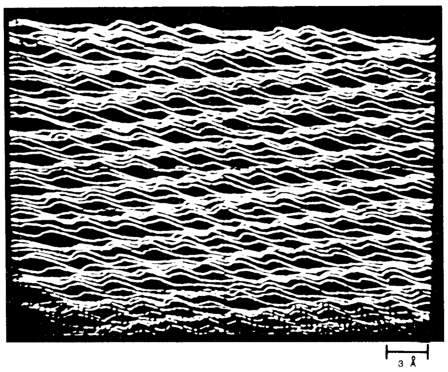
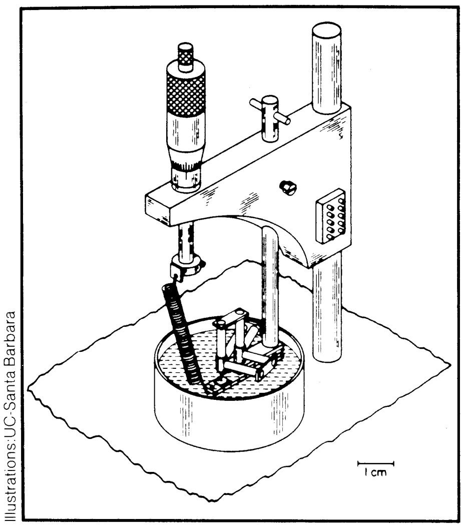




Images of an underwater graphite surface showing features smaller than 3 angstroms (above) are possible with a special scanning tunneling microscope (right) designed to work with immersed samples.

Illustrations: UC-Santa Barbara

leys that fell into the hexagonal pattern of graphite's characteristic honeycomb lattice. The researchers also obtained lower-magnification images of a gold film immersed in a sodium chloride solution.

Meanwhile, IBM and Stanford University scientists have modified a scanning tunneling microscope to map forces on the surfaces of both conducting and insulating materials. Conventional tunneling microscopes work best if the sample is an electrical conductor.

This new device, called an atomic force microscope, has a diamond tip mounted on a tiny gold-foil spring, which is sandwiched between a sample and a microscope needle's tip. Fluctuating forces between atoms in the sample and on the end of the diamond tip cause the tip to waver slightly.

As the diamond tip scans a surface, the changes in the tunneling current reflect the arrangement of atoms on the surface. A prototype instrument has mapped the surfaces of insulators to a resolution of 30 angstroms, which is getting near the atomic-scale resolution possible for conductors like graphite. *— I. Peterson*

Physics to the end of the century

Every decade or so the National Research Council issues a report on the state of the science of physics in the United States. These reports contain surveys of recent progress in the science, assessments of prospects for the immediate future and advice to the government on how to foster that future. Since World War II the federal government has been the largest patron of basic scientific research in the country, and although some astronomers have recently returned to the older custom of seeking large private gifts for capital equipment (SN: 1/12/85, p. 21), the government is likely to remain the builder and owner of the accelerators and similar equipment that physicists need.

"Physics Through the 1990s," the latest in this series of reports, authored by the council's Physics Survey Committee under the chairmanship of William F. Brinkman of Sandia National Laboratories in Albuquerque, N.M., was published last week. It is intended to cover physics to the end of the century. In its prognosticating and advisory aspects, the eight-volume report contains a few things that are not surprising and some that are mildly surprising.

One of the latter is a plea for better support of small research groups. "Research carried out by small groups . . . is responsible for over 70 percent of the physics doctorates that are awarded in this country," says the summary distributed to the press. The image of physics is that of a science where it can take upward of 1,000 people to mount a single experiment (SN: 1/19/85, p. 45). Dozens, even more than a hundred, routinely sign a single research paper. Yet there's another side. As the report points out, "[S]mall group research is the dominant mode for professional education in the universities. . . ." The committee recommends greater support, particularly in matters of equipment, for these groups.

The committee also foresees a possible shortage of physicists in coming years unless more young people can be recruited. In the 1960s there was a shortage of physicists, in the 1970s an oversupply, in fact something of an employment crisis. Now the pendulum seems to be swinging back. Momentarily supply and demand are in approximate balance, but a shortage could develop in the future.

The list of capital equipment desired is shorter than the ones presented in previous decades. For particle physics the committee recommends the Superconducting Super Collider (SN: 9/22/84, p. 181), the most powerful accelerator that ever was or is likely to be. For nuclear physics it recommends the Continuous Electron Beam Accelerator Facility, which is planned for construction in Newport News, Va., and an apparatus to collide atomic nuclei with each other at relativistic speeds. All three of these already have significant support in government agencies and Congress, as does the recommendation for condensed-matter physics, new synchrotron-radiation facilities and neutron scattering facilities.

In plasma physics the committee recommends continued efforts toward controlled thermonuclear fusion, both magnetic confinement and inertial confinement experiments. It endorses what it calls the next logical step, the so-called burning core experiment.

The really unusual departure is the recommendation of the Long-Baseline Gravitational-Wave Facility (SN: 8/4/84, p. 76). Gravitational waves are disturbances supposed to be caused by motions of large astronomical bodies. They are the gravitational analog of radio waves — cyclic disturbances of gravitational forces — as radio waves are cyclic disturbances of electric and magnetic forces. They have not yet been unequivocally discovered, but when they are found, they will tell us new things about the cosmos. Up to now they have been considered a rather exotic specialty. If the report, which is published by National Academy Press, is any indication, maybe they are now becoming mainstream. *— D.E. Thomsen*

Extremely magnetic degenerate dwarf

White dwarfs can be fascinating. They are sometimes degenerate, and they are often shifted well to the red. Yet some of them can be very magnetic.

These white dwarfs do not lurk in dark alleys; they are a class of stars found in the distant reaches of our galaxy. White dwarfs are a unique venue for astrophysics. Matter there behaves in ways unattainable on earth. One instance of such behavior is the almost unbelievable magnetic field of 700 million gauss (MG), recently found in the white dwarf PG 1031+234 by a group of astronomers led by Gary D. Schmidt of the University of Arizona's Steward Observatory in Tucson. Schmidt told SCIENCE NEWS that he has never seen a theoretical calculation of the upper limit on a white dwarf's magnetic field, but he expects that 700 MG approaches the maximum possible strength for such a field.

The earth's field, which is approximately 1 gauss, is more typical of magnetic fields found in nature. The most powerful long-lasting magnetic fields in terrestrial laboratories go to a quarter-million gauss, and perhaps a little higher than that. "The physical structure of matter as we experience it does not permit the existence of fields like those we have found," says Schmidt. In other words, it pays to be degenerate, but even among magnetic white dwarfs, where conditions are extreme, fields tend to run no higher than tens of millions of gauss. Only one other star has a known magnetic field in this extreme range — another degenerate white dwarf, catalogued as Grw +70° 8247, which has about 300 MG.

An account of the determination of PG 1031+234's magnetic field will appear in the Oct. 1, 1986 ASTROPHYSICAL JOURNAL. Joining Schmidt in the work were Steven C. West and James Liebert of the Steward Observatory, Richard F. Green of Kitt Peak National Observatory in Tucson and H.S. Stockman of the Space Telescope Science Institute in Baltimore.

PG 1031+234 is unique in another important respect: It rotates, and does so very fast for a white dwarf or any other kind of star, going around once in three hours and 24 minutes. Rotation allows astronomers to study the structure of the star's field from many different perspectives. Grw +70° 8247 does not rotate.

The structure of PG 1031+234's magnetic field is also somewhat complicated. There is a basic dipole structure similar to the earth's magnetic field, although the white dwarf's dipole is more widely angled to its rotation axis than is the case on earth. Added to the dipole is a large magnetic spot, a place where magnetic field lines emerge but continue straight out into space rather than bending around to another pole as a dipole field does. The spot is similar to the magnetic spots seen on the sun but is a great many times as strong.

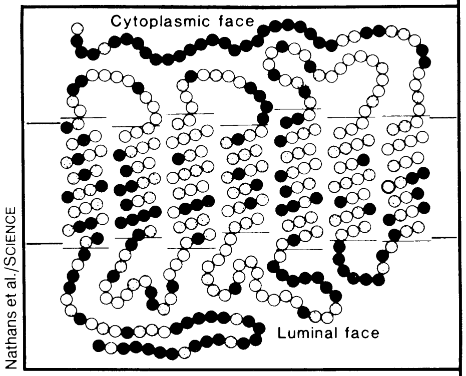
Both the rotation and magnetic field appear to be relics of PG 1031+234's youth, eons before it became a white dwarf. White dwarf status comes at the end of a star's life. It results from a tremendous collapse under the influence of the star's own gravitational self-attraction. A star the size of the sun can collapse to the size of the earth.

Such a collapse causes degeneracy, which in physicists' language has nothing to do with morals or ethics. It merely means that a large number of things are jammed together into only a few available energy states. To put it another way, the familiar structures of atoms with their well-defined shells of orbiting electrons are crushed out of existence. What remains is a collection of closely packed nuclei swimming in a "sea" of detached electrons.

Rotations and magnetic fields that already exist can be conserved through such a collapse. The collapse will greatly increase the strength of the magnetic field and the speed of the rotation. Thus the extreme values present in PG 1031+234 could have arisen from relatively ordinary values in a relatively ordinary progenitor star.

— D.E. Thomsen

The genes behind vision's palette



Nathans et al./SCIENCE

Visual pigment similarities: All four human pigments and bovine rhodopsin have the same amino acid in the locations indicated by empty circles; similar amino acids at the stippled circles; and at least one "nonconservative" amino acid difference at the filled circles.

The human brain visualizes the world as a mixture of three primary colors, sensed by pigmented cells in the eye. This view of color vision evolved over centuries of investigation, but has now for the first time been directly demonstrated. Genes that correspond to the red, green and blue color-vision pigments have been identified by Jeremy Nathans, Darcy Thomas and David S. Hogness of Stanford University. Unexpected aspects of their findings give clues to how color vision evolved and may still be evolving.

Tests on color-blind subjects provided critical information in the identification of the pigment genes. Color blindness is caused by the absence of a normal copy of one of these genes, the scientists have demonstrated in collaboration with Thomas P. Piantanida of S.R.I. International in Menlo Park, Calif., and researchers at Roswell Park Memorial Institute in Buffalo, N.Y. Furthermore, they traced a common condition of slightly altered color vision to the presence of an abnormal pigment gene. The brains of people with this condition portray colors as if they were using a slightly different set of paints.

"Through the application of modern recombinant DNA techniques and the analysis of genetic variants, a problem as old as the human effort to understand the real world has been brought to a higher, and most satisfactory, level of understanding," says David Botstein of Massachusetts Institute of Technology in the April 11 SCIENCE in an essay accompanying the color-vision research reports.

The key to the research success was the prediction that all the eye's pigment genes would have similarities due to a common evolutionary origin. Because one single-stranded DNA will bind to another resembling its complementary strand, an isolated gene can be used to search for related DNA sequences.

Nathans and his colleagues first used a gene that had already been identified as that of the bovine visual pigment called rhodopsin. With it they located the gene for the corresponding human pigment, which is used for vision in dim light but not for color vision. Then, with this human rhodopsin gene, they were able to identify three similar DNA sequences. They found the green- and the red-pigment genes on the X chromosome and the blue-pigment gene on the chromosome known as number 7.

Analyses of the genes indicate that a common ancestral DNA segment produced three genes: one that evolved to become the rhodopsin gene, a second that became the blue-pigment gene, and a third that duplicated in more recent evolution to become the green- and red-pigment genes.

The most surprising finding is that the X chromosome of people with normal color vision often contains two or even three copies of the green-pigment gene. The frequent presence of duplicate green-pigment genes "gives evolution some material to experiment with," says Piantanida.

The variation in green-pigment gene number seems to arise from unequal exchanges of DNA between paired chromosomes. These swaps also produce the chromosomes lacking a color-vision gene, in this way creating color blindness. Sometimes the exchanges appear to occur within genes. The result is genes that are hybrids of the red- and green-pigment genes. These hybrids underlie what has been a puzzling defect in color vision.

Among U.S. Caucasian men, 8 percent have defects in their red-green color vision. The most common defect is more subtle than an inability to distinguish red from green. It is observed when the men are asked to mix red and green light to match a certain shade of yellow. Those with "anomalous trichromatism" produce a different shade than does someone with normal color vision. Nathans and his colleagues have demonstrated that these men have, instead of one normal pigment, a hybrid pigment with different light-absorption characteristics.

Now that the visual pigment genes have been identified, scientists expect to be able to obtain for the first time adequate amounts of the pigments for biochemical study.

The intriguing question remains: During fetal development, how does each visual cell determine which pigment it must produce? *— J.A. Miller*