# THIS WEEK

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# Super structures mimic metals

*Concepts in metallurgy combine with 3D printing in an approach to designing strong, lightweight materials.*

Astronauts on the International Space Station have had access to an orbiting 3D printer for several years now. But the real advances are being made down on the ground. The technology might be known among the public for turning out trinkets and expensive gifts, but steady progress is also being made in more challenging engineering applications.

Take the fabrication of complex network structures known as architected materials. These 3D structures can be carefully designed to achieve high strength-to-weight ratios compared with those of many conventional solid structures. They require less material than a fully solid structure to achieve similar performance capabilities, making them potentially resource-efficient. And the weight saving means that less energy is required to carry them about, making them intriguing for applications in which energy efficiency is a priority, such as prosthetics or aerospace technology. Such structures are, however, very difficult to fabricate using conventional techniques. And that is where 3D printing — also known as additive manufacturing — comes into play.

In this week's *Nature*, scientists at Imperial College London and the University of Sheffield, UK, report how they used 3D printers to create an unusual — and potentially very useful — series of architected materials by borrowing concepts from metallurgy (M.-S. Pham *et al. Nature* **565**, 305–311 (2019); see also page 303). They deliberately introduce what look like imperfections into 3D-printed plastic and metal lattices, to make them stronger. This strategy mimics on a larger scale the structural and compositional imperfections that can enhance the mechanical performance of normal crystalline materials: the lattice of the architected material stands in for the atomic arrangement in a crystal.

In one class of architected structure, the researchers created a material mimicking a polycrystalline structure — that is, one in which, instead of a single regular lattice structure, the material is broken up into 'metagrains' with different lattice orientations. Furthermore, they were able to tune the size of these regions to replicate a known effect in which mechanical strength is controlled by grain size. (In a standard polycrystalline metallic system, it is the boundaries between the grains that hinder material deformation.)

In another approach, the scientists mimicked a technique called precipitation hardening, often used in the manufacture of high-performance alloys. They also studied dual-phase lattices (mimicking steels). They speculate that 3D printing could be used to give structures the same kind of reversible stress-induced phase transformation as is seen in superelastic materials — a desirable property in cases where resilience to, and recovery from, deformation is required.

The authors explored three very different materials for their structures, requiring three different printing technologies. As expected, the properties of these materials were important. Further base materials could be investigated, and other mechanistic approaches for controlling properties are available. The parameter space for future exploration is large.

These demonstrations are just proof of principle; architected materials more generally are still a very new concept. Much work needs to be done before these ideas can be used widely. For example, researchers need to be able to make much larger structures, to exploit the breadth of available engineering materials and to develop design tools that can cater for the complexity of real-world applications.

But 3D printing more generally is now making genuine inroads in manufacturing. Industrial researchers have found additive manufacturing in metals to be appealing because it creates much less waste than does machining sections from a solid block; as such, it is now being used to mass-manufacture a few specific aerospace components. And US aerospace company GE Aviation says it has used additive manufacturing to improve weight efficiency in its new Affinity supersonic jet engine — scheduled to fly in 2023 — making supersonic travel that bit cheaper. As we wrote in a Toolbox article this month, it is also making inroads in the research laboratory (see *Nature* **565**, 123–124; 2019).

***"It is said that 3D printing will be a key feature of the fourth industrial revolution."***

It is sometimes said that 3D printing will be a key feature of the fourth industrial revolution, the era of big data, connectivity and human–machine integration. Metallurgy — specifically, developments in iron and steel manufacture — was central to the original Industrial Revolution. Metal endures. And now, architected materials enabled by metallurgical know-how and 3D printing could also go from strength to strength. ■

# Screen time

*How much is too much? An analysis tries to get to the bottom of a crucial question.*

It has become a defining question of our age: do children and adolescents spend more time than is healthy staring at a phone, tablet or computer? Should parents limit their access? Should governments?

Nearly all US teenagers say they have access to a smartphone, and about half say they are online almost constantly, according to a 2018 Pew Research Center survey (see go.nature.com/2akajas). In the United Kingdom, the time young people spend online has almost doubled over the past decade, the communications-industry regulator, Ofcom, has found (see go.nature.com/2hd0c4p). Parental concerns about media use are rising, too — fuelled by headlines and political pronouncements. On 2 October 2018, Matt Hancock, UK secretary of state for health, issued an urgent warning, saying that the threat to children's mental health from social media is similar to that from sugar to their physical health.

In cases of such significant public concern, it often falls to the scientific community to provide and assess evidence, and then make some recommendations. But scientific research in this field has its own challenges, and almost as many uncertainties.

Current evidence for an association between digital-technology use and adolescent well-being is contradictory and comes mainly from household panel surveys and other large-scale social polls, with thousands to millions of respondents. The questions represent a compromise between usefulness and not placing too much burden on respondents. They are simplified, are not standardized and often do not map straightforwardly onto the validated instruments that clinical or social scientists use to measure constructs such as 'well-being' and 'technology use'.

So, researchers using these data to answer questions about the effects of technology need to make several decisions. Depending on the complexity of the data set, variables can be statistically analysed in trillions of ways. This makes almost any pattern of results possible. As a result, studies have suggested both the existence of and the lack of an association between screen time and well-being, even when analysing the same data set. Naturally, it's the research that highlights possible dangers that receives the most public attention and helps to set the policy agenda.

A study published this week in *Nature Human Behaviour* (A. Orben and A. K. Przybylski *Nature Hum. Behav.* https://doi.org/10.1038/s41562-018-0506-1; 2019) introduces a different approach. The authors examine three key large-scale data sets, two from the United States and one from the United Kingdom, that include information about teenager well-being, digital-technology use and a host of other variables. Instead of running one or a handful of statistical analyses, they run all theoretically plausible analyses (combinations of dependent and independent variables, with or without co-variates) — in the case of one data set, more than 40,000. This allows the authors to map how the association between digital-technology use and well-being can vary — from negative to non-significant to positive — depending on how the same data set is used.

The authors' overall calculations did find a statistically significant negative association between technology use and well-being: more screen time is associated with lower well-being in the young people surveyed. But the effects are so small — explaining at most 0.4% of the variation in well-being — as to be of little practical value.

To put this into context, the authors also looked at the associations between well-being and a range of other variables, such as binge drinking, being bullied, smoking, getting enough sleep, eating breakfast, eating vegetables, wearing glasses or going to the cinema. Well-being was more strongly associated, either positively or negatively, with most of these other variables than with digital-technology use. In fact, regularly eating potatoes was almost as negatively associated with well-being as was technology use, and the negative association between wearing glasses and well-being was greater.

***"We need more and better data to work out what impact the digital revolution is having."***

This article is hardly the final word: its conclusions rely on the examination of associations, rather than on potential causal relationships. However, it does suggest that dire warnings are not warranted. And it is a reminder that limited evidence can distort public discourse when the issue is of pervasive significance — such as when parental decisions and the health of children are involved. This is also the conclusion reached by the UK Royal College of Paediatrics and Child Health, in guidance on the health effects of screen time that it issued earlier this month.

The digital revolution is without doubt changing modern life. We need more and better data to work out what impact that is having: in this case, whether media use causes reduced well-being, whether reduced well-being causes greater media use or whether a third variable underlies both. In the meantime, the findings of this study put the association between adolescent technology use and well-being in perspective, and highlight the importance of robust analytical techniques for social big data. ■

# Movie magic

*Cinematic and scientific techniques combine to show how an extinct creature moved.*

The trolls and orcs in The Lord of the Rings films aren't real. The dragons and dire wolves on the hit television show *Game of Thrones* are simulated. The dinosaurs that rampaged through a string of Jurassic Park films don't exist outside a computer. Or do they?

These days, it can be hard to tell from the screen, given that computer-generated characters in films and video games now seem so realistic down to every tooth and claw. The realism comes from the long and fruitful interaction between science and the cinema that can be traced back to the pioneering work more than a century ago of the photographer Eadweard Muybridge (the eccentric spelling of his first name was a deliberate homage to Anglo-Saxon style).

The blending of cinematic and scientific techniques continues today. In a paper in this week's *Nature*, researchers describe how they used animation techniques to reconstruct the motion of a long-extinct animal (J. A. Nyakatura *et al. Nature* **565**, 351–355; 2019). The results will not be coming to cinemas near you any time soon. The study is an effort to answer a purely scientific conundrum.

The question is all about how early vertebrates moved on land. The earliest land vertebrates, or tetrapods, remained close to the ground. More-advanced tetrapods, the amniotes (which include today's reptiles, birds and mammals), adopted a more efficient style of locomotion in which the body is held clear of the ground, a much more effective way of getting around on land than salamander-like slithering. When did amniotes first adopt this mode of locomotion?

A chance to examine this came with the discovery of a crocodile-like animal called *Orobates pabsti*, which lived approximately 280 million years ago in what is now Germany. *Orobates* is a 'stem' amniote. That is, it is an offshoot of the evolutionary line that led to amniotes, but is not a member of the amniotes proper. It is therefore a good test case for studying the life of an animal on its way to becoming an amniote. By happy chance, many excellent fossils of *Orobates* exist, along with trackways — such as footprints — that can be confidently assigned to the creature.

Trackways can be used to understand the possible motion of an animal, but the researchers — John Nyakatura of the Humboldt University of Berlin and his colleagues — went further. They built computer models of *Orobates* to understand the plausible range of motion of its spine and limbs. They then used these to create dynamic computer models, in which the data were combined with realistic simulations of how the animal might have physically interacted with its environment. In other words, they gave the animal force, mass and weight. They even built a robot of the simulated creature. And here's where the movie magic comes in.

Ever since Walt Disney created *Snow White and the Seven Dwarfs* in 1937, film-makers have been familiar with a technique called rotoscoping: overlaying live-action footage with animation. In this study, the researchers used the same technique — in this case, high-resolution X-ray cinematography of modern animals including caimans, iguanas and salamanders — as a basis for overlaying images of skeletal elements in the digital domain, thereby constraining the movements of the digital models of *Orobates* to the realms of the possible. What's more, the researchers invite us all to join in the fun, by tweaking the parameters of their *Orobates* models online (see go.nature.com/2vuhueo). That means that we can all help to breathe life into a long-extinct creature, an activity as valid for entertainment as it is for scientific research. ■