are connected with life. In a supernova explosion, as we have already mentioned, vast quantities of atoms from the surface of the star are ejected at very high velocities into interstellar space. In the case of the neutron star, there is, because of its rapid rotation, a zone, not far from its surface, which is rotating at almost the velocity of light. Particles are ejected from that zone at speeds so great that the theory of relativity must be taken into account to describe them. Both supernova explosions and the high-velocity zone surrounding neutron stars must produce cosmic rays—the very fast charged particles (mostly protons, but containing all the other elements as well) which pervade the space between the stars.

Cosmic rays fall on the Earth's atmosphere. The less energetic particles are absorbed by the atmosphere or deflected by Earth's magnetic field. But the more energetic particles, the ones produced by supernovas or neutron stars, penetrate to the surface of the Earth. And here they collide with life. Some cosmic rays penetrate through the genetic material of life forms on the surface of our planet. These random, unpredictable cosmic rays produce changes, mutations, in the hereditary material. Mutations are variations in the blueprints, the hereditary instructions, contained in our self-replicating molecules. Like a fine watch repeatedly hit with a hammer, the functioning of life is unlikely to improve under such random pummelings. But as sometimes happens with watches or bulky television sets a random pummeling does occasionally improve the functioning. The vast bulk of mutations are harmful, but the small fraction of mutations that are an improvement provide the raw material for evolutionary advance. Life would be at a dead end without mutation. Thus, in yet another way, life on Earth is intimately bound to stellar events. Human beings are here because of the paroxysms in dying stars thousands of light-years away.

The birth of stars generates the planetary nurseries of life. The lives of stars provide the energy upon which life depends. The deaths of stars produce the implements for the continued development of life in other parts of the galaxy. If there are on the planets of dying stars intelligent beings unable to escape their fate, they may at least derive some comfort from the thought that the death of their star, the event that will cause their own extinction, will, nevertheless, provide the means for continued biological advance of the starfolk on a million other worlds. □

OFF *the* BEAT

Physics is as physics does

The recent survey that shows (again!) that students dislike physics and physicists (SN: 10/13/73, p. 230) leads me, as a former physics student, to comment. It is true that physics is dismally taught in most of our high schools and many colleges, but the matter will not be rectified by teaching physics as if it were one of the humanities.

Physics *is* one of the humanities. It has a beauty and an intellectual value all its own which must be taken on its own terms. In my undergraduate days the problem was that physics was taught for engineers. Since there are many more engineers than physicists, this practice may persist in some places. Students wasted a lot of time with such artifacts as frictionless ladders and bridge catenaries when they might have been working on something of physical interest (Hamiltonian dynamics, perhaps).

Physics should be taught as for physicists. It is not poetry nor prose, painting nor sculpture, and it will only suffer if it is taught as if it were one of them. Physics has its own integrity and is its own justification for being.

It is true that I did not apprehend this until several years after I last had to worry about integrating the most devilish differential equation a textbook writer could devise. (There is a beauty in differential equations too, but it is seldom apprehended while one is taking a course in them.)

Let us take Maxwell's equations as an example. Too often they are taught as a handful of formulas to plug into problems. They have all the limpid brevity of a haiku, and the beauty of their conciseness should be appreciated. Yet the profundity contained within that small collection of symbols is awesome. To be a little Pythagorean, in them is contained one of the foundation stones of the universe. If the students haven't learned that, they haven't learned any physics. Professor Hla Shwe of East Stroudsburg State College has rewritten part of the book of Genesis as follows:

"And the earth was without form and void. . . . And God said,

$$\text{'Curl } \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$$

$$\text{Curl } \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\text{Div } \mathbf{B} = 0$$

$$\text{Div } \mathbf{D} = \rho\text{'}$$

And there was light."

But then nobody likes to go to Sunday school either.

—Dietrick E. Thomsen

Sagan, Starfolk, UFO's

Carl Sagan, whose article "The Starfolk" appears in this issue, has probably spent more time studying and writing about the possibilities of intelligent extraterrestrial life than any other scientist in the past decade. So it's natural that he gets many questions about UFO's. But, like most other scientists, he puts little credence in UFO reports. "I don't think UFO's are connected with the problem of intelligent extraterrestrial life," he says, adding, with a smile: "They might be connected to the problem of *terrestrial* life with some *undetermined* degree of intelligence." Speaking to a capacity audience at the Goddard Space Flight Center a few weeks ago during the height of the flurry of UFO reports—"UFO flap, I believe is the technical term"—Sagan summarized his view of the situation this way: "The remarkable thing about UFO stories is that there are many interesting reports which are unreliable; there are many reliable reports which are not very interesting; but I don't know of any that are both interesting and reliable."

Sagan, in response to questions, also had some less than kind words for Erich Von Daniken's book *Chariots of the Gods*, which attempts to show that Earth was visited in the past by beings from other planets. "The book is absolutely dreadful," he says. "The only thing worse is the ABC documentary on the subject [*Ancient Astronauts*]. ABC's program had every conceivable error."

—Kendrick Frazier