associated with cancer. This suggests that a less 'cancer-centric' analysis might reveal other genes that can drive the expansion of clones in normal tissue.

We are only starting to map the extent of genetic alterations in normal tissues. The next challenge will be to fully understand their role in healthy tissues and in disease states. ■

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MATERIALS SCIENCE

Hardening mechanisms scaled up

Metals can be strengthened by mechanisms that work on the atomic scale. These same mechanisms used at a much larger scale have been found to also strengthen materials that contain hierarchical, engineered substructures. **See Article p.305**

GANG SEOB JUNG & MARKUS J. BUEHLER

Atomic-scale mechanisms that affect the structural properties of materials can also inform the design of new materials needed for engineering, such as high-performance alloys. On page 305, Pham *et al.*[1] report their use of 3D printing to translate some atomic-level hardening mechanisms typically found in crystalline materials to a larger scale. The resulting 'architected' materials contain substructures that are designed to mimic atomic arrangements in crystal lattices. Their work provides a fresh approach for developing designer materials and could facilitate the application of hardening mechanisms to different materials and on different scales.

Engineers have a diverse array of tools at their disposal for designing and constructing new materials. Additive manufacturing[2], also known as 3D printing, is one such tool that could revolutionize the field of materials fabrication, in part because it can produce almost any geometric feature. An idea that has received much attention involves using additive manufacturing to make materials that have complex microstructures[3], which are difficult to construct using conventional methods.

Natural materials such as bone, silk and nacre have exceptional properties that many conventional engineering materials lack. These properties arise from the materials' complex hierarchical structures — the macroscopic materials are built up from repeating patterns of smaller building blocks at several different length scales. Additive manufacturing has been used to reconstruct the hierarchical patterns of building blocks found in natural materials, but instead using conventional materials. The products have mechanical properties — such as high toughness, strong impact resistance and the ability to bear heavy loads — that exceed those of the conventional materials[4], and are called architected materials. Many studies have focused on developing approaches that allow hierarchical features of natural materials to be mimicked in completely different classes of material[5]. For example, one could generate a nacre-like material from synthetic polymers, rather than using the exact materials found in nacre.

Structures composed of repeating building blocks are commonly found in crystalline materials such as metals, ceramics and rocks. At the smallest scale, the atoms in crystals form a well-defined lattice in which the packing of atoms in the unit cell (the smallest repeating unit of the lattice) depends on the nature of the atoms' bonds and electronic structures. However, crystals are usually formed from microscopic grains whose lattices are oriented in different directions. If the configurations of atoms at the edges of different grains do not line up with one another, lattice defects form, which are commonly considered to be weak points. In brittle materials, cracks can be initiated from defects such as grain boundaries, and propagate rapidly.

But grain boundaries can have a positive role in ductile materials. Metals under a load typically fail not because bonds between atoms suddenly break, but because atoms slide along a specific plane within a lattice. Such sliding occurs as a result of defects known as

50 Years Ago

The collection of inventions that was on show … last week involved the onlooker in frantic changes of mood, switching his attention one minute to practical mechanical devices and the next to the thrills of psychedelic lighting or the niceties of tea blending … Among the household items was a flower pot designed to maintain a steady trickle of water in the gardener's absence, a new type of safety window for schools and hospitals, and for a wider audience a typewriter with keyboards in Japanese, musical notation or what you will.

From *Nature* 18 January 1969

100 Years Ago

The ex-President of the United States who died in the first week of 1919 was in many ways the most remarkable man … and combined with unusual qualities of intellect and co-ordinated development of bodily skill — for was he not a fine shot, a bold equestrian, an untiring marcher, an adept at most games and sports? — a kindness and sweetness of disposition, and a thoughtfulness for the happiness and well-being of all around him, very rare in great men of the world … Theodore Roosevelt was not only a great naturalist himself, but — what in its ultimate effect was even more important — he set, as President, the fashion in young America for preserving and studying fauna and flora until he had gone far to create a new phase of religion. Under his influence young men whose fathers and grandfathers had only studied the Bible, the sacred writings of the post-exilic Jews and Graeco-Syrian Christians, now realised that they had spread before them a far more wonderful Bible, the book of the earth itself. Geology, palaeontology, zoology, botany, ethnology, were part of Roosevelt's religion.

From *Nature* 16 January 1919