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Image rights

Researchers and journals must do more to counter inappropriate manipulation of figures in scientific papers.

Seven years ago, a cover of *The Economist* showed Barack Obama, head down on a Louisiana beach in front of an oil rig — the picture of lonely despair. The image perfectly encapsulated the news magazine's story about the massive pollution caused when BP's Deepwater Horizon platform exploded, and what the president of the United States could possibly hope to do about it.

But Obama was not alone when the picture was taken. His companions had been digitally erased — and so *The Economist* was criticized by other news media for altering the image to support an editorial narrative. Many news outlets have followed a code of conduct about image manipulation almost since the era of digital photography began: photos can be cropped, but may not be doctored unless the manipulation is flagged.

Science has in some ways been slower to come to this conclusion, but pressure is building. Websites such as PubPeer and Retraction Watch regularly expose manipulated images — from pictures of electrophoresis gels and western blots to micrographs of cells. The bands in a gel may be duplicated by cutting and pasting, for example, or one cell type might be digitally removed. Studies suggest that up to one in five published papers in the life sciences includes one or more manipulated images.

The latest high-profile case concerns the research group of cell biologist Karl Lenhard Rudolph at the Leibniz Institute on Aging in Jena, Germany. An independent investigation by the Leibniz Association, which runs 91 science institutions in Germany, identified 8 high-impact papers with manipulated images. On 15 June, the association issued a statement formally reprimanding Rudolph for failure to appropriately supervise his research group, and calling on him to publish errata and, in one case, a retraction. It also issued sanctions that include shutting him out of the association's competitive funding for three years.

The Leibniz Association is to be commended for enforcing standards of technical integrity as a duty of research-group leadership. But is the life-sciences community doing enough to reduce the sheer extent of image manipulation? Few manipulations arise because a researcher wants to cheat. Many scientists simply want to display a key point more clearly by improving contrast. But too often they are taking this type of beautification too far.

Such is the perceived danger of image manipulation that some journals, including the *Journal of Cell Biology* (a pioneer in this effort) and those published by Cell Press, check images in all the papers they accept for publication. But many journals do no checks at all. (*Nature*, currently reviewing its image-checking procedures, runs random spot checks on images and other checks as specified by editors. It also requires authors to submit unedited gel images for reference.)

The *EMBO Journal* checks all images and finds manipulation in 20% of papers accepted for publication — a number that remains stubbornly high despite the journal's openness about its policy.

How can this widespread practice be stopped at source? The Leibniz Association requires that the scientists it hires agree in writing to adhere to good scientific practice, and the institutes under its umbrella regularly organize scientific-integrity seminars. Such measures are increasingly being adopted by many universities and research institutions around the world, but are evidently insufficient.

Primary responsibility for image integrity lies with principal investigators, who need to be aware of its importance and ensure that the young scientists in their teams, who came of age in the digital era, wield Photoshop tools appropriately.

> ***"Studies suggest that up to one in five papers in the life sciences includes manipulated images."***

But that can be time-consuming. Most approaches are still manual, requiring each figure in a paper to be pulled out individually and run through a series of programs to check whether blots, bands, cells or other debris are where they are supposed to be. In the simplest cases, a figure may be fed into Photoshop and filters adjusted so that manipulations are easier to spot by eye.

Researchers and companies are developing algorithms to make detection more sensitive and reliable. Some companies are trying to automate the process so that the computer extracts images from papers and then runs checks sequentially. This promises publishers and large institutions options for outsourcing image analysis. One research-integrity company already offers an automated process that costs €10–15 (US$11–17) per paper, depending on the volume of papers checked — a tiny proportion of the overall costs of publishing a paper.

By both human and technological means, research organizations, researchers and journals need to do more to counter the image-manipulation challenge. ■

We jammin'

From avalanches to pharmaceuticals, the physics of powders relies on intuition.

For a cognitive skill that plays such a large part in science, intuition gets a raw deal. It is often dismissed as the irrational flipside of reasoned deduction: at best a problem-solving method engineered by evolution as a 'good enough' tool to deal with the mundane choices of life, at worst guesswork that proves no more reliable than random chance. But the intuition that many scientists, and anyone else making decisions in the light of experience, draws on is more a distillate from a well of implicit knowledge.

Johannes Kepler thought long and hard before formulating his 1611 conjecture that hexagonal and cubic close-packings of identical spheres are the densest possible arrangements for them. It wasn't until 1998 that mathematicians Thomas Hales and Samuel Ferguson claimed to have proved Kepler's intuition correct. And their formal proof was published only this May (T. Hales *et al. Forum Math. Pi* **5,** e2; 2017).

Kepler would surely have enjoyed the verification in *Nature Physics* this week of another piece of intuition about geometric packing. In the late 1980s, the Welsh physicist Sam Edwards and his student R. B. S. Oakeshott suggested that, for granular materials such as powders, sand and gravel, all packing arrangements dense enough to lock the grains in place through mutual contact — a jammed state, as in the case of salt that won't come out of the cellar unless shaken — are equally likely to occur. The assumption became a grounding principle for much theoretical work in the area of condensed-matter physics now known as granular matter.

Under this assumption, physicists can relate the number of possible configurations to a kind of entropy akin to that in thermodynamics. This allows them to treat granular media as an analogue of a fluid described using conventional Boltzmann–Gibbs statistical mechanics. The analogy is far from obvious at face value, because molecules in a fluid are in jiggling thermal motion, whereas grains in a heap are static, as if at zero temperature. Once a quantity is invoked to play the part of entropy, however, it supplies a kind of 'effective temperature' — the greater the entropy, the higher this 'temperature'.

That hypothesis helped to furnish the first theoretical framework for describing grainy systems, some time before 'granular media' — ubiquitous in industrial processing, food science and geomorphology — became a fashionable subject for physicists. It represents precisely the kind of foresight and imagination for which Edwards is now celebrated.

But was his conjecture about granular packing correct? Using computer simulations of the configurations of discs in two dimensions, researchers have answered in the affirmative — but only for a rather special situation (S. Martiniani *et al. Nature Phys.* http://dx.doi.org/10.1038/nphys4168; 2017). Mapping all the possible configurational states of such a system is computationally demanding, even for the system of just 64 disks studied here, but that number is small enough to sample the complete landscape of distinct possible arrangements.

Here's the punchline. Edwards' conjecture about the equiprobability of jammed packings holds only at the point at which the grains are on the brink of unjamming: that is, at the jamming–unjamming transition. It's possible to pack the grains more densely than this, but then not all such jammed states are equally likely.

"That it should be only here that Edwards' conjecture holds is surely no coincidence."

This threshold is a special place in the galaxy of granular configurations. It's the point at which the grains start to move: where a jammed powder hopper unjams, or a pile of snow slides in an avalanche. That it should be only here that Edwards' conjecture holds is surely no coincidence. The conjecture is in effect saying something about the symmetry of the system, namely, that no configuration is privileged over the others. The implication is that the jamming transition is at root a geometrical property of all grains, just as Kepler's closest packing is a matter of pure maths, not cannonballs.

The possible existence of underlying deep symmetries has long been among physicists' most valued intuitive guidelines for imagining how the Universe might be. That is what engenders a strong, if not universal, conviction in particle physics that a property called supersymmetry unites hitherto distinct classes of fundamental particles beyond the standard model. So Edwards was not just guessing about what was needed to create a working approximation of granular theory: he was listening to the best kind of intuition. ■

Lab lucre

The highest-earning academics aren't necessarily those who do the most research.

Michelle Pfeiffer once said that she acts for free — "but I demand a huge salary as compensation for all the annoyance of being a public personality". Many scientists have a similar attitude. They enjoy the process and thrill of research and would probably do it for free. The monthly wage is there to make up for all the stuff that goes with it — the form-filling, meetings, bureaucracy and a thousand other distractions.

Still, some scientists get more compensation than others. Why shouldn't one of them be you? For although reports — including *Nature*'s own biennial survey of salaries and attitudes — indicate that times are tough, every researcher knows, or at least suspects they know, a colleague who earns significantly more than they do but seems less dedicated to science. What's their secret?

An analysis in the journal *Science and Public Policy* has had a stab at finding out (M. Kwiek *Sci. Publ. Pol.* http://doi.org/b8v8; 2017). It is not a recipe for riches. There are caveats galore. And, as we have established, most *Nature* readers aren't in it for the money anyway. Right? Still, it wouldn't hurt to take a look.

The paper is based on data submitted by thousands of university-employed academics across ten European countries. And because gross salaries vary significantly from nation to nation (Switzerland pays the most and Poland and Portugal the least), the salaries were compared within, not across, national borders. The researcher involved — Marek Kwiek of the Adam Mickiewicz University in Poznań, Poland — singled out the top-earning 20% of academics in each country. And then he looked for what they had in common, on the basis of what they said their typical working week looked like and what they produced. To reduce the natural bias that younger and early-career scientists are paid less, he counted only those researchers who were at least 40 years old, with a decade or more of experience. And he kept researchers from significantly different fields separate by allocating them to one of five distinct clusters — from physical sciences and maths to humanities and social sciences.

He found that, generally speaking, a high-earning European academic is older, does not put in the longest hours at the bench, is a frequent co-author and spends more time than others on administrative duties. In fact, they spend more time than worse-paid colleagues on all academic activities — peer-reviewing, student supervision and so on — except for research and teaching. That differs sharply from what other, similar exercises have found, especially in the United States, where those academics who say they work the most hours and are first author on the most papers tend to reap the financial rewards. (The United Kingdom showed the most similarity to the United States in these results, with longer hours and a research focus more rewarded.) The European study, in contrast to some, also found no general link between high salaries and gender, except in Poland, where female high earners were rarer than male ones.

For a young scientist in Europe working 12 hours a day in the lab, the lack of an association between apparent effort and financial reward might seem, rightly, a bit depressing. That could be why the allure of the United States for the brightest and the best remains so strong. (Although many of the well-paid over-40s would no doubt claim that they, too, put in more hours in their early days.) For officials and policymakers, it shows that cultural and social differences remain strong between the Anglo-Saxon nations and continental Europe. For everyone else, it offers a little peek at how the other 20% live. And what they don't do for free. ■