Will we ever cryopreserve our organs?
By Daniel Cossins

Imagine if doctors could dip into freezers and take their pick of kidneys, livers or hearts for life-saving operations. Here's why it's so hard to **achieve**.

If you ever need a new kidney, a **replacement** heart or another **vital** organ, you won't exactly be spoilt for choice. That's because when it comes to healthy human organs for life-saving transplants, there is a **vast** gap between **supply** and demand.

In the United States alone, 26,517 organs were transplanted in 2013, yet over 120,000 patients are stuck on the waiting list. Quite simply, there are not enough **donations** to go around. To make matters worse, even the organs that are made **available** sometimes go **to waste** because they don't have much of a **shelf life** once they've been **removed** from a donor. At the moment the best we can do is to **preserve** them in a special **solution** just above 0C for a day or two, which doesn't leave much time to find well-matched patients to **receive** them.

But there is a possible answer. If scientists could find a way to deep-freeze organs and bring them back without i**ncurring** damage, we could potentially bank them for weeks or months. The same could be done for lab-**engineered** organs, if we can create them. With that in mind, the Organ Preservation Alliance, a charity started by Singularity University Labs at Nasa's Research Park in California, is planning a multi-million dollar prize to **fund breakthroughs**. So could we see a time when transplant surgeons can dip into freezers, and take their pick of kidneys, livers or hearts to carry out life-saving operations?

Scientists have been successfully freezing, or cryopreserving, small collections of human cells for 40 years. They preserve eggs and embryos by flooding cells with solutions of so-called cryoprotectant **compounds** which **prevent** the **formation** of ice crystals that can rip cells apart, and also guard against lethal shrinkage. Unfortunately, they hit **major obstacles** when trying to scale this process up, as the architecture within more **complex** tissues and organs is much more **vulnerable** to ice-crystal-related damage.

Nevertheless, a small group of researchers has not **given up**, and are trying to **solve** the challenge in part by taking cues from nature. Antarctic icefish, for example, **survive** in waters as cold as -2C thanks to antifreeze proteins (AFPs), which lower the freezing point of their bodily **fluids** and bind to ice crystals to stop them **spreading**. Researchers have used solutions **containing** icefish AFPs to preserve rat hearts for up to 24 hours at a few degrees below zero. Any colder, however, and icefish AFPs backfire: they **force** budding ice crystals to form **sharp** spikes that pierce cell membranes. Another anti-freeze compound, recently discovered in an Alaskan beetle that can tolerate -60C, might **prove** more useful.

But anti-freeze **ingredients** alone won't do the job. That's because freezing also wrecks cells by affecting the flow of fluids into and out of them. Ice first **forms** in the spaces between cells, reducing the **volume** of liquid and increasing the concentration of **dissolved** salts and other ions. Water rushes from cells out to compensate, causing them to shrivel and die.

For eggs and embryos that's where cryoprotectant compounds such as glycerol come in handy: they not only **displace** water to prevent ice formation within cells, but also help to prevent cell shrinkage and death. The problem is these compounds can't work the same magic in organs. For one, cells in tissue are much more **susceptible** to ice penetration. And even if cells are protected, ice crystals forming in the spaces between cells shred the extracellular structures that hold the organ together and **facilitate** its function.

No cryopreservation **technique** ever offers 100% survival of the component cells. In many applications this can be tolerated but for a single organ this may be a **significant** amount of injury to repair post-storage or transplantation. Ultimately, that means no matter how well cryopreserved **specimens** are, they are likely to be sub-standard compared with freshly procured organs.

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