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Material witness: A tangled history

PHILIP BALL

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Two recent essays on the life and work of Hermann Staudinger (*Angew. Chem. Int. Edn* **43**, 1054 & 1064; 2004) remind us that any attempt to tell the history of science as a linear narrative is usually futile or dishonest.

By the time of Staudinger's pioneering work on polymers in the 1920s, the word 'polymer' was already almost a century old (Berzelius, the doyen of chemical nomenclature, got there first in 1833). 'Polymerization', meanwhile, was introduced by Berthelot in 1863: he even spoke about "polyethylene".

But neither of these terms had much to do with the polymers that were already commercially valuable by then: half-natural materials such as vulcanized rubber, rayon and celluloid (reportedly the cause of exploding billiard balls), and synthetics such as Bakelite and polystyrene. For Berzelius, polymers were substances with different molecular weights but the same chemical composition, such as acetylene and benzene.

The battle Staudinger fought to establish that true polymers are giant, covalently bonded molecules, rather than loose colloidal aggregates of small molecules, was even acknowledged in his Nobel citation of 1953. The opposition was there excused as "understandable"; and much as we might be tempted to romanticize Staudinger's tenacity, it is true that there were good reasons for caution at the time. The idea, for example, that crystallographic unit cells could not be smaller than the molecules comprising them may have been wrong but was not foolish.

More revealing, perhaps, is the unwillingness to believe that chemistry could be so messy as to permit a monstrosity like the macromolecule. "Purify your products", Staudinger was told, "they will crystallize and turn out to be low molecular weight compounds." One suspects he was really being told to purify his ideas.

Equally telling is how Staudinger's struggle left his own theories literally inflexible to later refinements. Convinced that his macromolecules were rod-like, he was reluctant to accept the work of Paul Flory and others that invoked the entanglement of much floppier 'filaments'. "It is difficult to know what one should admire more", comments Helmut Ringsdorf in his essay, "the creativity of the scientist or the constancy of his adherence to his original idea."

Maybe we must conclude that all ideas can be proved right if you wait long enough. It has taken all the ingenuity of modern chemistry to make truly rigid macromolecular rods; meanwhile, the self-assembling, non-covalent polymers proposed in 1905 by Carl

Dietrich Harries to explain the structure of rubber are now provided by supramolecular science.

And several of Staudinger's own Nobel musings sound astonishingly prescient. Who would question that "the wonder of Life in its chemical aspect is revealed in the astounding abundance and masterly macromolecular architecture of living matter"? And who can fail to feel the frisson of his remark, in the year of Crick and Watson's epochal discovery, that "this stability of the macromolecules... supplies the living substance with the necessary basis for so specific a process as that of heredity"?