of the latter in the *Space Angels Network*, where Angel investment is a term to describe what people traditionally known as *rich benefactors* do in the modern business world. Space Angel investors are those Angels who want to take a gamble on space experiments – which may, or may not, end up changing the world, but might at least return a few bucks to their investors. After all, the money has to come from somewhere and good science does often generate good profit.

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