Unintentionally rust-proof

Ascribing the hardiness of ancient metals to technology is sometimes misplaced

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An astonishing find in recent times is the Qin Terracotta Army, a vast array of ceramic art found in the tomb of Qin Shi Huang, who was Emperor of China in the third century BCE. Among the finds were large numbers of swords, arrows and other implements, mostly in bronze, with portions, made of wood. The wooden parts had decayed, but the metal was found to be well preserved, with even polish and the sharpness of blades quite intact.

Researchers had found that the bronze parts had a surface content of chromium, which led to the belief that the metalworkers of the time had mastered a technique of "chromate conversion coating", which gave the swords and arrow-heads their durability. Marcos Martinón-Torres, Xiuzhen Li, Yin Xia, Agnese Benzonelli, Andrew Bevan, Shengtao Ma, Jianhua Huang, Liang Wang, Desheng Lan, Jiangwei Liu, Siran Liu, Zhen Zhao, Kun Zhao and Thilo Rehren, from the University of Cambridge, the Institute of Archeology, London, the site museum at X'ian in China, the University of Science and Technology, Beijing and The Cyprus Institute, Nicosia, write in the journal, *Scientific Reports*, that the traces of chromium are not really a part of the bronze implements and are not the reason for the implements' resistance to rust.

Qin Shi Huang ascended the throne when he was 13 and by the time he was 38 he had conquered the warring states of a vast territory and unified China, to become its first Emperor. His achievements were administrative and economic reform and include a vast road system and the beginning of the Great Wall of China. And then, was the great mausoleum, as large as a city, which he had built for himself during his lifetime.

The mausoleum consisted of a burial chamber the size of a football field, surrounded by halls ranged with full size terracotta sculptures of soldiers, captains and generals, horses, chariots, supposedly to protect the monarch after he died. Over 2,000 ceramic warriors have been excavated and many thousands are believed to be buried. Historians say the chambers contained replicas of palaces and scenic towers, "rare utensils and wonderful objects", a hundred rivers of mercury and crossbows rigged to shoot intruders. The figures of the soldiers, in realistic size and ritual dress, carried real life weapons, such as swords, daggers, spears, crossbows and arrows, mostly made of bronze.

Much of the metals may have been looted in later years, but the partial excavations after 1974 revealed over 40,000 articles of weaponry, including a large number of arrowheads in bundles of a hundred each. "In most cases, the organic components of the weapons, such as wooden shafts, quivers, scabbards or crossbow stocks, have largely decayed. However, the preservation of the bronze is remarkably good overall, with many of the weapons displaying shiny, almost pristine surfaces and sharp blades," the *Scientific Reports* paper says.

This remarkable state of preservation for over 2,000 years suggested some anti-rusting technology that the ancient Chinese had. Research that followed the discovery revealed that some of the metal objects were covered with a chromium oxide layer. Chromate conversion coating is rust-preventing measure that is used today with many common metal objects. It was hence suggested that the artisans of the time of Qin Shi Huang had some version of this process, which the weapon makers may have used. Such a process was found to be feasible, given the materials and methods available at the time, the *Scientific Reports* paper says, and although the process could not be replicated, the idea that the ancient Chinese had "highly developed technology" has taken root.

The researchers put this idea to test by systematic analyses of the surface of a large sample of the buried weapons. They used an extremely sensitive method, X-Ray fluorescence, where X-Rays are shone on the surface and traces of specific elements emit secondary X-Rays. What they found was that although there were traces of chromium in a large number of cases, these were only eight per cent of all the cases. The presence of chromium was hence not the reason for the apparent resistance to corrosion.

This apart, the team checked whether there was a pattern in the placement of the items that showed traces of chromium, to see if chromium treatment could be linked to some workshop or production location. Here again, the distribution was found to be quite random. Another possibility was that chromium present in the copper or tin ores used in creating the bronze had shown up on the surface. This was also ruled out because the reduction of chromium from its oxides would have called for energy beyond the capacity of the processes used to smelt copper, tin, lead or iron, which were practiced in the region.

The chromium traces hence must have got there after the article had been made. Here, there were two possibilities -- from the earth or from the pigments used to paint the terracotta warriors. Both those were ruled out, based on the nature of the soil and the pigments used. The final possibility was the lacquer coats that were applied before the pigments were put on. And here, it was found that there was a distinct source of chromium. And then, the lacquer as the source of chromium was confirmed by the greatest traces of chromium being on bronze surfaces where the surfaces were nearest to lacquered components, like handles or scabbards.

Having located the source of the chromium, there was still the need to explain how the bronze was preserved. Here, it was found that higher levels of tin in the bronze, and also traces of arsenic, contributed to preservation. But a more important reason was that the soil in the area was clearly alkaline, as opposed to acidic. Alkaline soil acts to neutralise the effects of salts, acids and even bacteria. Further, the soil was very fine, thus covering metal surfaces and keeping away the air and moisture that are needed for corrosion. A control test, with samples of bronze in the soil from the excavation pits and in soil with organic matter, and mildly acidic, confirmed it was the soil in the tomb that had helped preserve the bronze articles.

The paper says it was a long-term, international co-operative and interdisciplinary research that helped dispel the notion that the bronzes of Qin were the result of advanced technology.

A similar belief that the ancients had advanced capabilities arose from the anti-rusting property of the Iron Pillar in Delhi, which is made of the same material as Damascus steel, which provided the scimitars during the time of the Crusades. This especially tough and shatterproof steel, which came from southern India and Sri Lanka, was believed to be the mark of metallurgical expertise.

Scientific analysis, however, has shown that while the process and some ingredients used in forging the steel have their place, the operative difference lay in trace elements found in a particular strain of ore. When the supply of ore ran out, in the 1700s, so did the manufacture of Damascus steel.

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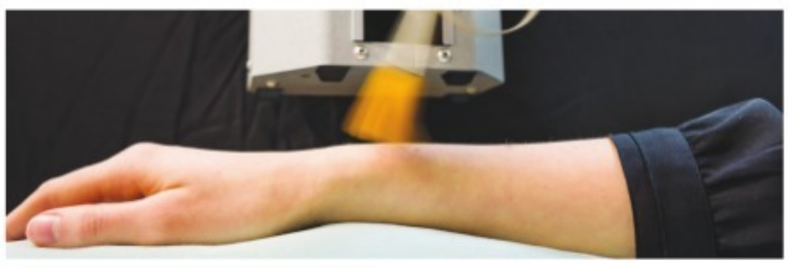
Intriguing indeed

Scientists are battling it out online on which is the best sense of them all



HARRIET DEMPSEY-JONES

If there is one thing Twitter has taught us, it's that the world loves a question that sounds stupid, but actually has a profound and interesting answer. For instance, what would happen if the world suddenly turned into blueberries, as answered by physics recently. Or what colour is that dress?

In a similar way, perception scientists have recently been fighting it out on Twitter to answer the seemingly trivial question of, "which is the best sense, and why?". The debate has opened up some surprisingly deep questions —like what actually makes a sense more or less valuable? And, are some senses fundamentally more important in making us human?

The question was also put to a poll. While most people would probably assume the obvious winner is vision, "somatosensation" — which we normally refer to as touch but technically incorporates all sensations from our body — took the day. But does this vote hold up when you take a closer look at the scientific evidence?

Losing your body

We need somatosensation to move successfully — seemingly more so than vision. While a big claim, it is arguably backed up by the rare handful of cases where this sense is lost. "Deafferented" patients are individuals who have lost most (or all) touch sensation, as well as the ability to sense the position (proprioception) and movement (kinesthesia) of their limbs. This may occur because the body attacks its own somatosensory nerves in post-infection autoimmune reaction, though in most cases the cause is unclear.

While there is no direct dysfunction in the patient's motor systems, most sufferers cannot complete even the most basic of movements. That's because the brain must feel the body's starting position to create the right motor plan, and needs sensory feedback to know if the plan was executed successfully.

Despite these barriers, one patient, dubbed "IW", shocked medical experts by regaining the ability to walk. He achieved this feat by meticulously planning what muscles to contract, in what order before moving— then staring at his limbs to track his success. This strategy is highly cognitively demanding, and not at all the norm, with most patients bound to wheelchairs.Many foodies might think that taste gets their vote for top sense. However, those who have tried eating after dental anaesthetic can attest to the risks and difficulties of eating without somatosensation— a challenge described by the deafferented patient "GL" in the scientific literature.

Another subcomponent of somasensation is the vestibular system, which is critical in keeping us upright. If you have ever been motion sick, you have a tiny insight into what happens when this critical system goes awry. In short, your eyes tell the brain you are moving, but your vestibular system says you are still — causing a conflict that can lead to vertigo, nausea and loss of balance.

Pain and temperature perception also get lumped in with somatosensation, failing to fit into any other category. Being born without sensitivity to pain is rare (around 45 documented cases) and highly dangerous. Some experts speculate the incidence may actually be largely underestimated, as sufferers don't survive long enough to be documented. This is because pain tells you something is directly impinging on your body in a bad way, and you better react fast. Patients must self-check multiple times daily, to prevent infection from cuts they haven't noticed.

Touch forms a core part of our humanity. It is the first sense to develop in a fetus in utero, and some suggest the integration of sensations related to the body may form the basis of our fundamental self consciousness.

The touch of another can also reduce anxiety, influence our behaviour, shape brain development and reduce brain responses to pain in babies. We even have a dedicated set of nerves that preferentially process "social" and "emotional" touch.

Vision versus touch

On the other hand, looking from a neuroscience perspective, it is easy to see (no pun intended) why vision almost won the poll. The brain seems to have a vision focus. The primary brain area for processing visual stimuli, the visual cortex, takes up the largest area of any individual sense. Partly because of this vast processing resource, vision is the most acute sense we have for various kinds of discrimination.

The high reliability of vision means that if there is a conflict between what two senses say, vision will typically warp our final perception to be in line with the visual information. In the famous rubber hand illusion, stroking a realistic dummy hand in front of a person (and hiding their own hand) can make the person feel as if it is their own hand that is being stroked — with vision hijacking their sense of touch. Similar things happen when you conflict hearing with vision.

Vision also allows reading, writing and art. You can see the faces of your loved ones, or danger coming from far away. But maybe we only think vision is so crucial because it is at the very forefront of our daily experience. As Kevin Wright, an assistant professor of neuroscience at the Oregon Health and Science University, who posted the best sense poll, states — people may simply perceive the loss of vision as being more life affecting because "we are more aware of our vision as opposed to our somatosensory function".

And the rest…

So are the other senses really less important? Our sense of smell is incredibly ancient and complex. If order indicates anything, smell is a form of chemoreception, which is thought to have been the first "sense" to evolve in our early multicellular ancestors. Smell is the only sense that bypasses our brain's sensory relay system—going straight to the cortex for processing.

Smell works together with taste to stop you eating spoiled or poisonous foods. Smell is also strongly linked to autobiographical memory, therefore forming a core part of the processes that maintain our identity. And hearing is better than both touch and vision for detecting danger coming up behind you. And it is certainly better than vision in the dark. And no hearing, no music. Enough said.

At the end of the day, somatosensation gets my vote because it keeps me upright, moving and alive —more so than the others. Looking to the future, however, I am excited to see how sensory substitution technology might upend our assessments of what sense is more or less important. As science reveals, for instance, that with the right device you can learn to see with touch or sound.

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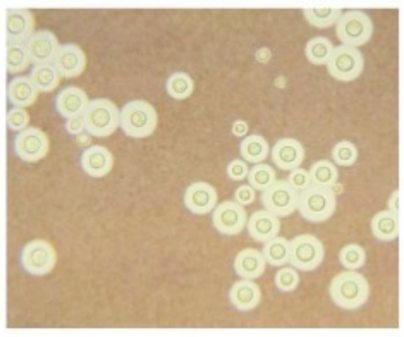
PLUS POINTS

Copycat fungus



Fungus can imitate signals from our immune system and prevent our body from responding to infection, new research from the University of Sheffield has found. Life-threatening fungal infection is a major killer of people with immune system problems such as blood cancers, HIV infection or following organ transplant. The new study focused on one of the most dangerous infections for people with HIV/AIDS — Cryptococcus neoformans — which causes hundreds of thousands of deaths worldwide every year.

Fungi are known to make molecules similar to those of our own immune system, but why fungi make these molecules and what their function is, has been a longstanding mystery. Now, scientists from the University of Sheffield have identified how specific immune signals called prostaglandins, made by fungi, are able to disarm immune cells. The team, led by Simon Johnston from the University's department of infection, immunity and cardiovascular disease, found that fungi, which are not able to make these signals, were less able to grow during infection.

Johnston, senior research fellow in infectious disease, said, "We've discovered these immune signals — fungal prostaglandins — deactivate immune cells, preventing them from destroying the infection. Opportunistic infections like Cryptococcus — which normally pose no threat, but are potentially life-threatening in those with weakened immune systems — are an increasing problem and are often very difficult to treat.

"Understanding how opportunistic infections cause disease is vital in order to develop new and more effective treatments, especially with the increase in antibiotic resistant infections."

Johnston said, "We are now working to find other ways these fungal molecules are affecting immune cells and how the immune cells are deactivated. The same deactivation of immune cells is seen in other diseases such as cancer. Our findings mean that we now have a new approach to solving this problem and will help the development of new treatments."

The study was published in the journal *PLoS Pathogens*.

First look today?

Representational image

The world, it seems, will see the first picture of a black hole. Today, astronomers across the globe will hold "six major press conferences" simultaneously to announce the first results of the Event Horizon Telescope, which was designed precisely for that purpose.

Of all the forces or objects in the universe that we cannot see — including dark energy and dark matter — none has frustrated human curiosity so much as the invisible maws that shred and swallow stars like so many specks of dust. Astronomers began speculating about these omnivorous "dark stars" in the 1700s, and since then indirect evidence has slowly accumulated.

"More than 50 years ago, scientists saw that there was something very bright at the centre of our galaxy," Paul McNamara, an astrophysicist at the European Space Agency and an expert on black holes, told *Agence France-Presse*, "It has a gravitational pull strong enough to make stars orbit around it very quickly — as fast as 20 years." To put that in perspective, our Solar System takes about 230 million years to circle the centre of the Milky Way. At its centre, the mass of a black hole is compressed into a single, zero-dimensional point. The distance between this so-called "singularity" and the event horizon is the radius, or half the width, of a black hole.

The EHT that collected the data for the first image is unlike any ever devised. "Instead of constructing a giant telescope — which would collapse under its own weight — we combined several observatories as if they were fragments of a giant mirror," Michael Bremer, an astronomer at the Institute for Millimetric Radio Astronomy in Grenoble, told *AFP*.

The straits times/ann