Scientists close to growing human brains, livers, heart and limbs in labs, pigs and rats

In the UK, there are some 7,000 people on the list who are in dire need of organ transplants and In the US, the number awaiting transplant is around 120,000, with 20 dying each day for want of an organ. Current organ transplant patients have to take immunosuppressant drugs all their life to prevent the body rejecting the new addition whereas using human cells, specifically those from the same patient, would reduce any possibility of rejection. In near term it is also being used to assess the drug safety and efficacy and disease research.

The scientists are working on developing organs in the laboratory that has given hope of transplanting complex organs like kidneys, pancreases and lungs for amputees in a decade or so. In 2013, a team from Japan, Yokohama City University's graduate school of medicine, became first to grow liver cells from skin stem cells in a petri dish and then transplanted them successfully into mice. Since then, scientists have been able to grow artificial versions of complex tissues, including entire limbs, Heart tissue, windpipes, mini brains and bladders , all from stem cells.

SCIENTISTS in China are extremely close to being able to controversially grow human organs in pigs so they can be transplanted to ill patients. Pigs are an ideal candidate to help as their organs, specifically the heart and kidneys, are very similar to that of a humans. Recent experiments in China have shown monkeys can survive for an extended period of time with organ transplants from pigs.

Zhao Zijian, director of the Metabolic Disease Research Centre at Nanjing Medical University in Jiangsu, told South China Morning Post: “We have patients dying from organ failure and their desperate relatives pleading for them to have the chance to live. China is also home to the largest pig cloning factory in the world – BGI – which produces up to 500 cloned piglets annually. Scientists believe this is the perfect set up – the cloners grow the pigs and the doctors add human organs. One researcher from BGI said: “This is unmatched by any other country. The world will eventually depend on China for organs.”

Stem cells are a class of undifferentiated cells that are able to differentiate into specialized cell types. Commonly, stem cells come from two main sources: Embryonic stem cells are derived from a four- or five-day-old human embryo that is in the blastocyst phase of development and Adult stem cells that are found inside of different types of tissue such as the brain, bone marrow, blood, blood vessels, skeletal muscles, skin, and the liver. Both embryonic stem cells and IPS cells have the ability to turn into any part of the body. However, using embryonic stem cells is very controversial because it results in destruction of embryo itself.

Miniature brain

In 2013, scientists from the Institute of Molecular Biotechnology in Vienna, Austria announced they had successfully created a miniature brain in the lab. Using stem cells, they grew a model of a developing brain that was about the size of an embryonic human brain at nine weeks old. The cerebral organoid didn’t look exactly like a real brain, but it had active neurons and had much the same organizational structure. Researchers used human embryonic stem cells and induced pluripotent stem cells (IPS cells) for this research. IPS are derived from skin or blood cells that have been reprogrammed back into an embryonic-like pluripotent state that enables the development of an unlimited source of any type of human cell needed for therapeutic purposes.

Now scientists are creating the three-dimensional organoids from human stem cells comprising functional neurons, distinct layers of cortex, and other architecture that mimics the full-sized version. In January, Salk Institute researchers developed human-pig chimeras, creating the possibility that pigs with human brain cells might also develop human consciousness.

George Church’s lab at Harvard says it has been able to give the organoids a blood supply. “Vascularization” could allow organoids to grow much larger than their current quarter-inch or so diameter, perhaps casting off the “mini” and becoming a full-blown brain growing in a dish. Another advance getting a lot of buzz in brain organoid circles is giving one sensory input, probably via a retina, as one lab is rumored to have done.

In the new papers, according to STAT, scientists will report that the organoids survived for extended periods of time — two months in one case — and even connected to lab animals’ circulatory and nervous systems, transferring blood and nerve signals between the host animal and the implanted human cells. This is an unprecedented advancement for mini-brain research

Organoids are poised to revolutionize research on the human brain since scientists can perform tests on them that would be unethical to attempt on living humans. Scientists are debating whether these brains are “conscious,” and a whole new set of ethical concerns have arisen for the researchers who work with them.

Scientists from Japan create primitive liver bud in mice

In 2013, a team from Japan, Yokohama City University’s graduate school of medicine, became first to grow liver cells from skin stem cells in a petri dish and then transplanted them successfully into mice.

Takebe and his colleagues utilized recent technique of co-culturing multiple cell types together. They utilized three different types of cells, liver cell precursors from human IPS cells (induced pluripotent stem cells), blood vessel precursors called endothelial cells, and connective tissue precursor cells called mesenchymal stem cells. The blood vessel and connective tissue precursor cells were harvested from umbilical cords. These cells got assembled into 5 milimeter sized liver buds in five days with each developing their own blood vessels. These liver buds were transplanted into mouse brain, where they were observed connecting themselves to blood vessels in a mouse. About 10 days later, the buds started working like liver breaking down human drugs and blood proteins.

There is need to observe the long-term effects of the transplant as stem cells tend to form tumors. The liver buds also did not achieve all the functions of a mature liver as the buds did not form a bile duct system that drives away toxins from the body.

Growing Lungs: Scientists Are Using Stem

Cells to Try and Grow Human Lungs in a Dish

Researchers from the UCLA have found a way around some of the limitations of lung cell cultures in recreating lung scarring by growing three-dimensional “organoids” instead of relying on flat cultures. The method uses stem cells to grow pea sized three dimensional samples of lung tissue.

The researchers used stem cells taken from actual adult human lungs to coat tiny sticky hydrogel beads. These eventually grew and self-assembled to envelope the hydrogel beads, which were all placed inside linked wells. The resulting structure produced evenly distributed three-dimensional patterns consistent with actual air sacs like those in human lungs.

While we haven’t built a fully functional lung, we’ve been able to take lung cells and place them in the correct geometrical spacing and pattern to mimic a human lung,” says UCLA associate professor of pediatric hematology and oncology and lead author Dr. Brigitte Gomperts.

With this technique, researchers can grow infected lung organoids so they can further study the biology of the disease. They can also conduct various drug experiments to come up with a precise, personalized treatment plan before administering anything to the patient, minimizing risks of damage.

It’s also very easy to reproduce: “We can make thousands of reproducible pieces of tissue that resemble lung and contain patient-specific cells,” says materials science and engineering graduate student Dan Wilkinson.

World’s first bioLimb

Recently, researchers at Massachusetts General Hospital grew an entire rat arm in a dish. The bioengineered rat forelimb contained bone, cartilage, blood vessels, tendons, ligaments, and nerves, and could pave the way for entire limb transplants for amputees.

The forelimb was created with a technique called “decellularization,” which uses living donor cells to regrow organ tissue. The arm from a dead rat is turned to white scaffold . Next, it is seeded with human endothelial cells, which recolonize the surfaces of the blood vessels and make them more robust than rat endothelial cells would. Finally, scientists inject mice cells, such as myoblasts that grow into muscles.

Though prosthetic limbs have been improving, they are far from ideal. And while the improving field of limb transplants gives hope, the patient has to take immunosuppressant drugs all their life to prevent the body rejecting the new addition because it once belonged to someone else.

Heart

A team from the University of Pittsburgh, Pennsylvania, used induced pluripotent stem (iPS) cells generated from human skin cells to create precursor heart cells called MCPs. iPS cells are mature human cells “reprogrammed” into a versatile, primitive state from which they can be prompted to develop into any kind of cell of the body.

These cells developed into heart muscle, and once exposed to a blood supply, the miniature heart (grown on a mouse heart that had had all its cells removed) began to contract spontaneously. “We hope our study would be used in the future to replace a piece of tissue damaged by a heart attack, or perhaps an entire organ, in patients with heart disease." Heart tissue regeneration has already proven successful in monkey transplants.

3D printing EAR

Cornell bioengineers and physicians have created an artificial ear that looks and acts like a natural ear, giving new hope to thousands of children born with a congenital deformity called microtia. Physicians managed to 3D print a realistic ear using living cells from cows and collagen from rat tails.

The process is also fast, "It takes half a day to design the mold, a day or so to print it, 30 minutes to inject the gel, and we can remove the ear 15 minutes later, " said co-lead author Lawrence Bonassar, associate professor of biomedical engineering.

The novel ear may be the solution reconstructive surgeons have long wished for to help children born with ear deformity, said co-lead author Dr. Jason Spector, director of the Laboratory for Bioregenerative Medicine and Surgery and associate professor of plastic surgery at Weill Cornell. "A bioengineered ear replacement like this would also help individuals who have lost part or all of their external ear in an accident or from cancer," Spector said. For people missing an ear, the reconstruction process is slow and painful, involving harvesting cartilage from the patient's ribs. However, new techniques might make it easier.

References and Resources also include:

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