Feature

Where art and biology meet

Nature inspires art, but conversely, art can also aid biological understanding, which, in turn, can help the appreciation and conservation of art works. **Michael Gross** investigates examples of symbiosis across the 'two cultures' divide.

From the still life with a bowl of fruit to scenes of wildlife in the woods, from Michelangelo's David to Damien Hirst's Verity, biology often provides the shapes, forms, colours and concepts that most inspire visual artists to create their own representation of life. Apart from the unique case of Leonardo da Vinci, the scientific and the artistic eye cast on living things have rarely resided in the same head, as the analytical, dissecting interest of the scientist has been considered a contrast to the holistic, spiritual view of the artist.

As one possible exception, scientific illustrations could be described as works of art that have greatly aided scientific understanding. Many of them, from Leonardo through to the highly aesthetic and influential protein structures drawn by Irving Geis, are appreciated as art by scientists, but not usually by the visitors of art galleries.

And yet, today, as biology has more powerful imaging tools than ever, wild nature is more threatened than ever, and visual art can be shared around the world in seconds, new ways are emerging in which art and biology can work together for the benefit of nature, mankind, and our cultural heritage.

Printed holes

Scientific information can turn up in the most unlikely places, for instance in the tiny flaws of printed pictures. In 2006, Blair Hedges from the Pennsylvania State University published a study using the time-dependent breakdown of wood and copper print stocks to date historic prints, in an approach methodically similar to isotope dating.

"I collect Renaissance art, such as prints and maps, and realised that there was a lot of interesting science that could be applied to art," says Hedges, who maintains a website of historic maps, www.caribmap.org. "I've noticed printed wormholes over the years, especially when working on the 'print clock' and decided to follow it up."

In his recent study of the printed records of 'wormholes' in wooden printing stocks, Hedges manages to map the changing geographic distribution of two distinct species of wood-boring beetles, presumed to

Memento mori: The Ghost Forest installation created by the artist Angela Palmer at its final resting place at the National Botanic Garden of Wales. (Photo: Colin Baglow.)

Holistic views: Renaissance woodcut art print, The Rich Man by Cornelis Anthonisz (1541), showing printed wormholes. (Image: Rijksmuseum, Amsterdam.)

be the Mediterranean furniture beetle (*Oligomerus ptilinoides*) in the South, and the common furniture beetle (*Anobium punctatum*) in Northern Europe, which can be distinguished by the diameters of the round exit holes from which the beetles emerge after pupation (Biol. Lett., http://dx.doi.org/10.1098/rsbl.2012.0926). *Anobium* exit holes are typically 1.4 mm in diameter, whereas *Oligomerus* leaves a hole of 2.3 mm diameter.

As woodblocks were used repeatedly and usually with precise indications of the place and time of the printing, any observation of a new printed hole that wasn't present in previous editions yields a precise historical record of the presence of one of the two species. Otherwise, museum records of the species were insufficient to map their history in any detail.

With more than 3,000 of such measurements, Hedges could show that from the 15th through to the late 19th century the two species were separated, surprisingly, by a clear and stable boundary, running across central Europe, through France, Switzerland, and Austria. He hypothesized that they maintained this natural separation because of competition for the same food source: dry, dense hardwood of the same type used in art blocks. In modern times, however, the species expanded and overlapped, as global trade in wood products, including lumber and furniture, increased during the last century.

Some of the original print blocks used, now centuries old, are also conserved in museums, complete with the wormholes. While these 'real life' holes were of little value for the historic and geographic analyses, they may still hold DNA evidence, which Hedges now hopes to retrieve, in order to confirm the identity of the species associated with the holes and possibly evidence of their evolutionary history.

Hedges continues to enjoy straddling the worlds of art and science: "The only problem I have is that I always get distracted by the subject matter, the art, while collecting the data, which slows me down," he says.

Behind the scenes at the museum

More commonly, science applied to works of art or cultural artefacts aims to date or analyse the works investigated, rather than the insects that diminish its appearance.

For instance, Marco Leona at the Metropolitan Museum of Arts, New York, has applied surface-enhanced Raman spectroscopy (SERS) to a leather fragment from an ancient Egyptian quiver, dated to the Middle Kingdom (2124–1981 BC) and found a spectrum characteristic of madder lake (alizarin), a red dye made from the roots of plants such as common madder (*Rubia tinctorum*). This discovery shifted the date of the first use of a dye extracted from a plant source back by seven centuries (Proc. Natl. Acad. Sci. USA (2009) *106*, 14757–14762).

Applying the same method to other objects in the treasure troves of the Metropolitan Museum, Leona discovered traces of lac dye, made

Exit holes: Partially carved woodblock, The Wedding of Mopsus and Nisa by Bruegel (1566), housed in Metropolitan Museum of Art, New York, showing actual wormholes. (Photo: Richard Field.)

Blue period: Wood infected with the fungus *Chlorociboria aeruginascens* has provided artists with natural colour since the Renaissance. (Photo: Dan Molter.)

from scale insects (*Coccoidea* superfamily), e.g. *Kerria lacca*, in two mediaeval wood sculptures of the Madonna and child. Historic evidence of this dye being traded in Europe only begins several decades after these works were produced.

Another biological dye popular in historic woodwork is produced by the intriguing blue-green fungus known as the green elfcup (*Chlorociboria aeruginascens*). Wood infected with this fungus is also known as 'green oak' and has been used since the 15th century.

Apart from biological dyes, the SERS method can also be adapted to detect proteins in artworks, such as the collagen from animal glue, and albumins, if the artist has used egg. Julie Arslanoglu from the Metropolitan Museum, together with colleagues, has combined SERS with the use of antibodies coupled to nanoparticles. With this approach, they could achieve the protein specificity of an ELISA assay with the local precision of SERS analysis (Anal. Bioanal. Chem. (2011) *399*, 2997–3010).

Another important reason for scientists to work behind the scenes at art museums is to help conservation of precious works of art. Cell biologist and electron microscopist Robert Koestler, for instance, now at the Smithsonian Museum Conservation Institute, made his name in this field during his time at the Metropolitan Museum, where he developed methods of killing insects and fungi without damaging the artworks they reside in. Koestler introduced the use of argon gas to suffocate pests. This treatment may have to be applied for up to several weeks, but, as the noble gas is chemically completely inert, it cannot damage the artwork in any way.

The ghosts of living things

One of the modern artists seeking inspiration in biology is Mark Quinn, who created a portrait of geneticist John Sulston using bacteria transformed with Sulston's own DNA. Since then, he has produced more work inspired by biology, including paintings of human irises and fingerprints, exploring the issues around data that can be used — like DNA — to determine a person's identity. Earlier in his career, he also created a sculpture of his own head by filling a mould with his own blood and freezing it. He renews this self-portrait at regular intervals with fresh blood.

The very material reality of her own head also inspired artist Angela Palmer, who in her series Life Lines, which was exhibited in London from May to June 2012, reproduced MRI and CT scans of bodies, including her own head, on glass plates, creating an eerie sense of the contrast between life's physical presence and fragility.

Palmer, who studied at the Ruskin School of Drawing and Fine Art in Oxford, got the idea for this work from an earlier visualisation of actual scientific research, namely the three-dimensional outline of the penicillin structure that Oxford crystallographer Dorothy Hodgkin had drawn on stacks of Perspex sheets in the 1940s. "The finished pieces, presented in three dimensions in a vertical plane, reveal the extraordinary inner anatomical architecture concealed beneath the surface, thus creating the most objective form of portraiture," Palmer comments in a statement on her website. "The image floats ethereally in its glass chamber, but can only be viewed from certain angles — from above and from the side the image vanishes and the viewer sees only a void."

She applied the same technique to a 2,000-year-old mummy of an Egyptian child, resulting in a sculpture made of 111 sheets of glass, which is now on display at the Ashmolean Museum in Oxford next to the actual mummy. The numerous scans required for this work also revealed many details of the child's cause of death and other medical problems.

Angela Palmer is also responsible for the Ghost Forest installation, which was displayed in Copenhagen, London, and Oxford, and which recently moved to its final resting place at the National Botanic Garden of Wales at Llanarthne, Carmarthenshire. It includes ten large tree stumps from a commercially logged rainforest in West Africa. The trees are meant to draw attention to the alarming loss of natural resources and especially of the rainforests.

They were exhibited in Copenhagen during the climate change conference in December 2009, then spent two years on display outside Oxford's University Museum, where they attracted prominent visitors including Michelle Obama. In July 2012, they were moved to Wales, where they rest on the ground next to Norman Foster's Great Glasshouse and will be allowed to decay naturally over time. Their final move, a massive logistical challenge, was funded by Size of Wales, a charity that aims to conserve an area of tropical rainforest the size of Wales.

Thus, by representing, using, and incorporating biology, art can hopefully help to create awareness of and preserve the richness of life on our planet. Another poignant example of art turning fleeting manifestations of biology into permanent works is provided by the US artist Anthony Michael Simon, who in 2009 moved from Chicago to rural South Korea, in order to find inspiration from a different kind of environment.

In a kind of artistic dialogue with Nature, Simon started to highlight specific elements of plants, such as the leaves of a tree, by spray-painting them. After extending that approach to a gigantic spider web he had encountered during his tree-modifying excursions, he found out that he could encourage spiders he caught in the woods to spin their complex three-dimensional webs between three vertical Perspex rods in his study, rather than between trees. The artist then sprayed a protective coating on the webs, followed by bright colours. The resulting complex and colourful webs capture the fragility of life and the permanence of art, like the old saying, *ars longa, vita brevis*.

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Q & A

W. Tecumseh Fitch

Tecumseh Fitch is the head of the Department of Cognitive Biology at the University of Vienna. His research has followed two main paths: the evolution of cognition, and the bioacoustics of vocal production. He studies both topics from a broad comparative perspective. Initially trained in evolutionary and behavioral biology, he did a PhD in cognitive science at Brown University, after deciding to study language evolution from a biological perspective. He taught in both biology and psychology departments at Harvard and St Andrews before moving to Vienna in 2009 to co-found the new Department of Cognitive Biology, within the Life Sciences Faculty at the University of Vienna. *He has recently published a book '*The Evolution of Language*' (CUP, 2010) and is a recipient of an ERC Advanced Grant. He has worked on a wide variety of species, including whooping cranes, deer, elephants, dogs and many primate species, and much of his work features direct experimental comparisons of such species with human beings.*

You've repeatedly switched among disciplines in your career: why? I got my start in behavioral biology and evolution, studying coral reef fish behavior in the Caribbean and the Red Sea, which was fascinating and great fun. Unfortunately, however, I have a weak stomach and got sea-sick one too many times, which led me to decide to continue my biological career on dry land. As part of this work I'd learned some Spanish and Hebrew and I became interested in language, and started reading people like Noam Chomsky and Philip Lieberman. The more I read, the more it seemed to me that the field, particularly in the case of language evolution, was overlooking some basic biological insights about evolution and neglecting the power of the comparative approach. So I decided to try to combine the study of animal communication and human language in a way that would be beneficial to both fields.

Because I knew next to nothing about language or psychology, I decided to do a PhD in Cognitive and Linguistic Sciences, in one of the first cognitive science PhD programs, at Brown University. That's when I started learning about acoustics and signal processing, and realized that insights from speech science could be applied to animal vocalizations (my PhD was about formant frequencies in non-human primates). After that, to learn more about acoustics, I did a post-doc in the Speech and Hearing Sciences program at MIT/Harvard, which had a strong engineering slant and gave me total freedom to take more courses in acoustics and speech science. Since then I've bounced back and forth between teaching in Biology and Psychology departments.

Despite all this disciplinary wandering, my perspective has remained biological, and I've remained focused on the broad set of issues surrounding the evolution of communication and cognition. In my opinion, the interesting scientific questions don't respect disciplinary boundaries, so neither should scientists who seek the answers. By now, I've collaborated and published with physicists, engineers, psychologists, linguists and computer scientists, and in every case have learned things of central relevance to the fundamental biological questions I'm interested in.

What is your view of the relationship between psychology and biology? I think things are in flux. In the days of Charles Darwin or William James there was little distinction made between biology and psychology, and both of these scholars moved flexibly between these topics. But today the two fields have diverged almost completely, to the detriment of both. The biggest issue right now is that the cognitive revolution happened in human psychology, and by 1980 it became acceptable again to use mentalistic theories and explanations — in humans. But in animal cognition and neuroscience, such explanations are still viewed suspiciously, and many people still only accept cognitive explanations if all possible associationist or behavioristic explanations, however complex and post-hoc, can be clearly ruled out. Although things are changing, I think