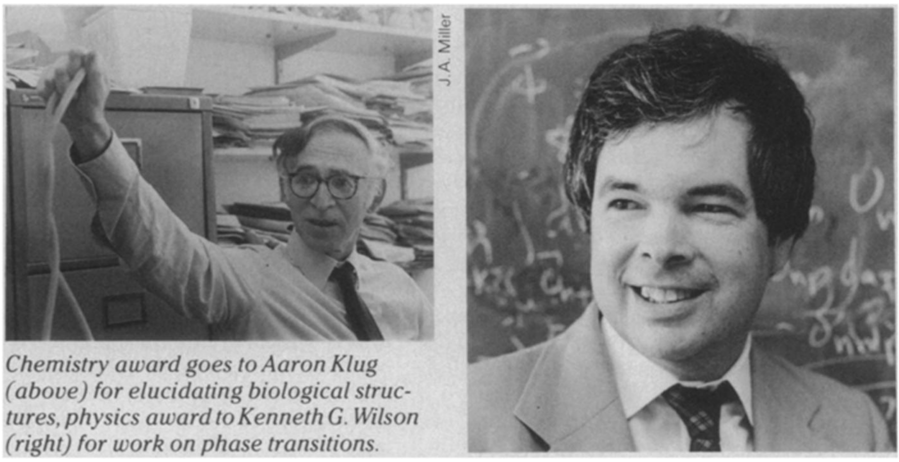
Biological structure, nature of matter are topics of Nobel prizes

The 1982 Nobel prizes in physics and chemistry went to scientists from the United States and Britain, respectively. Aaron Klug of the Medical Research Council Laboratory of Molecular Biology in Cambridge, England, was awarded the chemistry prize "for his development of crystallographic electron microscopy and his elucidation of biologically important nucleic acid-protein complexes." Kenneth G. Wilson of Cornell University won the physics prize for his theoretical work on the behavior of matter.

Klug, who is originally from South Africa, has worked to determine the detailed conformation of what chemists call "large structures" or "macromolecular assemblies." Such aggregates of molecules as simple viruses and cell components are too large for the conventional X-ray diffraction techniques, but still too small to be viewed with a light microscope.

Klug devised methods for applying electron microscopy to such biological structures. "We were forced to develop apparatus and techniques to tackle things that are difficult," Klug told Science News in an interview in Cambridge last year.



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Chemistry award goes to Aaron Klug (above) for elucidating biological structures, physics award to Kenneth G. Wilson (right) for work on phase transitions.

Among the techniques developed by Klug is optical diffraction of micrographs to analyze repeating structures in viruses, muscle and flagella. Klug also employed densitometers and digital computers to interpret electron microscopic images. An important process he developed takes a number of electron micrographs, viewing a specimen from different angles, and constructs the complete structure as a three-dimensional contour map.

Klug has applied the image processing and reconstruction techniques to a variety of problems. He is well-known for his detailed analysis of how the tobacco mosaic virus assembles itself. He says this work was most important for its working out of the techniques. "It was a workhorse for methods," Klug says. "No other system is known in such detail."

The simple virus, a strand of nucleic acid encased in a rod of stacked protein units, aggregates from a flat disk of protein units with an RNA loop inserted into its center. Klug and colleagues determined the structure of the disk at a resolution of better than 3 angstroms to get a detailed atomic model. The virus grows by adding disks that interact with the RNA. Klug says, "This is what we're now aiming for with chromatin [the material of chromosomes] —the interaction of structure and chemistry."

In recent work Klug has described the three-dimensional structure of nucleosomes, the bead-like repeated chromosome subunits made up of proteins, called histones, and DNA. The "very surprising" finding was that the DNA chain wraps around clusters of histones. "It's not beads on a string but a string on beads," Klug says. He and co-workers determined that 166 nucleotide pairs of DNA superhelix make a ramp winding two full turns around a core of eight protein subunits. A separate histone on the outside seals off the nucleosome. Klug says, "The structure of the nucleosomes give a hint as to how things work inside the cell."

The 1982 Nobel prize in physics goes to Kenneth G. Wilson of Cornell University for work on the theory of phase transitions in physical systems. Phase transitions are changes in the way some substance is ordered, such as the change from liquid to gas or from paramagnetic state to ferromagnetic state. Most often phase transitions are induced by changes in temperature, but they can also result from changes in other ambient conditions (chemical balance, for example). The work for which Wilson is cited involved discovering a way to calculate what happens in phase transitions in spite of difficulties engendered by widely varying distance scales.

A problem in physics usually involves a distance scale, that is, a degree of refinement of detail, proper to itself. Calculation can ignore other scales. For example, calculating the orbits of the planets involves distances in the millions of kilometers. The person doing this calculation works on that scale without having to worry about changes taking place on the scale of the molecules or atoms in those planets. Conversely, a scientist working on nuclear structure is concerned with a scale of a few fermis; what is happening at the same time on the moon is not of interest.

Phase transitions, however, do not have this simplicity. Scientists trying to follow the changes in important properties of a substance undergoing a phase transition find that those properties undergo complicated fluctuations in which a wide variety of distance scales are involved. This circumstance led to extreme mathematical difficulty. Wilson is credited with putting together a comprehensive and simplified theory that permits the calculation to be done. Phase transitions are most commonly encountered in the physics of solids and liquids, but they play crucial roles in such branches as astrophysics, nuclear physics, particle physics and cosmology.

A native of Waltham, Mass., Wilson was educated at Harvard University and California Institute of Technology. He has been a professor at Cornell since 1971.

—*J. A. Miller, D. E. Thomsen*

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color images

The mistake was moot for objects like plastic or a waxed apple, whose surfaces were white. For homogeneous surfaces like metal, the mistake was disastrous. Cook explains why: Wax, or plastic—even colored plastic—is typically composed of a transparent or white substrate whose hue is achieved by embedding particles of colored pigment into it. Therefore, light reflected directly from the surface — a specular reflection — "is only slightly altered in color from the light source," Cook says: It would essentially be white. Only reflections penetrating the surface could be expected to interact with the pigments enough to acquire a colored, uniformly distributed diffuse spectral quality.

With metals, incoming light barely penetrates the surface, so all reflection "essentially occurs at the surface," Cook explains. To model the proper spectral distributions associated with metals, painted surfaces or other materials, Cook recommends consulting tables of standard thermal-radiative properties for values to plug into mathematical formulas described in the paper he co-authored with Kenneth Torrance in the ACM Transactions on Graphics (Vol. 1, No. 1).

The proof is in the seeing. A computer-generated bronze-colored vase (left) was computed using a white specular component, and appears to be made of plastic. Similar vases (right), computed with thermophysical spectral data from standard-reference tables, exhibit more realistic metallic and matte finishes. —*J. Raloff*