star's crust or from matter falling onto the crust and somehow fracturing it. Depending on the particular hypothesis, the falling matter could be anything from gas thrown off by a companion star to the nucleus of a comet drawn in by the neutron star's gravitation.

Another hypothesis posits that chunks of antimatter occasionally collide with a star, and that the mutual annihilation of some of the star's matter and the antimatter yields the gamma rays. It has also been proposed that there are tiny black holes left over from the formation of the universe that are slowly evaporating; at the end of their life they emit huge amounts of energy, some of which is in the form of gamma rays. Closer to home is the suggestion that an occasional grain of interstellar dust, approaching the solar system at nearly the speed of light, encounters photons moving outward from the sun and generates a burst of gamma rays by fluorescence. In a recent article in *The New Scientist* Andrew Fabian and James Pringle of the University of Cambridge remark: "Let us . . . hope that the rate of discovery of new bursts exceeds the rate of production of new theories."

Good Juice

The traditional procedure for harvesting a forage crop such as alfalfa usually entails making three trips through the field: one to cut the crop, one (sometimes bypassed) to rake it so that it will dry more thoroughly and one to pick it up. The procedure results in certain losses; for example, as much as 20 percent of the dried leaf and small-stem material, which is the most nutritious part of the plant, can shatter and fall to the ground. The proteins and amino acids of forage crops are not fully utilized in another sense: since such crops can be digested only by ruminants, the nutrients in them are not directly available to other animals, including man. In an effort to exploit the full potential of forage crops an interdisciplinary group at the University of Wisconsin has developed a program for extracting proteins and amino acids from such plants in the form of juice, producing a concentrate that is suitable for a wide range of animals and leaving a solid residue that is still nutritious for ruminants.

In the Wisconsin method the crop is harvested in a single pass through the field and then put into a machine that separates the juice from the fiber. The concentrate can be sold off the farm as high-protein feed, a food or a food additive, and the residue can be dried or put into a silo. Indeed, according to Neal Jorgensen, a dairy-science specialist with the program, the process "enhances silage production," because after the extraction of juice "the remaining nutrients in the plant fibers are readily exposed to fermentation bacteria and enzymes" and fermentation is faster than in conventional ensiling.

The Wisconsin workers tried their process on a number of crops and found that alfalfa yields the most protein per acre. Mark A. Stahmann, a biochemist with the program, wrote: "Fresh-cut alfalfa contains about 21 percent protein and 23 percent fiber. With our small machine we extracted 43 percent of the protein. This was spray-dried to form a green powder containing 35 percent protein, .7 percent fiber and about 40 percent nitrogen-free extract, largely carbohydrates. The residue contained 16 percent protein and 33 percent fiber. The spray-dried alfalfa juice contained 16 times more thiamine than dehydrated alfalfa, about twice as much riboflavin, three times more carotene and 3½ times more xanthophyll."

The Wisconsin group is also interested in extracting protein from vegetable wastes such as beet tops, carrot tops, bean plants and potato vines. Stahmann has estimated that some 21 million tons of these wastes, containing 393,000 tons of protein, are lost in the U.S. annually. Protein extracted from such sources, he says, could be made into nutritious concentrates for animals and "might be converted into food for humans as is now done with soybean meal."

The Artificial Lung

The artificial lung may soon join the list of dependable man-made temporary replacements for malfunctioning human organs. It is still in an experimental stage and far from being available for routine treatment, but in the past seven years it has saved some patients suffering from acute respiratory failure; it can take over the function of the lungs for much longer periods than the heart-lung machines developed in the 1950's. Now a major test of the artificial lung is under way in nine centers established during the past year in a three-year collaborative program sponsored by the National Heart and Lung Institute.

What the human lung does, of course, is exchange gases: oxygen and carbon dioxide. Blood flows through fine capillaries wrapped around 300 million tiny sacs, the alveoli, into which inspired air is drawn. Molecules of gas diffuse across the thin membrane consisting of the walls of the alveoli and the capillaries in the direction of the concentration gradient. There is more oxygen in the air than in the deoxygenated hemoglobin of the venous blood, and so oxygen molecules diffuse from the air to the blood; conversely, carbon dioxide is more concentrated in the blood and so it diffuses in the opposite direction. In the artificial lung, or membrane oxygenator, the same result is achieved, albeit less efficiently. A silicone-rubber membrane is substituted for the alveolar and capillary tissue; oxygen moves over one side of the membrane and venous blood over the other side, and the gases are exchanged. In a version developed in 1962 by Theodor Kolobow of the Heart and Lung Institute the membrane is shaped into a flat sleeve that is wrapped repeatedly around a spool. Oxygen is aspirated through the sleeve, and blood from a large vein of the patient is circulated in the spaces between the layers of the coiled sleeve.

The thinnest practicable rubber membrane is far thicker than the natural one and its total surface is only some five square meters as compared with the human lung's 75 square meters of gas-exchange surface. Moreover, the blood layer is so relatively thick that a stagnant layer develops along the membrane, further reducing gas exchange. As a result most artificial lungs can transfer only about 250 milliliters of oxygen per minute, which is the normal requirement for a resting adult.

Acute respiratory failure can result from a wide variety of diseases and conditions including pulmonary embolism, pneumonia, direct injury to the lung and a "shock lung" syndrome that sometimes follows massive trauma. The function of the artificial lung is to take over part or even all of the gas-exchange function until the natural lung recovers. To date some 150 patients in the advanced stages of acute respiratory failure have been supported on the artificial lung for up to three weeks; about 15 percent of the patients eventually recovered. The therapy should be applied in far more cases and should be instituted earlier, according to Warren M. Zapol of the Massachusetts General Hospital, one of the leaders in developing the membrane oxygenator. The objective of the new investigative program organized by the Heart and Lung Institute is to accumulate a large number of cases under standard conditions and criteria of success in order to evaluate the effectiveness of the artificial lung as compared with conventional treatments.