



50 YEARS AGO

In an article on "Nuclear Knowledge and Christian Responsibility" in the *London Quarterly* for January 1957, Prof. C. A. Coulson emphasizes that if the under-developed countries are also to enjoy the benefits of civilization, or indeed if our civilization is to continue, a fair and reasonable distribution of nuclear energy is an absolute necessity... he argues that it is a Christian responsibility to see that nuclear energy, like any other scientific discovery, is rightly used... Urging that we should be profoundly grateful for our nuclear knowledge, Prof. Coulson indicates some of the ways in which we should share and develop nuclear energy and its applications... We should also rejoice in new possibilities for curing disease and improving health in parts of the world where disease is rampant and health poor and should see that no one makes personal profit out of this situation to the detriment of the world-wide distribution of the new products.

From *Nature* 2 March 1957.

100 YEARS AGO

On Leprosy and Fish Eating. A Statement of Facts and Explanations. By Jonathan Hutchinson — The object of this work is stated in the preface to be "to carry conviction to the reader that the fundamental cause of the malady known as true leprosy is the eating of fish in a state of commencing decomposition."... Mr. Hutchinson would associate the former prevalence of leprosy in the British Isles and in Europe with the Roman Catholic ordinances prescribing fish-food on two out of every three weekdays... We think that Mr. Hutchinson goes much too far in thus ascribing all variations in the prevalence of leprosy as being correlated with those of a fish-diet; even in the fact that the disease is more prevalent among men than among women he sees support for his hypothesis, for he suggests that women are more fastidious feeders than men.

From *Nature* 28 February 1907.

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MICROSCOPY

Atomic fingerprinting

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Atomic force microscopy is a well-established technique to image all kinds of surfaces at the atomic scale. But the force patterns that emerge can also pin down the chemical identity of individual atoms.

Picking lentils from ashes is one of the many challenging tasks delegated to fairy-tale characters. In a famous story, Cinderella completes this chore assisted by some helpful doves. Sugimoto *et al.*, in work that appears on page 64 of this issue¹, tackle a similar, but potentially more useful problem: how to identify a particular element on a surface that contains a mixture of elements using only a mechanical probe.

This is, in fact, one of the thorniest problems in surface science. Although the atomic force microscope (AFM) is starting to be used routinely to 'image' surfaces on the atomic scale, interpreting its images is still extremely difficult. The AFM was invented just over 20 years ago, and is now the most widely used scanning probe. Unlike the more mature scanning tunnelling microscope (STM), which can be used only for conducting surfaces, the AFM can image both insulating and conducting samples. But its evolution into a metrology tool capable of discriminating, or even determining, the chemical identities of individual atoms is a new development. It is akin to asking Cinderella to perform her sorting task blindfolded, relying only on the sensation in her fingers.

An AFM works by probing the force acting between its sharp tip and the atoms of the sample's surface. Over the past decade, there have been many spectacular achievements in the imaging and even manipulation of surface structures and individual atoms using an AFM in its dynamic or 'non-contact' mode^{2–5}. In this mode, the AFM's tip is attached to the end of a flexible cantilever, which is oscillated at its resonant frequency and with constant amplitude in a direction perpendicular to the sample surface.

As the tip vibrates, it interacts with the sample's surface, causing the resonant frequency of its oscillations to change. These variations can be measured precisely as a function of tip position, and converted into a three-dimensional image of the surface that contains details at the atomic scale. But relating even simple image patterns to the position of surface atoms and

their chemical identities is a tricky task. The imaging mechanism is complex, and, crucially, the exact composition of the tip's apex on the atomic scale — and so its contribution to the strength of the interaction — is impossible to establish with certainty^{2,4}.

So how does one sort the lentils from the ashes — or, less figuratively, tell apart atoms such as silicon (Si), tin (Sn) and lead (Pb) — using such a method? Sugimoto *et al.*¹ first looked at whether Sn and Pb atoms adsorbed on a silicon surface could be distinguished from each other by correlating topographic AFM images with the adsorbates' known concentrations. To create a transferable mechanistic 'sensation' of these atoms, they then measured with very high accuracy the dependence of the force on the distance between the AFM's tip and the individual atoms on the surface, in a similar way to previous studies^{6,7}.

After repeating their measurements many times, the authors realized that the forces measured above Si, Sn or Pb atoms vary from experiment to experiment. That is most probably because the shape and composition of the tip apex on the atomic scale differed between experiments. If the tip's structure were impossible to determine or control, and the experiments were to be deemed irreproducible, then the whole exercise would be ruined.

Trying to identify a characteristic that would allow force curves measured with different tip terminations to be compared, the authors noticed that the strongest interaction was always between the tip and Si atoms on the surface. So they divided the maximum attractive forces for Sn and Pb adsorbates by the maximum force measured with the surface Si atoms. In this way, they managed to obtain what seemed to be distinct, reproducible force 'fingerprints' for each different type of atom.

How can one be sure that the subtle differences between the force fingerprints are in fact due to the different chemical identities of the atoms? To understand and support their findings, the authors used atomistic modelling¹ to determine plausible atomic structures for the