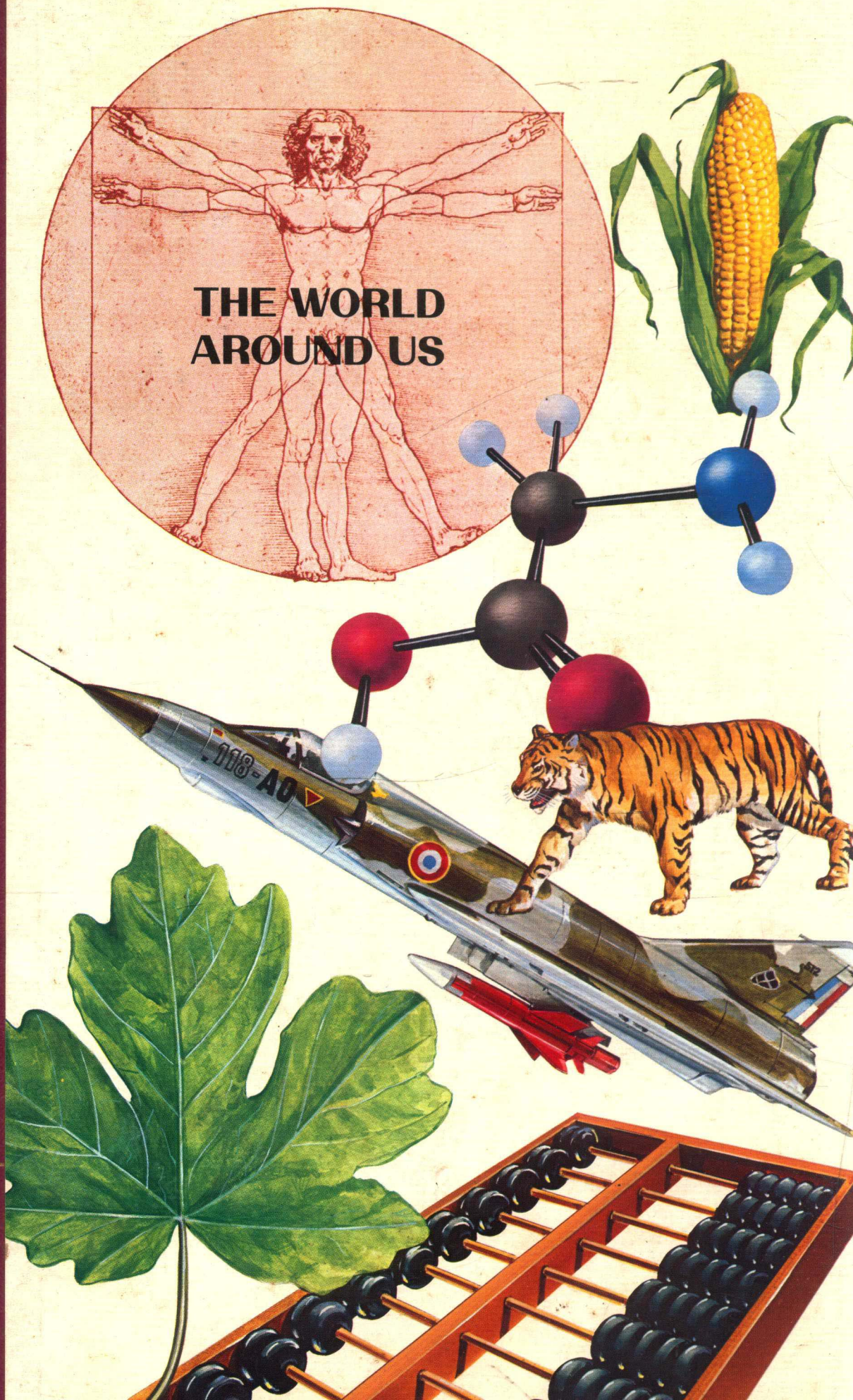
SCIENCE AND TECHNOLOGY ILLUSTRATED

THE WORLD AROUND US



Science Technology

The World Around Us

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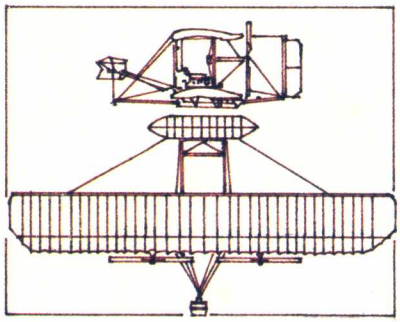

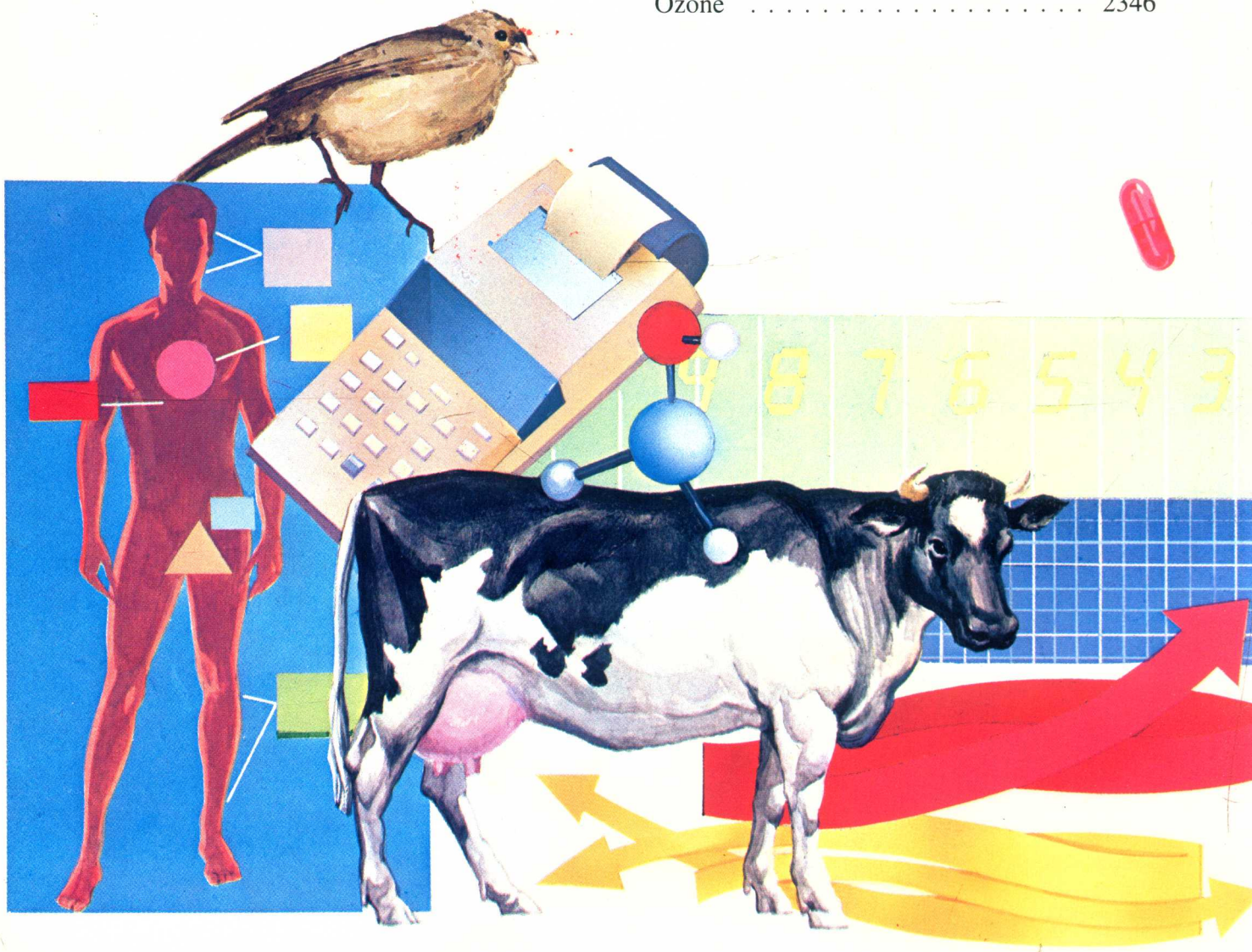

Science and Technology Illustrated

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Volume 19

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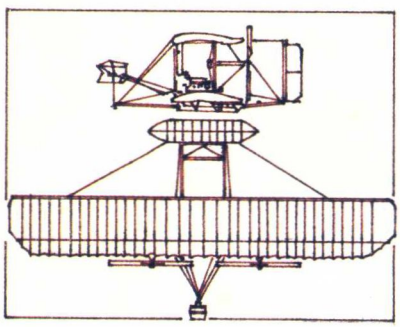
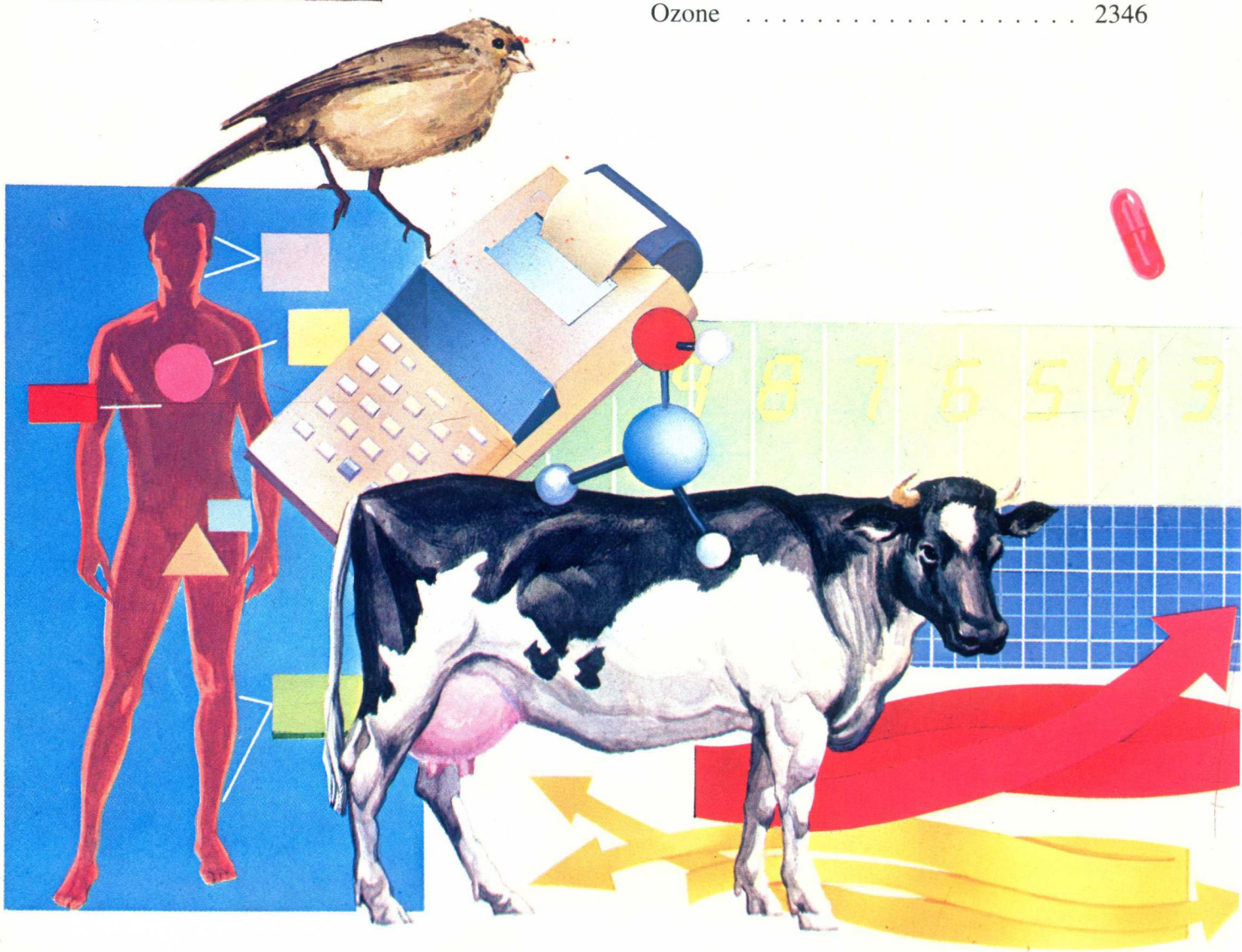




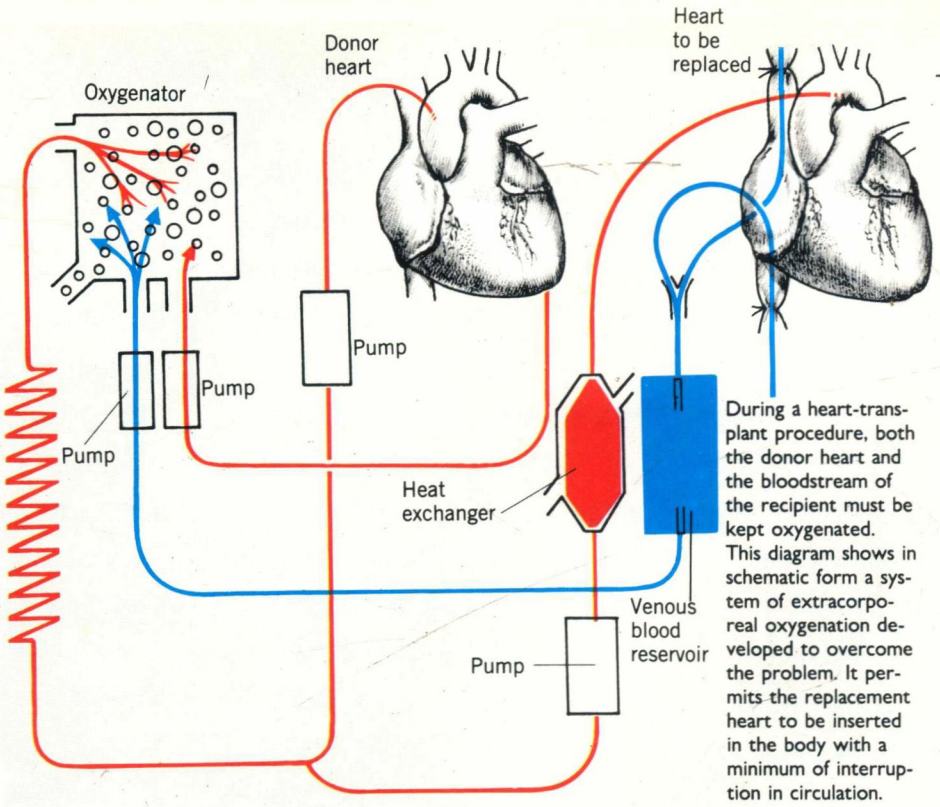
Organ Transplant

If an automobile is not running properly because it has a defective carburetor, there is a simple solution. A mechanic just takes out the faulty carburetor and puts in a new one. That is the basic principle behind transplanting organs in the human body. If an organ—say, a kidney—is defective and cannot be treated and corrected by conventional means, it is now possible to remove the old one and put in a new one. If the transplant is successful, the patient will be able to return to a normal life.

The Nature of Transplantation

Early Hindu surgeons, some 600 years before Christ, reconstructed noses with skin flaps taken from arms. This early form of grafting was the precursor to the transplants of today. But, whereas in grafting, a patient may receive tissue from a healthy portion of his or her own body, in organ transplantation the organ must come from a donor. In the case of paired organs, like the kidneys, where only one is needed for survival, the donor can be alive. In the case of singular vital organs, such as the heart or the liver, the donor must, of course, be dead.

The history of organ transplantation is relatively recent. Transplantation was first made feasible in 1912, when a method for joining blood vessels was developed by the French surgeon Alexis Carrel. The biggest breakthroughs in organ transplantation occurred in 1950, when the first successful transplant of a human kidney took place at Loyola University in Chicago, and in 1967, when the first human heart transplant was performed by the South African, Christiaan Barnard.

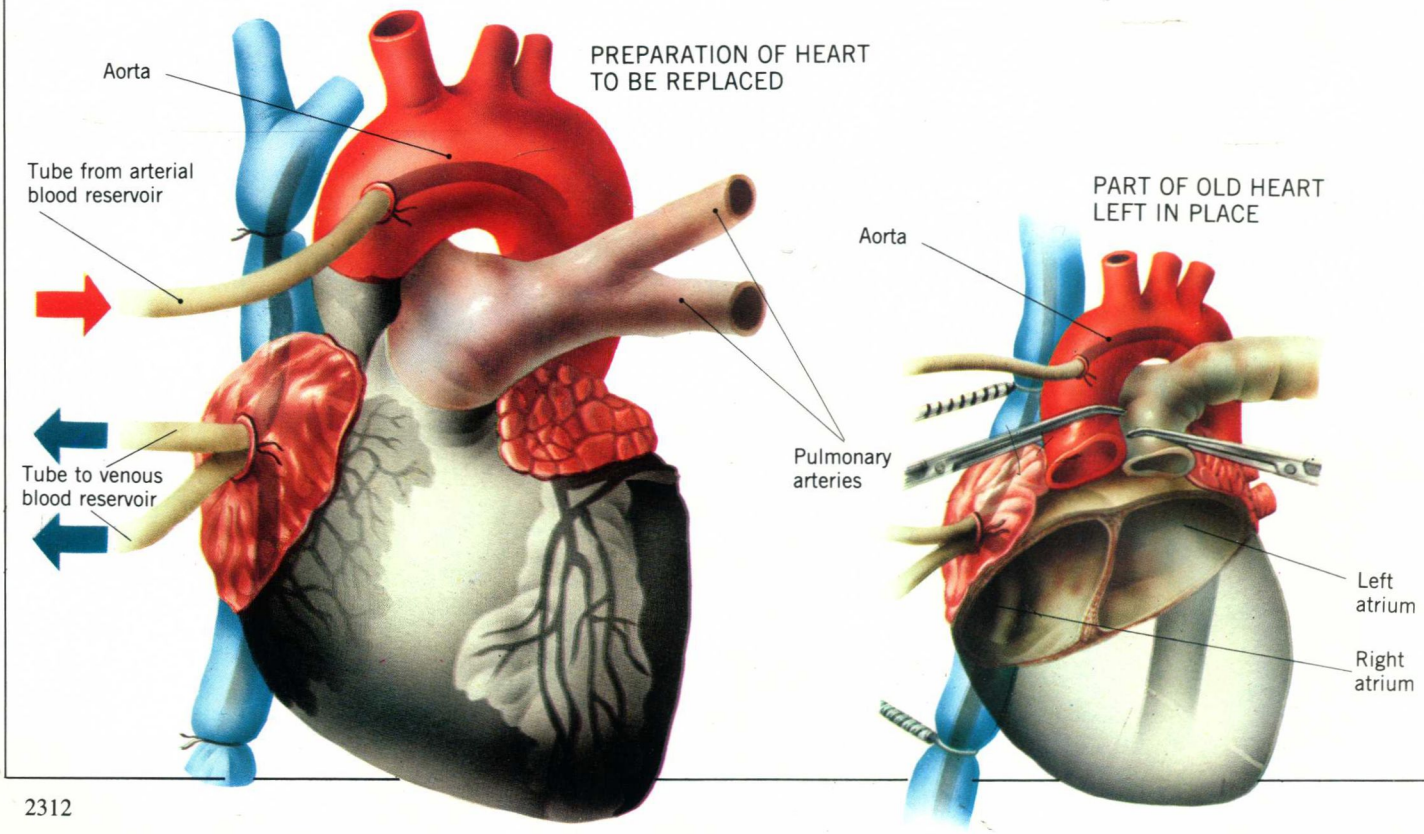


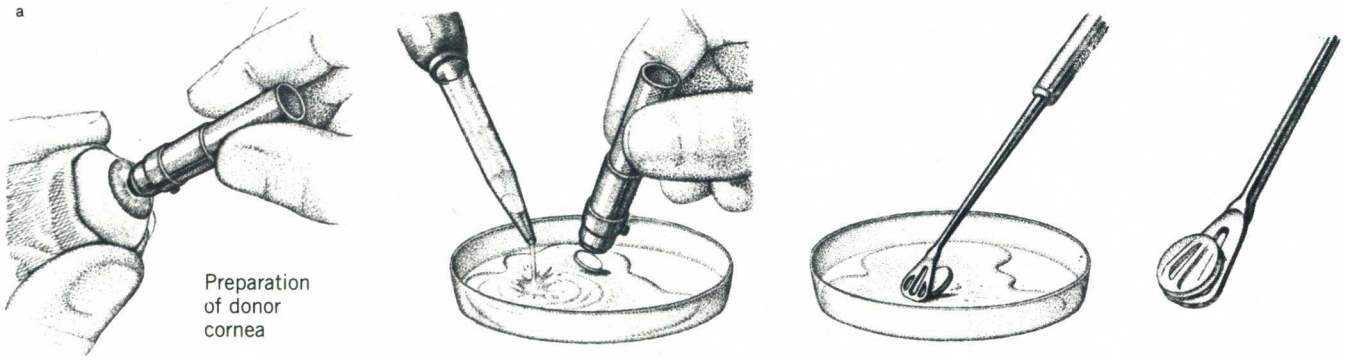
During a heart-transplant procedure, both the donor heart and the bloodstream of the recipient must be kept oxygenated. This diagram shows in schematic form a system of extracorporeal oxygenation developed to overcome the problem. It permits the replacement heart to be inserted in the body with a minimum of interruption in circulation.

The Kidney

Since the kidney was the first human organ to be transplanted, there is considerable experience and knowledge in the field of kidney transplants. The operation itself involves comparatively straightforward surgery. A patient's diseased kidneys are removed, and a healthy one is implanted. The new kidney may come from either a living person or a cadaver. A living donor—a relative, if possible—is the best choice.

The reason for this preference has to do with the body's immune system, a complex defense mechanism against infection. Unfortunately, this mechanism cannot differentiate between infective microorganisms and potentially lifesaving or-



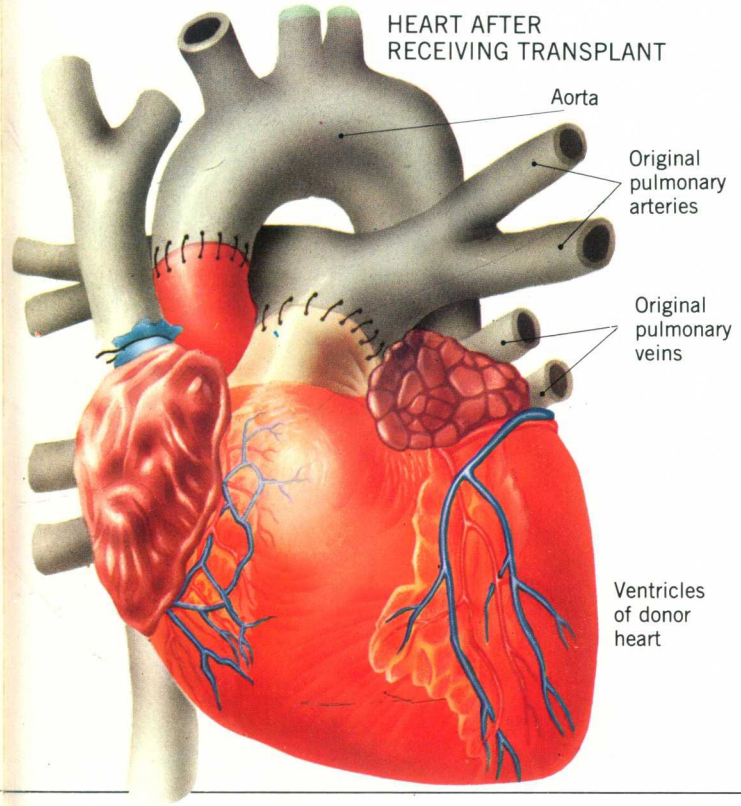


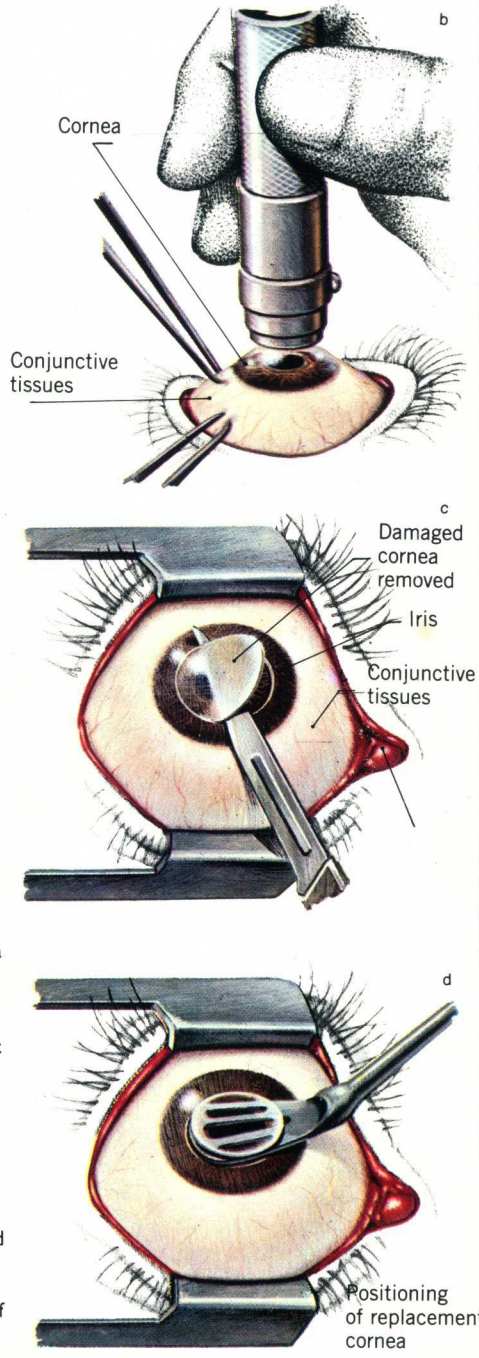
gan grafts. It will try to fight off the organ graft, just as it would an infection. Because a relative may have a genetically similar immune system, the donated organ may not be rejected so severely by the host's body as it would if it were donated from a cadaver (which would most likely not be a relative's).

In all cases, the patient is given drugs called immunosuppressives, which inhibit the work of the immune system. Unfortunately, although these drugs may be give the organ a greater chance of survival, they also increase the body's vulnerability to infection. Postoperative care in a scrupulously clean environment is therefore of the utmost importance. Once any complications are taken care of, the patient can be released, often within a few weeks of the operation. Except for a continued regimen of immunosuppressives, the patient will be able to return to a normal life.

Heart, Liver, and Lungs

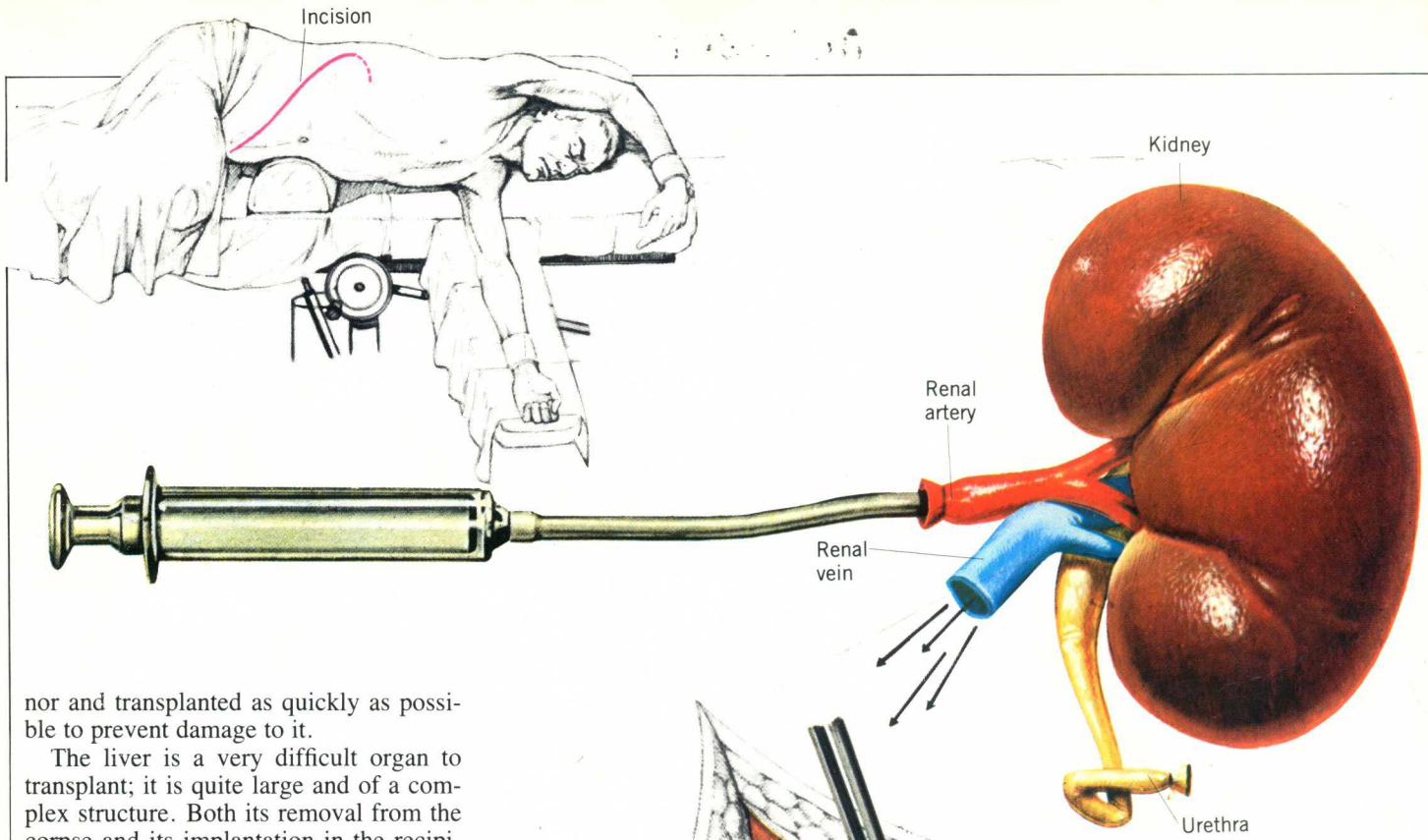
After World War II, great advances were made in direct operations on the heart. These advances, together with experimentation on transplants in animals, laid the groundwork for the revolutionary surgery of heart transplantation. There are greater problems in transplanting a heart than in transplanting a kidney, though the features of rejection are similar. The cells that produce immune reactions migrate into the muscle cells of the heart, damage it, and also block the coronary arteries, thus depriving the heart of its own circulation. A heart is more likely to be rejected than a kidney, a problem that could stem from the fact that the heart must, by necessity, be cadaver-donated. Even with the most exact tissue and blood typing, there will never be a perfect match. The heart is also very sensitive to lack of blood supply and must be removed from the do-





Sequence of illustrations beginning at top of page and continuing at right illustrates stages in a corneal transplant. The replacement cornea is removed from the eye of the donor, often an accident victim, and kept in a sterile solution while the patient's eye is prepared to receive it. Then, after the removal of the damaged cornea, the new cornea is carefully attached.

Left: Three main stages in heart-transplant surgery. From left to right, the patient's damaged heart is attached to external blood-oxygenation equipment; then, with temporary sutures in place to prevent blood loss, the bulk of the old heart is removed; finally, the new donor heart takes the place of the damaged organ.



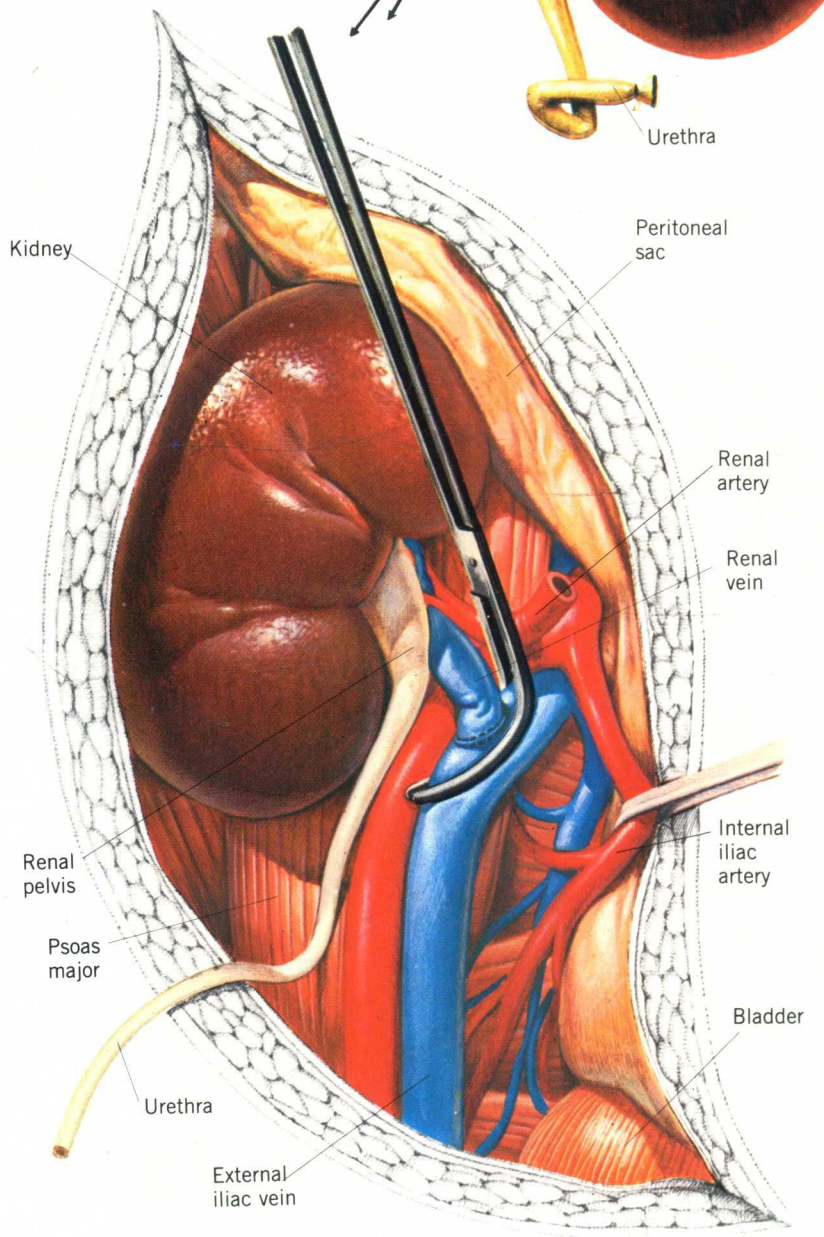
nor and transplanted as quickly as possible to prevent damage to it.

The liver is a very difficult organ to transplant; it is quite large and of a complex structure. Both its removal from the corpse and its implantation in the recipient are major operations that must be done swiftly, since the liver, like the heart, is extremely sensitive to blood loss. Once transplanted, the liver must function immediately, or the patient will die, for there is no artificial liver machine (as there is an artificial kidney machine) that can perform the duties of the liver and keep the patient alive.

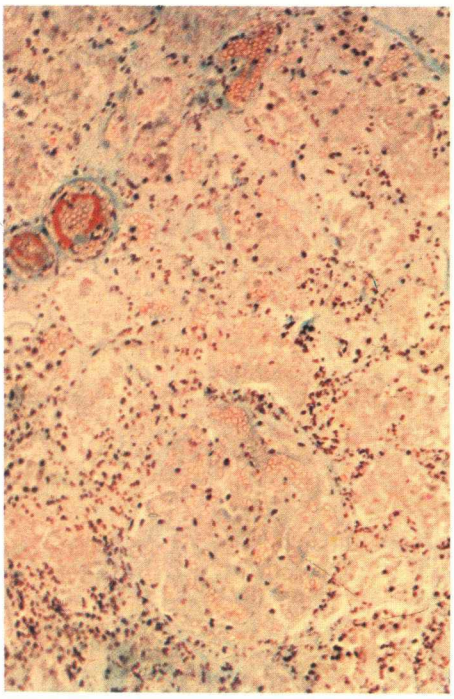
Transplantation of a lung is also a difficult procedure. Because the lung inhales and exhales air, it is very susceptible to infection, a weakness that is compounded by the use of immunosuppressives to combat rejection. Care must be taken not to damage the nerves that connect the lungs to the central nervous system and regulate breathing. Since 1963, there have been fewer than 100 lung transplants.

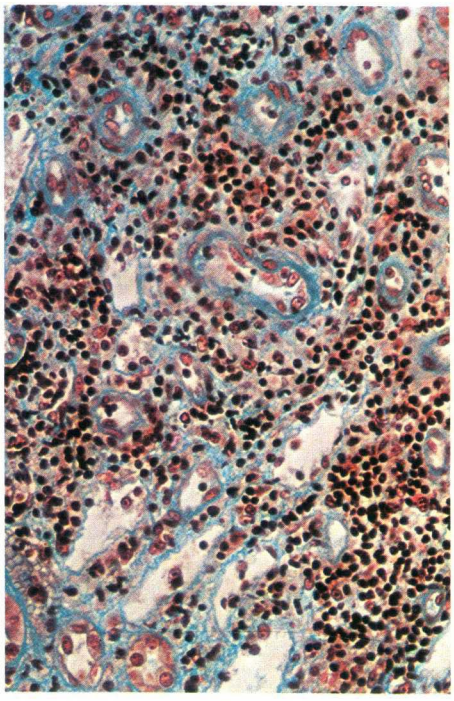
Recent Developments

In the late 1960s, there was great optimism for transplantation, and many operatons were performed. However, the number dropped off sharply in the early 1970s, when problems with rejection kept the success rates low. With the recent development of the immunosuppressive drug cyclosporine, there has been a dramatic increase in transplant operations and their success rates. The success rate of liver transplants in children based on a one-year follow-up has increased to 70 percent from 38 percent in the past; in adults, from 27 to 68 percent. Up to 80 percent of kidneys transplanted from cadavers now function after a year, compared to the less-than-50-percent success rate of a few years ago.

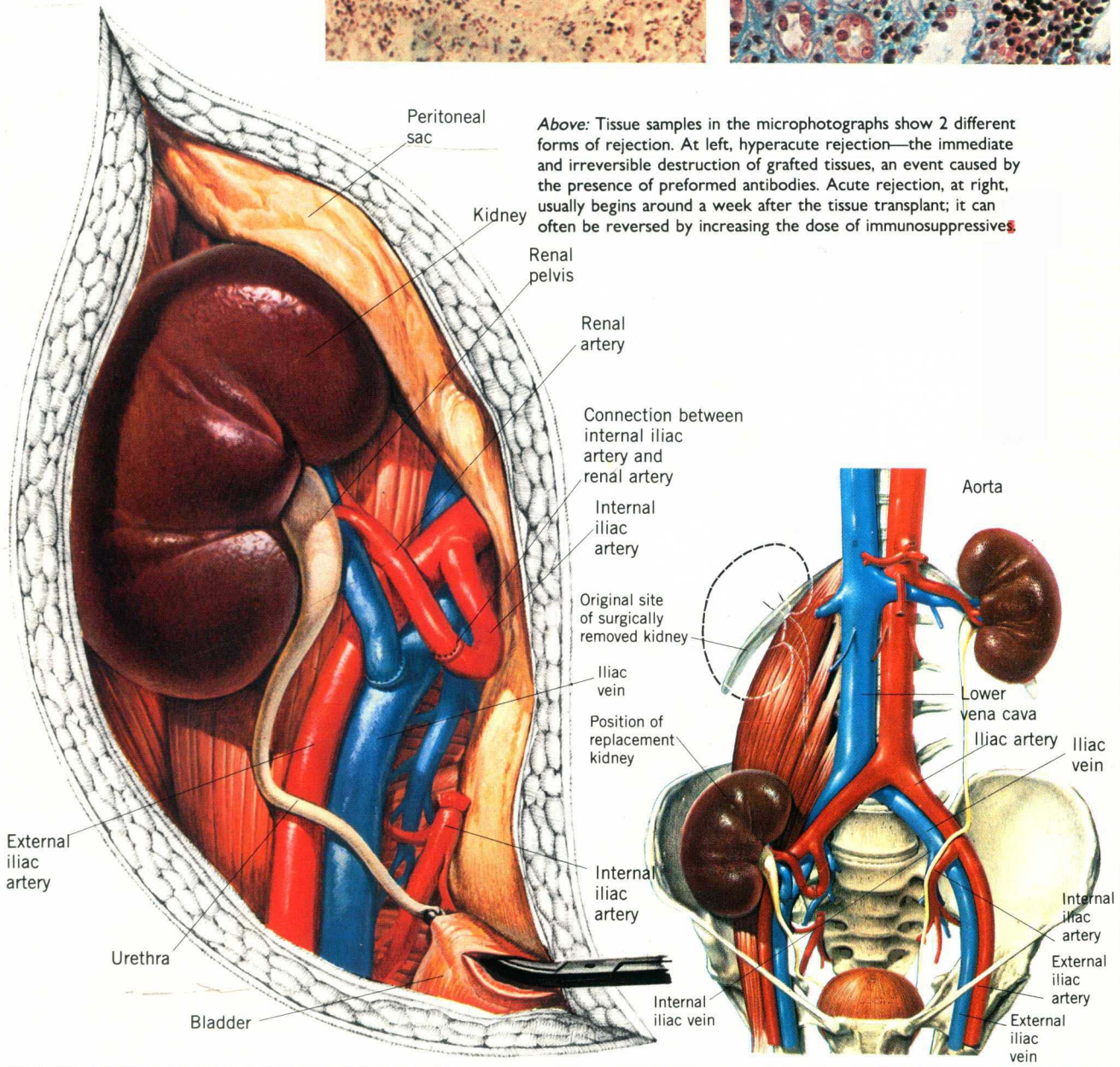


Left and below: Series of illustrations shows aspects of a kidney-transplant operation. The patient is positioned on the operating table, and an abdominal incision is made to permit access to the lumbar and inguinal regions. In the meantime, a donor kidney is flushed with a sterile solution to remove all traces of donor's blood. Then the patient's diseased kidney is removed. As seen below, the new kidney is attached to the appropriate blood vessel, and the urethra is inserted directly into the bladder. *Below right:* Position of new kidney within body.





Above: Tissue samples in the microphotographs show 2 different forms of rejection. At left, hyperacute rejection—the immediate and irreversible destruction of grafted tissues, an event caused by the presence of preformed antibodies. Acute rejection, at right, usually begins around a week after the tissue transplant; it can often be reversed by increasing the dose of immunosuppressives.



Organometallic Compounds

The term "organometallic" sounds somehow paradoxical. *Organo* suggests life, yet nothing seems so devoid of life as metal. The paradox is resolved when we realize that organic chemistry is the study of compounds involving carbon atoms. Organometallic compounds are compounds in which a metal atom is bonded to a carbon atom. Certain of these compounds are important to life processes, among them Vitamin B_{12}, which is a carbon compound called cobalamin and includes an atom of the metal cobalt.

Main and Transition Metals

Organometallic compounds can be divided into two broad classes: those including atoms of main metals, and those including atoms of transition metals. The terms "main" and "transition" here refer to the place of the metal in the periodic table of the elements—a table that arranges the elements according to certain properties of their atoms. Examples of main metals are aluminum, tin, lead, and bismuth. Examples of transition metals are zinc, iron, copper, silver, and gold. There is argument as to whether certain other elements with metallic properties, such as silicon, truly count as metals. Thus, it is debated among chemists whether carbon compounds that include an atom of silicon are truly organometallic.

Main Metal Organometallics

Organometallic compounds involving main metals have a wide variety of uses. Until very recently, the most prominent example was tetraethyllead, which was added to gasoline to prevent engine knock. Tetraethyllead works by delaying the ignition of the gasoline in the engine. However, lead compounds in engine exhaust interfere with the devices now used to clean the exhaust before it is released into the atmosphere, thus contributing to the problem of air pollution. For this reason, the use of tetraethyllead has declined.

Organo-aluminum compounds are used to aid the production of synthetic rubber, biodegradable detergents, and pharmaceutical chemicals. Organo-tin compounds are used as stabilizers in polyvinylchloride (PVC), helping the PVC to maintain properties such as color during heating. Organo-tins are effective poisons for fungi and other organisms. Thus, they are used to preserve wood, to protect various crops, and in antifouling paints for ships. Organometallic compounds of the exotic metals gallium and indium are being considered for use in the production of semiconductors for electronics components.

Transition Metal Organometallics

In general, organometallic compounds involving transition metals have a different kind of use from those involving main metals. The organo-transition compounds are not themselves part of a final product, put to this or that application. Instead, they serve as catalysts, speeding up chemical reactions by which the final products are produced. Many chemical reactions used in industry would, by themselves, proceed too slowly to be economical. Catalysts act to accelerate reactions, roughly by bringing the atoms of the reactants together in close proximity. The catalyst, however, does not itself participate in the reaction. Although at the end of the reaction the reactants have been transformed into a new product, the catalyst remains