system, says he is very pleased that the work of Furchgott, Ignarro and Murad has been recognized.

Stamler accepts that Moncada "had the vision to appreciate the field in the broader sense and to shoulder the burden of later research". But he believes that earlier work had already opened the way for the later discoveries, as the Nobel committee has recognized.

Solomon Snyder of Johns Hopkins University in Baltimore, Maryland, says he agrees with this interpretation, and accepts that the committee would have done much scholarly work before making its decision.

He says the medical significance of Murad's work on nitroglycerin is enormous. Murad showed that the active metabolite of nitroglycerin is nitric oxide, leading drug companies to search for other drugs that could release the gas.

Ironically, Alfred Nobel, the inventor of dynamite — in which the explosiveness of nitroglycerin is kept in check by a porous material composed of diatoms — was ordered by his doctor to "eat" nitroglycerin for a heart condition, but refused to take it.

Nitroglycerin is a potent drug now used in the treatment of angina. Just 0.5 mg placed under the tongue can make a patient suffering an angina attack feel better within minutes, due to the dilation of the affected blood vessels.

It is now clear that nitric oxide is the major determinant of blood pressure. But its medical significance does not stop there. In 1992 Snyder and colleagues showed that nitric oxide synthase (NOS), the enzyme that produces nitric oxide, is expressed in neurons in the penis and that nitric oxide mediates erectile function. **Rory Howlett**

Physicists rewarded for 'fractional electrons'

AP

Physics laureates: Robert Laughlin (left) shortly after hearing of his award, Daniel Tsui (centre) and Horst Störmer.

[LONDON] This year's Nobel prize for physics has been awarded to the researchers who first observed and explained the fractional quantum Hall effect. This is the effect in which an electric current within a two-dimensional conducting material appears to be made up of charge carriers bearing a fraction of the charge on an electron.

Horst Störmer of Columbia University, New York, and Bell Laboratories, and Daniel Tsui of Princeton University, who both saw the effect experimentally in 1982, share the prize with Robert Laughlin of Stanford University, California, who provided a theoretical explanation shortly afterwards.

The standard Hall effect is the lateral deflection of moving charge carriers — an electric current — in a magnetic field. It was discovered in 1879 by Edwin Hall, and today provides the basis for determining the charge and density of charge carriers in a semiconductor (electrons and holes are deflected in different directions).

In 1980 Klaus von Klitzing found that, when the charge carriers are confined within a very thin conducting film (that is, in two dimensions), the magnitude of the Hall current (or, equivalently, the conductance of the material) no longer varies smoothly with magnetic-field strength at very low temperatures.

Instead, the conductance varies with field strength in a series of abrupt steps. In other words, the conductance is quantized: it changes in integral multiples of the fundamental quantum unit of conductance, e^2/h (where e is the charge on the electron and h is Planck's constant).

The fractional quantum Hall effect represents a deeper puzzle, since it seems to reveal a change in the nature of the fundamental particles. Much the same can be said of superconductivity, in which electrons appear to attract one another (or, more properly, to show bosonic instead of fermionic behaviour), and of superfluidity, in which the atoms of the superfluid no longer generate viscosity.

The FQHE was seen by Tsui and Störmer for the transport of a two-dimensional electron 'gas' in a semiconductor heterostructure fabricated by Art Gossard, now at the University of California at Santa Barbara. On applying magnetic fields of up to 30 tesla to a sample cooled to about a tenth of a degree kelvin, they observed jumps in conductance with a value of $e^2/3h$, implying that the charge carriers had a fractional charge of $e/3$. Subsequent studies revealed charges of $2e/5$, $3e/7$ and other (odd-denominator) fractions.

Laughlin proposed that the magnetic flux lines penetrating the sample encourage the charge carriers to condense into quasiparticles. He demonstrated that such quasiparticles act as though they have fractional charges with the values seen in the experiments.

The crucial insight, says Moty Heiblum of the Weizmann Institute in Israel, was the recognition of the role of electron correlations. In semiconductor physics, says Heiblum, "all of us managed to work with a single-electron picture for many years". But the study of strongly correlated electrons in solid-state physics has now become an important field of research. **Philip Ball**

Theoretical chemistry makes its mark

[LONDON] The award of the Nobel prize for chemistry to Walter Kohn of the University of California at Santa Barbara and John Pople of Northwestern University, Illinois, signals a recognition that computational chemistry is now a tool at the chemist's disposal to equal any experimental or analytical technique.

Kohn provided the theoretical framework for calculating the electronic structure of molecules without having to grapple with the formidable task of solving the full Schrödinger equation. He showed that the total energy of a system can be expressed simply in terms of the distribution of its electron density, without regard to the details of the electron motions; the density is a function of the spatial coordinates, and the energy is a 'function of a function', or a functional.

Kohn developed what was later to be called density functional theory in 1964, with applications in physics in mind. This theory is now widely used to calculate the electronic band structures of solids, and also in liquid-state physics.

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Pople: work has 'led to an industry'.

The application of approximate computational methods to chemistry, meanwhile, was pioneered by Pople. Towards the end of the 1960s he developed the GAUSSIAN-70 program for calculating the electronic structure of molecules and the nature of their interactions and reactions.

Current modifications of this program are now used by thousands of chemists throughout the world, according to Roberto Car of the Ecole Polytechnique Fédérale in Lausanne, Switzerland. "[Pople] has built an industry around this," says Car.

That view is echoed by Nicholas Handy at the University of Cambridge, who feels that the laureates are "exactly the right two people" to be recognized. P.B.

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