The tissue of life

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The budding tissue-engineering field promises one day to solve one of medicine's biggest problems, the dearth of available organs for transplantation.

For now, tissue engineering — the ability to create three-dimensional cell bundles that can replace tissue lost to trauma or disease — is being used to a modest degree nationwide. Several companies offer skin and cartilage tissue, representing the first wave of engineered organic products.

Broadly defined, tissue engineering is the development and manipulation of laboratory-grown molecules, cells, tissues or organs to replace or support the function of defective or injured body parts.

Although cells have been cultured, or grown, outside the body for many years, the possibility of growing complex tissues — literally replicating the design and function of human tissue — is a more recent development.

The process requires not only growing cells, but considering how blood vessels might grow around the new cells and whether the new tissue, such as new cartilage tissue in someone's knee, will have the mechanical strength needed to perform within the body.

Among the tissue types scientists are working on reproducing are bone, liver, muscle cartilage, heart muscles and nerves.

The intricacies of this process require input from many types of scientists, including the problem-solving expertise of engineers, needed to envision the work in three dimensions.

Others involved in the research include cell biologists, robotics engineers and specialists in computer-assisted design, who can envision how the new cells would be constructed around various scaffolding systems, or frameworks. The new cells and blood vessels begin to grow while the scaffolding dissolves.

Dr. Robert Nerem, director of the Georgia Tech/Emory Center for the Engineering of Living Tissues, says tissue engineering is in its infancy.

"In the last 10 years, it has accelerated, yet it's still very much a fledgling industry," says Dr. Nerem, whose center is exploring tissue engineering involving cardiovascular and orthopedic cells, among other uses.

Five tissue-engineering products have received approval by the Food and Drug Administration in the past year, Dr. Nerem says — four skin substitutes and one cartilage-replacement product, known as Carticel.

Once destroyed either by trauma or age, cartilage generally does not replenish itself under normal conditions.

Jennifer Elisseeff, assistant professor at the Johns Hopkins Whitaker Biomedical Engineering Institute in Baltimore, is part of a team trying to create cartilage replacement using methods similar to tissue engineering.

Ms. Elisseeff's work involves injecting a fluid filled with nutrients and stem cells from adult goats into damaged cartilage tissue, then using light to solidify the liquid. The gel provides the scaffolding while the stem cells grow into tissue similar to cartilage. Ms. Elisseeff has done the procedure with tissue in the laboratory and is preparing to try it with live animals — goats. There is no timetable as yet for human testing.

"Researchers are close to generating a very normal-looking cartilage tissue," she
says. Such efforts would help those whose cartilage loss has led to pain and inflammation of the joints, she adds.

Tissue engineering differs from cloning, a more contentious way to create tissue, in that cloning extracts the nucleus from an adult cell, then injects it into an embryonic cell. All cells that grow from that new embryonic cell will have the same makeup as the parent cell.

Tissue engineering doesn't involve such modified embryonic cells, nor does it create exact duplicates of the original cells.

The industry, which has deep roots in several places across the country, notably Boston, Seattle and Pittsburgh, must do more than simply master various cell types, says professor Makarand V. Risbud of Thomas Jefferson University's Cell and Tissue Engineering program in Philadelphia.

They must create scaffolding, which can be a solid, a gel or a synthesized material, Mr. Risbud says.

That process underlines the need for cross-disciplinary work on the tissue-engineering front, he says.

"I have a basic polymer chemist working on the scaffolds," he says, "Then, I have a cell biologist to help understand how the cells behave on the scaffold. An orthopedic surgeon, he adds, works on how to apply the work to the human body and its intricate movements.

Cells for tissue engineering can come from the patient or from donated adult stem cells. Using the latter, while preferable for potential "off the shelf" tissue, brings up the possibility of the host rejecting the donated tissue, he says.

Dr. Marion Jordan, director of the Washington Hospital Center's Burn Center in Northwest, says his colleagues use a biosynthetic material called Integra to help burn victims recover lost skin.

It isn't tissue engineering in its purest form because engineered skin tissue cannot be used for large expanses of skin, but it uses similar principles.

The product, a combination of cow proteins and powdered shark cartilage, serves as a scaffolding to allow small blood vessels to grow along with new skin cells. The process still involves taking skin from another part of the patient, but the amount of skin required is less and so the patch where the skin is taken heals more quickly, he says.

David Shreiber, assistant professor of biomedical engineering at Rutgers University in New Jersey, says cells can be cultivated either from the host patient or from cell banks.

In the former case, a doctor would perform a biopsy on the patient, taking tissue away to be shipped off to a lab and expanded. Later, it would be re-injected into the person.

Mr. Shreiber says the tissue-engineering field is just getting started but the field's potential remains enormous. Such tissue work could, in the near future, help people adapt better to prosthetic and dental implants.

Dr. Nerem expects to see tissue-engineered bone in the next few years, with manufactured blood vessels a possibility in about a decade.

Replacing heart valves is at least 15 years away, he adds.

Dr. Nerem says that although the promise of tissue engineering has yet to be fulfilled, its need will become even more apparent in the years to come.

"The problem with the transplant world is that the discrepancy between patient need and donor availability just gets wider and wider," he says. "We'll never solve that without an external supply of vital organs."

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