Health

The bionic boom

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The cochlear implant was developed in the 1970s. It is a small device placed under the skin behind the ear that electrically stimulates nerves within the cochlea - the part of the inner ear responsible for hearing. Sound is picked up by a microphone attached to the back of the ear, then processed by a device located nearby. Signals are sent by up to 24 electrodes into the brain. Manufacturers are working on improving the implant, including obtaining a closer "fit" between the electrodes and the bit of the cochlea that needs to be stimulated, and measuring the activity of the auditory nerve in the vicinity of each electrode so that the device can be tuned more accurately.

Scientists are working on two types of artificial liver: an external device similar to a kidney dialysis machine to detoxify the blood (an import function of the liver) and a "new" liver grown from human stem cells.

In the US, researchers have passed blood through membranes sitting in a suspension of cells from pig livers to demonstrate that the blood is detoxified by the pig cells. It would be used to keep patients alive while they awaited a transplant.

In the UK last year, scientists at the University of Newcastle grew sections of human liver from umbilical cord stem cells. Initially such tissue could be used to test drugs, but eventually it may be possible to generate a liver suitable for transplant.

There is as yet no artificial stomach for use in humans, but that's not to say that there won't be at some point. Scientists at the Institute for Food Research in Norwich have built what they believe to be the first prototype for research purposes.

The computer-controlled device consists of a chamber that mimics the human stomach, complete with acidic digestive juices and enzymes. It also churns around in the same way.

The stomach is fed real food and scientists observe how the contents are digested and absorbed.

They hope to get a better understanding of the process, which could help in the design of healthier foods and diets.

The kidney is a sophisticated filter that removes toxins from the blood. When this organ fails, the filtration must be carried out artificially - in a process called dialysis - in which blood is drained from the body and passed through a machine.

While a dialysis machine, the prototype of which was developed in the 1940s, is, in effect, an artificial kidney, doctors have been attempting to make smaller and more efficient filters, with the ultimate aim of a wearable or even implantable substitute. Researchers at the University of Michigan, for example, are working on new filter systems by precisely controlling the size and shape of pores in the membranes across which the blood is filtered.

This would produce a smaller and more efficient device. Yet, while dialysis machines are getting smaller, , the prospects of a "wearable" kidney remain some years away.

Artificial skin has been used for several years by surgeons treating people who have serious burns. Normally, if a patient has lost a large amount of skin, the surgeon takes some from other parts of

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the patient's body to graft over the affected areas.

However, in severe cases there isn't enough unaffected skin to take from elsewhere. "Artificial skin" consists of an outer layer of the rubbery material silicone, and an inner layer made from collagen and shark cartilage. This provides a kind of scaffold that the body's underlying cells can recognise, and they soon start to deposit their own skin proteins. Now researchers are working on ways to include growth factors in artificial skin so that it would attract new cells to the growing layer and encourage it to heal faster.

An artificial brain has been one of the staples of science fiction for a hundred years, and is likely to remain so for the next hundred. But researchers are beginning to understand how to wire silicon chips to the brain, with the prospect of artificial implants that can restore lost function. At the University of Southern California, Professor Theodore Berger's team has shown that it is possible for a silicon chip to "talk to" a mammalian brain. In other words, it might eventually be possible to replace damaged areas with a microprocessor implant that could receive and process signals. Ultimately this could "repair" brains in people who have Alzheimer's disease or who have other damage.

In the US, the ambitious research programme the Artificial Retina Project aims to develop a "bionic eye" for people with disease of the retina (the light-processing layer of cells at the back of the eye). It consists of a miniature camera and computer chip mounted on a pair of spectacles, and a small implant behind the ear linked to electrodes attached to the cells of the retina.

As an image is picked up by the camera, the information is converted into electronic signals that are passed via the implant to the electrodes on the retina, from where they travel via the optic nerve to the brain.

Scientists have been trying for decades to make a blood substitute that can transport oxygen to tissues efficiently and with no dangerous side-effects, reducing the need for blood donations. There have been two main approaches. One is to use nature's oxygen-carrying molecule, haemoglobin, found in red blood cells. The other is to use synthetic oxygen-carrying chemicals, such as per-fluorocarbon. Pure haemoglobin is problematic, causing complications with the kidneys. But by encapsulating the haemoglobin it may be possible to avoid this. Researchers at Sheffield University are now focusing specifically on the portion of the haemoglobin molecule that carries the oxygen.

For people with serious chest diseases, an infection could prove deadly as their lungs could fail, so an "artificial lung" can be a lifesaver. One of these, developed around five years ago, consists of a bunch of thin, hollow polymer fibres. The patient's blood is diverted out of the body to flow around these fibres, which absorb the oxygen and unload carbon dioxide. Yet the devices are inefficient and need a lot of blood. Scientists at the University of Pittsburgh have now shown that, if the fibres are coated with an enzyme, the device can be much more efficient, reducing clotting and inflammation. Artificial lungs, the size of a CD case, are used in emergencies.

The development of an artificial heart that can function indefinitely without being rejected by the body has proved elusive. The first patient to receive an implanted artificial heart, in the US in 1982, survived for 112 days. They are now used in a small number of patients who are awaiting a transplant. So far the longest that someone has survived with an artificial heart is just over 20 months. An artificial heart typically weighs a kilogram and is made of metal and plastic and powered by external batteries. Researchers in Texas have been working on a "non-beating" heart that pumps blood continuously. The idea is that these are more durable and can

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be made smaller.

People with diabetes need constantly to check the levels of glucose in their blood and, when necessary, inject themselves with insulin.

Researchers are hoping that an "artificial pancreas" will do this automatically.

The technology aims to combine two existing devices - a glucose monitor and an insulin dispenser - in a single, wearable, unit. Blood glucose would be continuously monitored by a sensor placed on or just beneath the skin. The readings would be fed into a microprocessor that would calculate any trends in its rise and fall. When a particular dose of insulin was required, a signal would be sent to the dispenser to deliver the appropriate amount of the hormone.

Prototypes of the system are undergoing preliminary trials, though it is too early for researchers to give an indication of when it may be widely used.

More than two million transplants are carried out worldwide each year to replace damaged or diseased bone. A bone substitute must have a porous structure to allow blood vessels and cells to infiltrate it and grow. It must have the appropriate mechanical strength to help support weight. One recently developed process involves taking sea-coral and treating it chemically to convert the coral to hydroxylapatite - the main mineral component of bone - leaving the porous structure intact. Researchers are now developing polymers that can "bleed" a type of glue when they are damaged and, effectively, heal themselves.

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