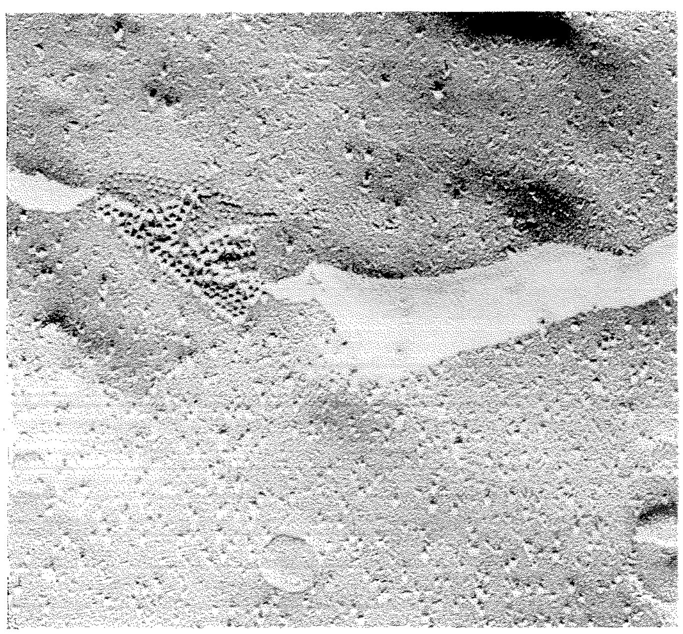
Research Notes

Bridging the Gap Junction

It is well known that specialized kinds of cells in the human body—brain, nerve, and muscle cells, for example—have sophisticated and well-defined systems of interaction and communication. However, scientists now believe there is another cell interaction that occurs in most, if not all, tissues regardless of their function—a generalized interaction that takes place in the excitable tissues of the heart, smooth muscle, and nervous system, as well as in the non-excitable tissues of the rest of the body.

Research by Jean-Paul Revel, professor of biology, indicates that this cell interaction (called "electrotonic coupling") may be associated with special intercellular contacts called "gap junctions." These junctions are about 20 Angstrom units wide (80 billionths of an inch).



This electron micrograph of a portion of two baby hamster cells and the space between them (light band across the center) is magnified about 150,000 times. The narrowing of intercellular space at the left—and the pits and particles associated with it—is a "gap junction."

Revel has found what appears to be an array of small pits or closely packed particles bridging the gap between two cells. While it has not been proved conclusively, there is a high degree of circumstantial evidence linking the particular shape and internal structure of the gap junctions to electrotonic coupling and possibly to other forms of intercellular communication as well.

The purpose of the contacts, or gap junctions, seems to be to pass ions between cells. The ions vary in molecular weight from 39 to about 10,000 as a rule, but in some cases ions with molecular weights of as much as 50,000 have been passed.

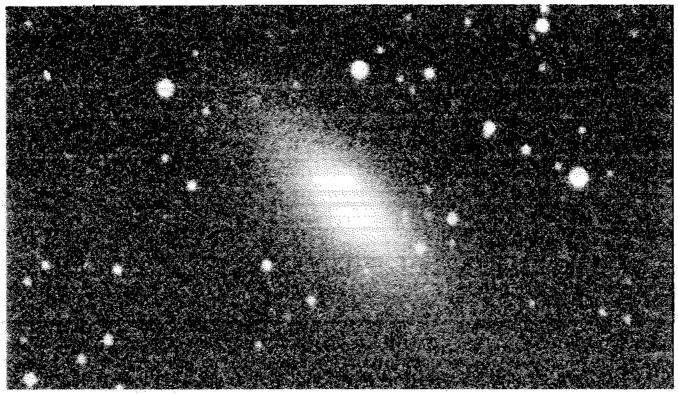
What the roles of electrotonic coupling and the gap junction are in the body is not yet clear, but it is surmised that they may play an important part in the control of cell growth. If this is so, it would give scientists some clues about cell differentiation and development in multicellular organisms—why cells from the same ancestor diversify to form the various specialized organs and tissues.

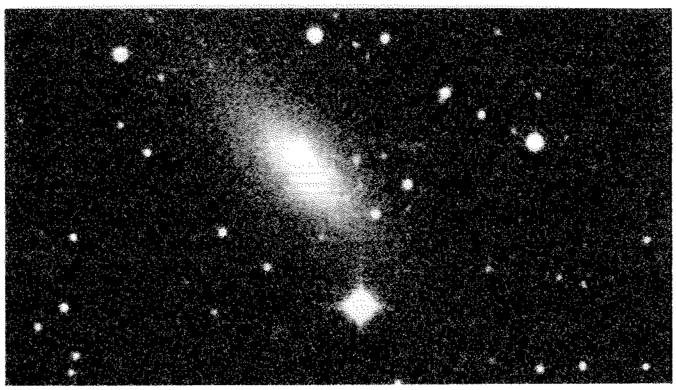
Cosmic Explosion

On the night of May 13 the 18-inch Schmidt telescope at Palomar Observatory was set to scan an area of the sky in the Constellation of Centaurus when its camera caught a star in another galaxy in the act of exploding. This exploding star, called a supernova, is the brightest one seen in 35 years. In fact, it is brighter than the entire galaxy in which it resides.

The supernova was discovered by Charles Kowal, a member of the staff of Caltech's Robinson Laboratory, who apparently photographed the explosion near its peak. Of magnitude 8.5, it was not quite bright enough to be seen with the unaided eye, and it is fading away rapidly, though it will be visible in small telescopes through July.

Stars at least four times as massive as the sun are believed to end their cosmic lives in supernova explosions after they have exhausted their hydrogen and helium fuels. They collapse, and this results in a titanic explosion. Normally, the maximum brightness of a supernova lasts a couple of weeks. Then it loses its brilliance and may collapse into a pulsar—a class of fast-spinning stars





Comparison of two photographs of stars in the Constellation of Centaurus reveals a supernova occurring in the tenuous spiral arm of the galaxy NGC 5253 (just below center). Of magnitude 8.5, it is the brightest recorded in 35 years.

that emit rapid radio pulses. (Smaller, sun-size stars are thought to shrink into white dwarfs.) Astronomers are interested in the explosion phenomenon because it marks the end of the evolutionary life of a larger star and because supernovae offer the possibility—through their brightness and red shifts—of becoming a yardstick to measure the universe.

Kowal discovered the supernova while examining photographs of a large spiral galaxy (NGC 5236) which has had four supernovae since 1923. The small galaxy (NGC 5253) in which this supernova was found is near the large one and had a supernova in 1895 of magnitude 8.

Kowal spends six nights a month at Palomar surveying the sky for supernovae in a research program directed by W.L.W. Sargent and Leonard Searle, staff members of the Hale Observatories. Aided by a grant from the National Science Foundation, they oversee the supernovae search that was started in the 1930's by Fritz Zwicky, professor emeritus of astrophysics. The Palomar search has resulted in the discovery of 200 of the 300 supernovae that have been recorded—most of which are only about one-thousandth as bright as the one Kowal just discovered.

New Data on Ground Shaking

The San Fernando earthquake, already more than a year in the past, is still providing engineers with a gold mine of information—and some knotty problems as well. Evaluation of the data by Paul Jennings, professor of applied mechanics; Ronald Scott, professor of civil engineering; and Donald Hudson, professor of mechanical enginering and applied mechanics, has led them to question a number of longstanding assumptions about the nature of earthquake motions.

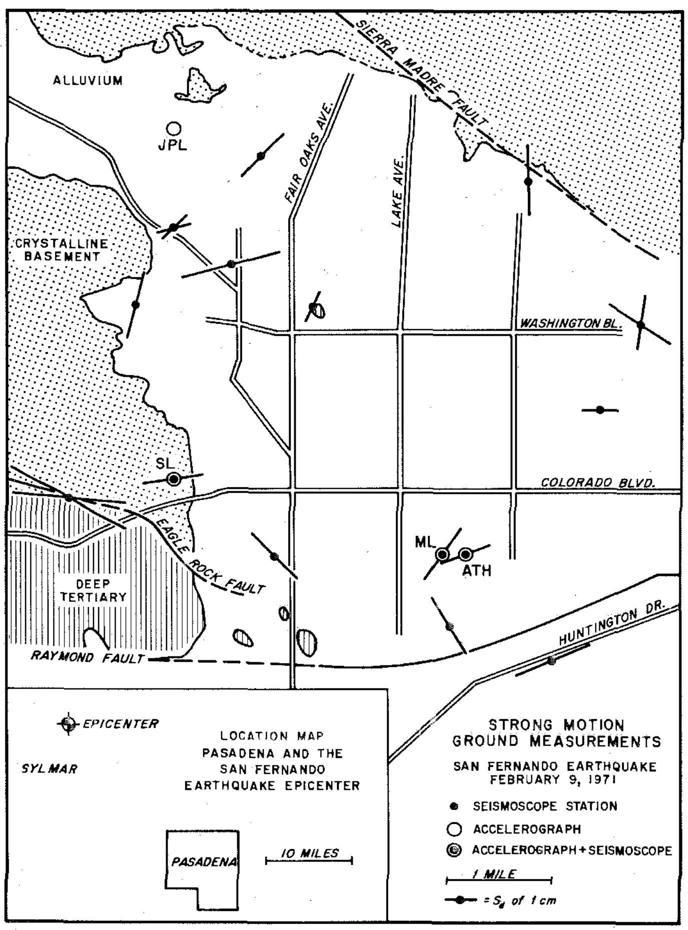
The general picture that emerges from a study of the distribution of accelerograph and seismoscope readings is one of considerable complexity. In general, recorded accelerations for this quake were very similar whether the strong-motion instruments were located on rock or on alluvium. At some stations located on rock—Caltech's Seismological Laboratory, for example—the instrumental response was relatively large; some stations on alluvium showed small response. On the campus, where the alluvium is about 900 feet deep, the seismoscope readings for Millikan Library and the Athenaeum show significantly different values—and these two buildings are less than three-tenths of a mile apart.

The instrument data do not support the assumption that the firmer the ground on which a structure is built, the less an earthquake will shake it. The general character of the motions recorded appears to be unrelated to the firmness of the ground over a wide range of conditions. It may be that the soils in this area are not sufficiently soft to show the sort of effects that have occurred on the very soft deposits of Mexico City, for example. Perhaps the soils here are so firm that any soil effects are much smaller than the fluctuations in motion from other causes, such as the travel paths of the seismic waves and the nature of the motion at the source of the earthquake.

Instrument readings of the quake indicate that its motions varied more than the scientists expected in three ways:

First, the assumption that the farther a site is from a quake epicenter, the less intense the shaking it receives still holds true generally, but it is not borne out consistently. There was a lot more scatter than expected. At one point 40 miles from the epicenter, the peak acceleration was only .08 of the force of gravity, but at another place, also 40 miles from the epicenter, it was .24g.

Second, the motion varied more widely at points near each other than anyone had previously considered likely. An example of this is the variation in shaking at the Millikan Library and at the Athenaeum. Although the general character of the shaking was the same, the shaking at the library was somewhat greater. Why this should be



Unexpectedly complex records of the San Fernando earthquake made in Pasadena contradict some longstanding assumptions.

is not clear. The explanation that occurs first is that the difference is due to the different character of the buildings. But even though Millikan is eight stories high and the Athenaeum only two, present theories of building dynamics do not explain why the first was shaken more violently than the second.

The third variation from expected motion was the differences in the strength of shaking in different directions at the same point. At Millikan and the Athenaeum, there was very little difference between the east-west and north-south components of motion. However, at the Seismological Laboratory the east-west motion was two to three times stronger than the north-south. Possible explanations for this include modification of the earthquake waves by local geology along the travel path, and the type of motion generated at the earthquake source.

One conclusion that can be drawn thus far from the studies of the San Fernando earthquake is that predictions of ground shaking based on measurements at a number of sites of many small earthquakes may not correspond very well to what actually occurs during a damaging earthquake. Up to the present, calculations have been based on what scientists believe to be the "average" conditions of ground shaking that a particular location can expect. But long-term average conditions are of small comfort to an engineer whose structures are destroyed by an earthquake that happens to depart from the average.

The significance of average conditions becomes vague when it is considered that most structures will probably be exposed to only one damaging earthquake during their lifetime. By the time the local distributions of a number of large earthquakes are superimposed, the average conditions will be considerably smoothed out, and the seismic zoning map may approach a one-zone pattern. Considerable caution must thus be used in the preparation of detailed local seismic risk maps.

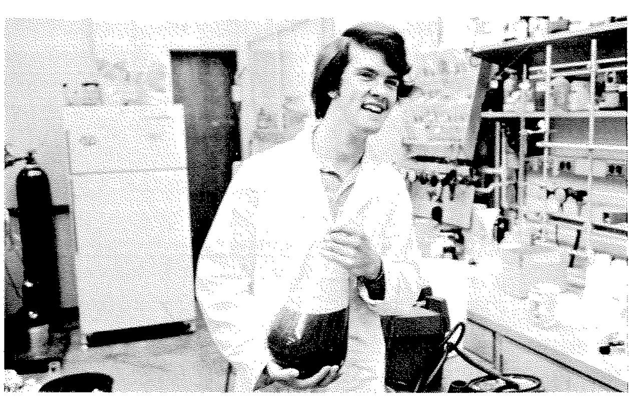
All these variations in strong earthquake motion will make the job of structural engineers harder. The variations in ground motion are too large to be ignored, and it does not appear possible to describe the strength of shaking consistently by means of simple rules or calculations.

The Bean Freaks

Harry Gray's "bean freaks" now know that scientific research sometimes requires more than just mental effort. The graduate students under Gray, professor of chemistry—they are formally known as the bio-inorganic chemistry group—are studying the metalloproteins involved in photosynthesis, the process by which light energy is transformed into chlorophyll and chemical energy in plants. One student, Don Fensom from the University of Sydney in Australia, is studying the metalloprotein *plastocyanin*. To complete his work this spring he needed about five grams of the purified substance. This meant Fensom and his friends had to pull up about a quarter of an acre of green bean plants by their roots at the Jeffrey Ranch of the Western Marketing Company near Irvine, load about a ton (907,000 grams) of plants onto a truck, and drive them back to Caltech. At the Institute they spent three days stripping half a ton of leaves from the plants, stuffing them into 50-pound-capacity bags, and storing them in a freezer to prevent decomposition.

For their leaf-stripping efforts, the bean freaks—including Barry Donher, John Robbins, Jill Rawlings, Bob Holwerda, and Leslie Hodges—received a rich bonus: a 50-pound feast of fresh green beans.

Each bag of leaves was reduced to a green liquid mush in a blender. The fibrous residue was filtered out by pouring the mixture through a porous plastic material.



Barry Donher holds the results of a day's filtering—several quarts of dark brown juice. The next step is to add various chemical agents to precipitate out most of the plant material except for plastocyanin and a few other metalloproteins.

Fensom processes the liquid several times through a series of filtration columns to separate the proteins on the basis of electric properties and molecular weight. The resulting liquid, now dark blue, is pure copper protein—plastocyanin.

Telescopes with Television

For almost 100 years photographic plates at the focal point of a telescope have been the major means of recording astronomical images. Useful as this technique is—and will remain in many areas of astronomy—some of the world's largest telescopes, including those of the Hale Observatories, are being switched to the use of sophisticated television systems to record the details of planetary atmospheres, faint galaxies, and quasi-stellar objects.

One such system, the image intensifier tube, has been used since the 1950's and simply brightens the image. Another older type of device, the photomultiplier tube, produces an electrical signal that is a measure of light intensity. It registers light from a single undifferentiated element but cannot map an entire image. A third device, called an image dissector, functions like a single photomultiplier tube with directional capabilities and is able to scan an entire image in successive elements.

A successor to this is a device developed at Princeton University and used on the 200-inch Hale telescope to obtain details of gaseous cloud banks apparently associated with a quasar that may be the second most distant object known.

The device is called a vidicon, and it differs from earlier systems in that it has a memory. It can build up images on a target for an exposure as long as six hours. Working by converting a visible image into a pattern on a target, vidicons for astronomy are designed for very slow scan rates in order to achieve better sensitivity to all wavelengths of light, especially the infrared and ultraviolet.

One adaptation, the modified SEC (secondary electron conductivity) vidicon, has been used by Maarten Schmidt, professor of astronomy and a staff member of both the Hale Observatories and the Owens Valley Radio Observatory; J. Beverley Oke, professor of astronomy and associate director of the Hale Observatories; and Donald Morton of Princeton to delineate six specific layers—and several other possible ones—between earth and the quasar PHL-957, which is about nine billion light years away.

In related research, James A. Westphal, associate professor of planetary science, and Thomas McCord, associate professor of earth and planetary sciences at MIT and director of MIT's Wallace Astrophysical Observatory, have adapted the vidicon for use as a photometer. The heart of the system is a silicon diode vidicon tube. Incoming photons (packets of light) are collected by the telescope and focused onto the tube's wafer of silicon, which is two-fifths of an inch square. In the diode the photons are transformed into electrical charges. A microscopic electron beam scans the wafer, extracts the information, and stores it on a computer tape.

This system will give telescopes ten times keener vision at great distances than the traditional methods. The photometer will be used by Westphal and McCord to observe the recently discovered neighboring galaxies, Maffei I and II (*E&S*, February 1971). These two galaxies are difficult to see optically from the earth because they lie on the other side of the disk of the Milky Way Galaxy, with much interstellar dust intervening. The photometer will be used to observe them in the infrared, which penetrates the dust.

In its initial testing stages, the photometer was used by McCord and Westphal at the Cerro Tololo Inter-American Observatory in Chile to measure the reflected light (albedo) of Mars and Jupiter, and they have begun using one on the 100-inch telescope at Mt. Wilson for taking spectra of cosmic objects.

In addition to sensing stars, quasars, and planets, vidicon systems have been used to steer large telescopes more efficiently. It is now possible to use stars fainter than those the eye can see to guide telescopes, and this results in saving a great deal of observing time that would otherwise be wasted in sighting and checking. Also, an astronomer can oversee all the details from a warm, lighted room instead of spending the night bundled up in a small cage at the end of the telescope—the astronomers' usual lot.