

THE DANCE OF THE SOLIDS

by John Updike

EDITOR'S NOTE: These verses were composed after the writer had read the issue of *SCIENTIFIC AMERICAN* (September, 1967) devoted to materials. They appear in his forthcoming book *Midpoint and Other Poems*, and are reproduced with the generous permission of Alfred A. Knopf, Inc.

ARGUMENT: *In stanzas associated with allegory the actual atomic structure of solids unfolds. Metals, Ceramics and Polymers. The conduction of heat, electricity and light through solids. Solidity emerges as being intricate, giddy, playful.*

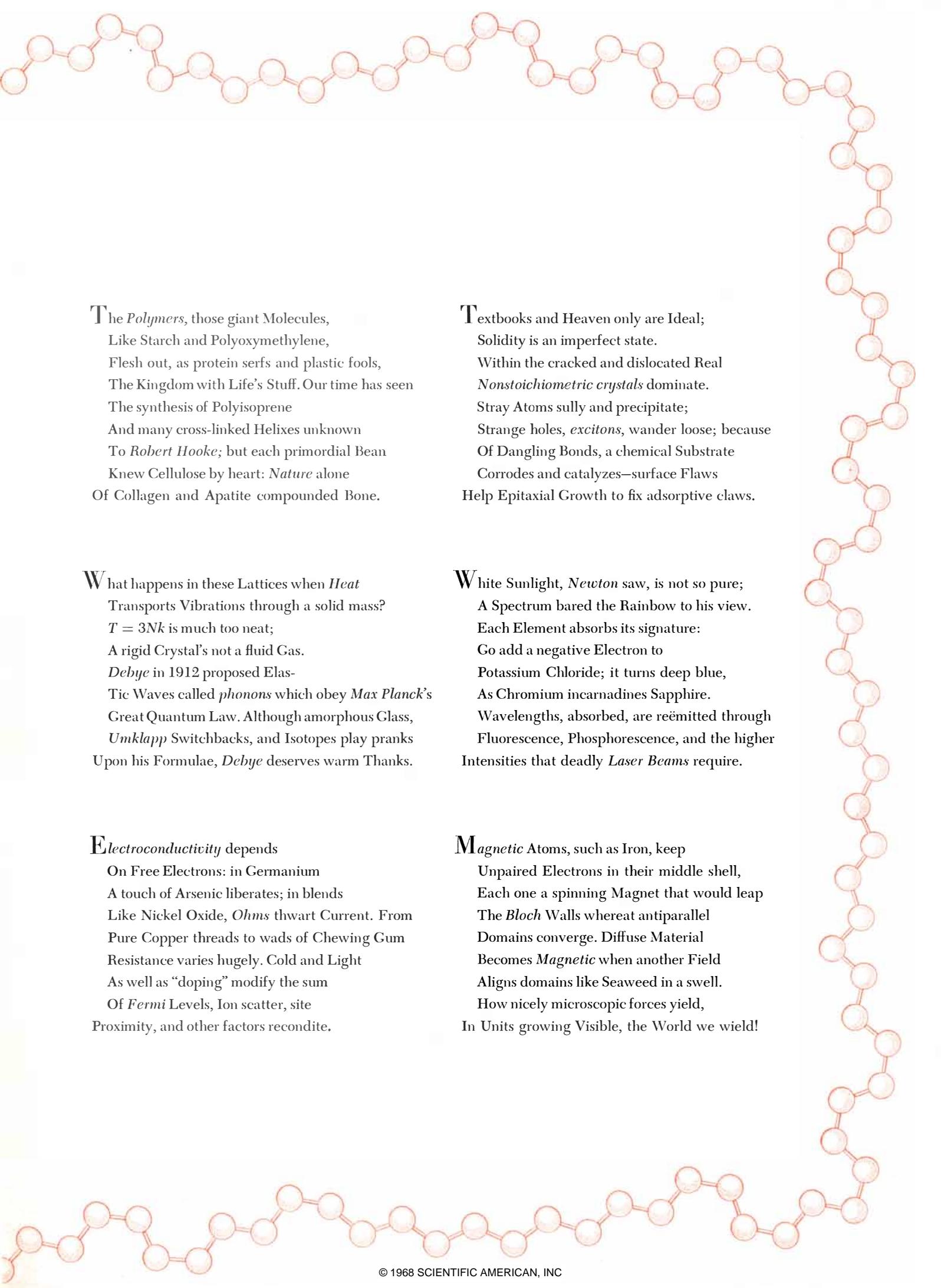
All things are Atoms: Earth and Water, Air
And Fire, all, *Democritus* foretold.
Swiss *Paracelsus*, in's alchemic lair,
Saw Sulfur, Salt, and Mercury unfold
Amid Millennial hopes of faking Gold.
Lavoisier dethroned Phlogiston; then
Molecular Analysis made bold
Forays into the gases: Hydrogen
Stood naked in the dazzled sight of Learned Men.

The Solid State, however, kept its grains
Of Microstructure coarsely veiled until
X-ray diffraction pierced the Crystal Planes
That roofed the giddy Dance, the taut Quadrille
Where Silicon and Carbon Atoms will
Link Valencies, four-figured, hand in hand
With common Ions and Rare Earths to fill
The lattices of Matter, Glass or Sand,
With tiny Excitations, quantitatively grand.

The *Metals*, lustrous Monarchs of the Cave,
Are ductile and conductive and opaque
Because each Atom generously gave
Its own Electrons to a mutual Stake,
A Pool that acts as Bond. The Ions take
The stacking shape of Spheres, and slip and flow
When pressed or dented; thusly *Metals* make
A better Paper Clip than a Window,
Are vulnerable to Shear, and, heated, brightly glow.

Ceramic, muddy Queen of human Arts,
First served as simple Stone. Feldspar supplied
Crude Clay; and Rubies, Porcelain, and Quartz
Came each to light. Aluminum Oxide
Is typical—a Metal is allied
With Oxygen ionically; no free
Electrons form a lubricating tide,
Hence, Empresslike, *Ceramics* tend to be
Resistant, porous, brittle, and refractory.

Prince *Glass*, *Ceramic's* son, though crystal-clear,
Is no wise crystalline. The fond Voyeur
And Narcissist alike devoutly peer
Into Disorder, the Disorderer
Being Covalent Bondings that prefer
Prolonged Viscosity and spread loose nets
Photons slip through. The average *Polymer*
Enjoys a Glassy state, but cools, forgets
To slump, and clouds in closely patterned Minuets.



The *Polymers*, those giant Molecules,
Like Starch and Polyoxymethylene,
Flesh out, as protein serfs and plastic fools,
The Kingdom with Life's Stuff. Our time has seen
The synthesis of Polyisoprene
And many cross-linked Helixes unknown
To *Robert Hooke*; but each primordial Bean
Knew Cellulose by heart: *Nature* alone
Of Collagen and Apatite compounded Bone.

What happens in these Lattices when *Heat*
Transports Vibrations through a solid mass?
 $T = 3Nk$ is much too neat;
A rigid Crystal's not a fluid Gas.
Debye in 1912 proposed Elas-
tic Waves called *phonons* which obey *Max Planck's*
Great Quantum Law. Although amorphous Glass,
Umklapp Switchbacks, and Isotopes play pranks
Upon his Formulae, *Debye* deserves warm Thanks.

Electroconductivity depends
On Free Electrons: in Germanium
A touch of Arsenic liberates; in blends
Like Nickel Oxide, *Ohms* thwart Current. From
Pure Copper threads to wads of Chewing Gum
Resistance varies hugely. Cold and Light
As well as "doping" modify the sum
Of *Fermi* Levels, Ion scatter, site
Proximity, and other factors recondite.

Textbooks and Heaven only are Ideal;
Solidity is an imperfect state.
Within the cracked and dislocated Real
Nonstoichiometric crystals dominate.
Stray Atoms sully and precipitate;
Strange holes, *excitons*, wander loose; because
Of Dangling Bonds, a chemical Substrate
Corrodes and catalyzes—surface Flaws
Help Epitaxial Growth to fix adsorptive claws.

White Sunlight, *Newton* saw, is not so pure;
A Spectrum bared the Rainbow to his view.
Each Element absorbs its signature:
Go add a negative Electron to
Potassium Chloride; it turns deep blue,
As Chromium incarnadines Sapphire.
Wavelengths, absorbed, are reëmitted through
Fluorescence, Phosphorescence, and the higher
Intensities that deadly *Laser Beams* require.

Magnetic Atoms, such as Iron, keep
Unpaired Electrons in their middle shell,
Each one a spinning Magnet that would leap
The *Bloch* Walls whereat antiparallel
Domains converge. Diffuse Material
Becomes *Magnetic* when another Field
Aligns domains like Seaweed in a swell.
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