Pig in us: Xenotransplantation and new age of chimeric organs

Imagine stripping out the failing components of an old car — the engine, transmission, exhaust system and all of those parts — leaving just the old body and other structural elements. Replace those old mechanical parts with a brand new electric, hydrogen powered, biofuel, nuclear or whatever kind of engine you want and now you have a brand new car. It has an old frame, but that's okay. The frame wasn't causing the problem, and it can live on for years, undamaged.

When challenged to design internal organs, tissue engineers are taking a similar approach, particularly with the most complex organs, like the heart, liver and kidneys. These organs have three dimensional structures that are elaborate, not just at the gross anatomic level, but in microscopic anatomy too. Some day, their complex connective tissue scaffolding, the stroma, might be synthesized from the needed collagen proteins with advanced 3-D printing. But biomedical engineering is not there yet, so right now the best candidate for organ scaffolding comes from one of humanity's favorite farm animals: the pig.

Chimera alarmists connecting with anti-biotechnology movements might cringe at the thought of building new human organs starting with pig tissue, but if you're using only the organ scaffolding and building a working organ from there, pig organs may actually be more desirable than those donated by humans.

How big is the anti-chimerite movement?

Unlike anti-GMO and anti-vaccination activists, there really aren't too many anti-chemerites around. Nevertheless, there is a presence on the web of people who express concern about mixing of humans and non-human animals. Presently, much of their concern is focussed on the growing of human organs inside non-human animals, pigs included. One anti-chemerite has written that it could be a problem for the following reason:

> Once a human organ is grown inside a pig, that pig is no longer fully a pig. And without a doubt, that organ will no longer be a fully human organ after it is grown inside the pig. Those receiving those organs will be allowing human-animal hybrid organs to be implanted into them. Most people would be absolutely shocked to learn some of the things that are currently being done in the name of science.

The blog goes on to express alarm about the use of human genes in rice and from there morphs into an off the shelf garden variety anti-GMO tirade, though with an an anti-chemeric current running through it. The concern about making pigs a little bit human and humans a little bit pig becomes a concern about making rice a little bit human. But the concern about fusing tissues and genes of humans and other species does not fit with the trend in modern medicine.

Utilization of pig tissue enters a new age

For decades, pig, bovine and other non-human tissues have been used in medicine. People are walking around with pig and cow heart valves. Diabetics used to get a lot of insulin from pigs and cows, although

today, thanks to genetic engineering, they're getting human insulin produced by microorganisms modified genetically to make human insulin, which is safer and more effective.

When it comes to building new organs from old ones, however, pig organs could actually be superior for a couple of reasons. For one thing, there's no availability problem with pigs. Their hearts and other organs also have all of the crucial components of the extracellular matrix that makes up an organ's scaffolding. But unlike human organs, the pig organs don't tend to carry or transfer human diseases. That is a major advantage that makes them ideal starting material. Plus there is another advantage: typically, the hearts of human cadavers are damaged, either because heart disease is what killed the human owner or because resuscitation efforts aimed at restarting the heart of a dying person using electrical jolts and powerful drugs.

Rebuilding an old organ into a new one

How then does the process work? Whether starting with a donated human or pig organ, there are several possible methods. But what they all have in common is that only the scaffolding of the original organ is retained. Just like the engine and transmission of the old car, the working tissue is removed, usually using detergents. One promising technique that has been applied to engineer new hearts is being tested by researchers at the University of Pittsburgh. Detergents pumped into the aorta attached to a donated heart (donated by a human cadaver, or pig or cow). The pressure keeps the aortic valve closed, so the detergents to into the coronary arteries and through the myocardial (heart muscle) and endocardial (lining over the muscle inside the heart chambers) tissue, which thus gets dissolved over the course of days. What's left is just the stroma tissue, forming a scaffold. But that scaffold has signaling factors that enable embryonic stem cells, or specially programed adult pleuripotent cells to become all of the needed cells for a new heart.

Eventually, 3-D printing technology may reach the point when no donated scaffolding is needed, but that's not the case quite yet, plus with a pig scaffolding all of the needed signaling factors are there and they work just as well as those in a human heart scaffold. All of this can lead to a scenario, possibly very soon, in which organs are made using off-the-self scaffolding from pig organs, ready to produce a custom-made heart using stem or other cells donated by new organ's recipient.

David Warmflash is an astrobiologist, physician, and science writer. Follow @CosmicEvolution to read what he is saying on Twitter.