

100 years ago

EDISON'S PERFECTED PHONOGRAPH



THE marvellous results attained by Mr. Edison's recent improvement on the original phonograph of 1878 have induced us to present a view of the latest form of the instrument.

The illustration shows the reproducing diaphragm in position, the operator listening through the tubes, and standing behind the instrument so as to be seen.

From *Nature* 39, 107; 29 November 1888.

molecular signals will be a step to understanding these processes at the cellular level.

The hormonal control of gene activity has long fascinated developmental biologists, especially when the consequences of hormone action are as dramatic as they are in the higher insects — controlling the metamorphosis of a maggot (an expressive word, usually banned from polite drosophilists' conversation) into a winged fly. A few genes are known to respond very rapidly to ecdysteroids, steroid-moulting hormones, and many years ago it was suggested that some of these genes encode proteins that not only turn themselves off but also turn on later-responding genes. This may indeed be so, at least as a first approximation, for Hogness and C. Thummel (University of Utah) have now characterized the products of two of the so-called early ecdysone-responsive genes. Both are DNA-binding proteins and one (the product of the *E75* gene) encodes proteins that have both zinc fingers and domains that resemble those of vertebrate steroid and retinoic-acid receptors. R. Hill (CSIRO, Sydney) has shown that antibodies against the *E75* protein associate with both the *E74* and the *E75* early genes in polytene chromosomes, as well as at a developmentally changing set of sites which include those of some late genes. But there are still surprises in store for the study of the ecdysone response — for example, P. Cherbas (Indiana University) has found that one of the early ecdysone-inducible genes of tissue-culture cells (*eip40*) encodes a γ -cystathionase. □

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Spectroscopy

New aspects of Raman scattering

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RAMAN spectroscopy, relying on the inelastic scattering of light, is a widely accepted analytical tool. In particular, it is regularly used to identify molecular species, their structures or internal energy distributions, where other techniques fail. Indeed, at a recent conference* devoted to the method, 475 papers were presented, most concerning new studies using the Raman effect as a tool. Some, however, described new aspects of the physics of the effect, particularly time-dependent ones resulting from molecular-dynamic interactions and which might be revealed using femtosecond lasers. This illustrates how, 60 years after its discovery, and 100 years after its discoverer's birth (marked in *Nature* with extracts¹ from his acoustical studies), the Raman effect continues to stimulate fundamental physical research.

The essential aspects of Raman scattering experiments are well understood (see figure). A laser at frequency ω_L is focused into the sample while the frequency distribution of the scattered field (ω_S) is examined by means of a monochromator. Emission lines appear at energies $\hbar(\omega_L - \omega_i)$ corresponding to molecular transitions whose polarizabilities can oscillate significantly at these frequencies. The dynamical characteristics of the sample are contained in the intensities, shapes and polarization properties of the Raman transitions.

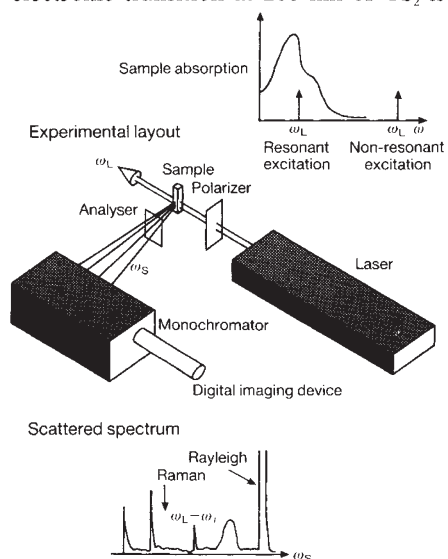
The width is a measure of the dephasing rate of the molecular vibrations: the rate of random interruptions in the coherent evolution of the field at ω_S that result from the scattering molecule interacting with its surroundings. Attempts to elucidate liquid and solid-state dynamics require a fuller understanding of such ultrafast molecular relaxation processes. It is now clear that Raman spectroscopy can contribute substantially to this, particularly in combination with advances² with femtosecond lasers.

The bound states of atoms in collision-free conditions undergo spontaneous emission as the only mechanism irreversibly to extract energy from a radiation field. This process is Raman or Rayleigh ($\omega_S = \omega_L$) scattering. Collisions between atoms allow energy to be exchanged with the field so that the spontaneous emission following near-resonance excitation can become shifted from the laser frequency to produce, in time, a fluorescence or collisionally redistributed emission. For molecules, the collisions also generate a population distribution of the many nearby excited states,

leading to a third type of spontaneous emission.

In condensed matter, where all these processes occur, resonant Raman scattering is easily identified because of the energy-conserving relationship ($\omega_S = \omega_L - \omega_i$) of its narrow line emission and the laser frequency. The response time of Raman scattering is determined by the difference in the periods of the light and the material electronic oscillations or by the dephasing rate of the optical transition that is being driven if the excitation is resonant. If the resonant Raman scattering from bulk matter were time-resolved, the signal would decay with the same effective dephasing time that determines the growth of the fluorescence signal. These times are probably in the range of 10–100 femtoseconds (fs) for liquids and could be studied by pulsed-laser methods.

The absolute cross-section (probability) of resonant light scattering also depends on the rate at which the resonant optical transition is dephased or relaxed. A knowledge of the radiative emission rate, which depends on the integrated absorption, and the yield of Rayleigh plus Raman scattering thus provides a measure of the rate of dephasing in the optical transition. Also, the scattering efficiency can be used to determine whether the optical absorption band is inhomogeneously broadened over the timescale determined by the dephasing. These concepts were recently brought out and applied quantitatively to the CS₂ molecule by Myers and co-workers³ who show that in hexane solution at 300 K the electronic transition at 200 nm of CS₂ is



Standard layout of a Raman-scattering experiment, with typical absorption and scattered spectra as inserts (see text).

* Eleventh International Conference on Raman Spectroscopy, London, 5–9 September 1988.