The Raman effect was discovered by Sir Chandrasekhara Venkata Raman in 1928, who received the Nobel Prize for Physics for this discovery in 1930. Atoms in a molecule move about their equilibrium position in so-called vibrational modes. When light interacts with a molecule Raman scattering can occur.

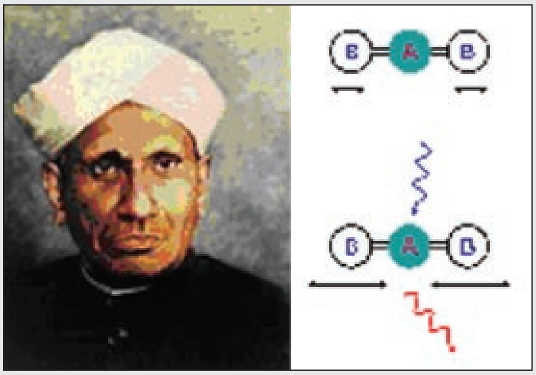
Raman spectroscopy

In a Raman scattering event an incident photon transfers some of its energy to the molecule, which leads to the excitation of a vibrational mode in the molecule. It also results in the scattered photon having a lower energy than the incident photon by the exact same amount. This energy difference is measured using a Raman spectrometer. Usually the wavenumber shift $\triangle$ cm^{-1} is used, defined as $\triangle$ cm^{-1} = $(1/l_{incident} - 1/l_{Raman}) * 10^{-7}$ (l in nm).

The precise amount of energy that is required to excite a molecular vibration depends on the masses of the atoms involved in the vibration, their chemical bonds, the molecular structure, and on interactions of the molecule with its environment. This and the fact that a molecule of N atoms has 3N-6 independent vibrational modes, many of which can be Raman-active, explain the molecular specificity of Raman spectra.
In complex mixtures all molecules contribute their signal to the overall Raman spectrum of the mixture. The Raman signal intensity of individual molecular species is linearly dependent on their concentration. This means that Raman spectroscopy is a very suitable technique for obtaining qualitative and quantitative information about the molecular composition of a sample, which may be a gas a liquid a solution, a suspension, a solid, or .... a biological cell or tissue.

An alternative way of looking at a Raman spectrum is to consider that each type of cell or tissue has its own unique molecular composition. As explained above, a Raman spectrum is in fact a representation of this molecular composition. It follows that a Raman spectrum is a highly specific spectroscopic fingerprint, which can be used as such to identify cells and tissues, including diseased tissues.

Rapid progress in instrumentation has reduced signal collection times from typically hours in the 1970's to seconds nowadays. Signal analysis is possible in real-time. This has paved the way for many ex vivo and in vivo (cell) biological and clinical applications, which can now take full advantage of the fact that Raman spectroscopy is a non-destructive technique, which does not require any sample pre-treatment (labelling, staining or other contrast enhancement media) and can be applied with high spatial resolution.



Left: Sir Chandrasekara Venkata Raman
Right: A Raman scattering event, leading to excitation of a molecular vibration and scattering of a photon with lower energy than the incident photon.

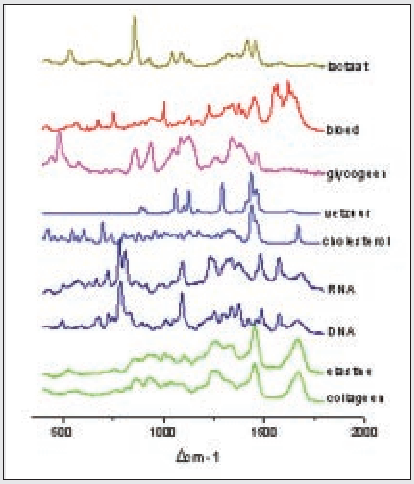


Illustration of the molecular specifity of Raman spectra