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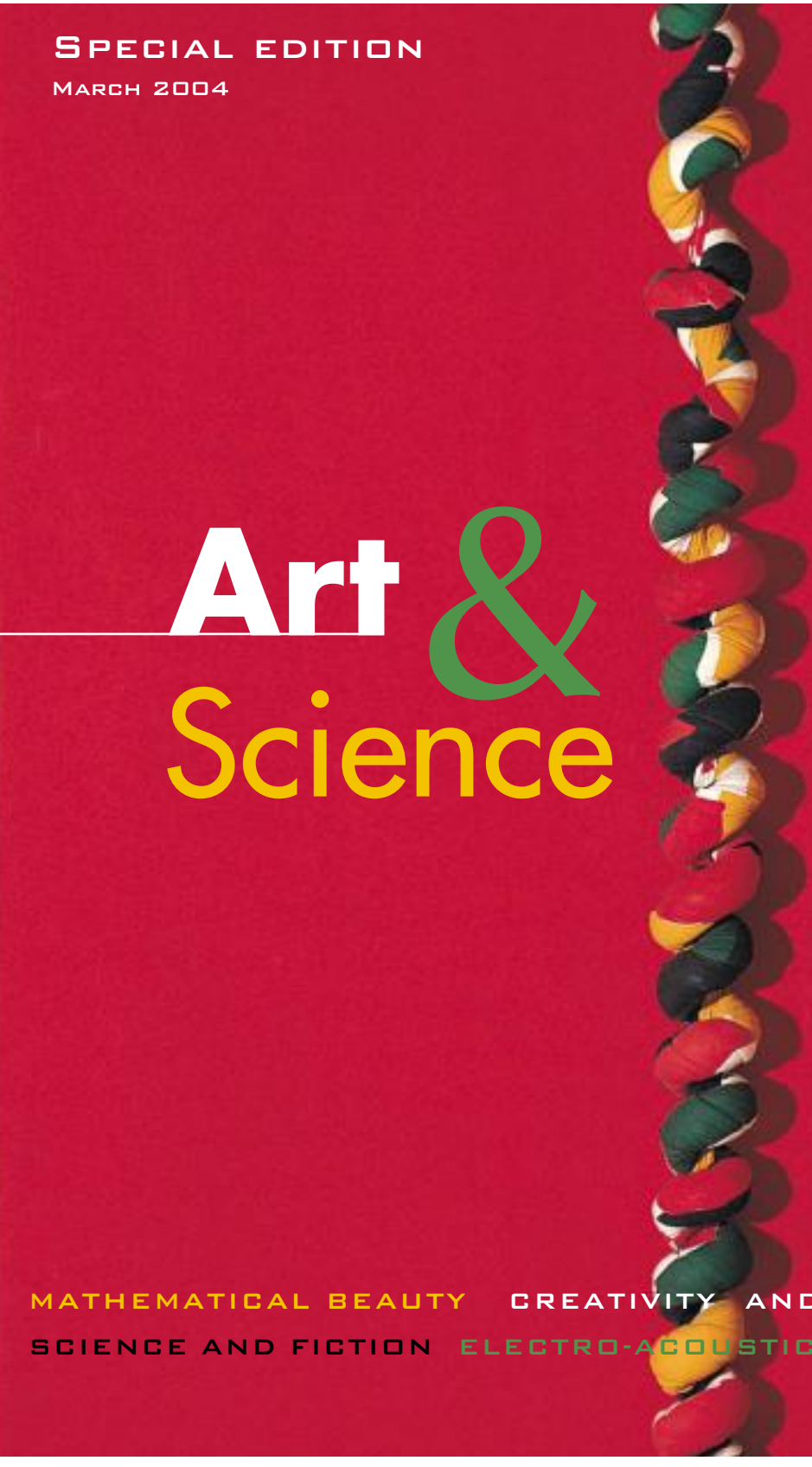

Art & Science

MATHEMATICAL BEAUTY CREATIVITY AND IMAGINATION BIOTECH ART

SCIENCE AND FICTION ELECTRO-ACOUSTICS RESEARCH AND HERITAGE

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SOUNDS AND NOISES

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Creation and technology

MEMORY

Cultural heritage

Cover: Jorge Eielson, Amazonia (detail), 1993 – Courtesy Galleria d'Arte Niccolli, Parma

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Tiede–Taide, two cultures

Science has long abandoned its quest for truth, and art no longer operates in terms of beauty. Science continues to perceive the world and attempts to understand it. Art translates and transfigures it. Art and science both involve thought, intuition, imagination, and research. But what do they have in common and what separates them?

In Finnish, this very unusual language from outside the Indo-European framework, science is translated as 'tiede' (from the verb *tietää*, to know) and *art* as 'taide' (from the verb *taitaa*, to make something known). "Conditioned by their language, Finns are led to seek the connection between these two fields of human activity," explains mathematician Osmo Pekonen. "Any politician, journalist or sponsor who pronounces the word *tiede* with any solemnity almost instinctively adds the word taide. When you practise or sponsor one, you should not forget the other."

Has RTD *info* adopted the Finnish mindset? Is a Framework Programme or a Commission action plan about to be launched to research the relationship between science and the arts? Interactions between science and society are unquestionably an expanding European activity. Let us add, more simply, that this special issue responds to the desire of many readers to see science presented differently, as a vital component – just like art – of our shared European culture.

Working on this topic, you quickly become aware of its prolixity, if not banality. Art and science, arts and sciences – in the singular or plural without knowing exactly why – are constantly present in symposia, specialist reviews, lectures, and seminars. Clearly, these are areas in which exchanges and collaboration also offer European 'added value'. The media unconscious has to exist and we are simply going with the flow, but is this sufficient reason for putting the clock back?

What spurs on our quest is the quality of the people encountered, the projects undertaken, and the places imagined. The question posed, in a different way each time, is that of the frontiers and areas of *entente* between these two universes, of what is specific to each of them and how they can enrich one another in a reciprocal way.

Each encounter opened up new prospects – avenues that had to be abandoned because a 44-page magazine has its limits. Ideally, we would have met and spoken with architects, evoked the relationships between music and mathematics, talked about how artists grasped new technologies and virtual space, visited science and technology museums, questioned the way education maintains the famous divide between *scientific* and *literary* cultures. But this would have required more space and more time, and we have been forced to cut short an investigation close to the hearts of scientists and artists alike.

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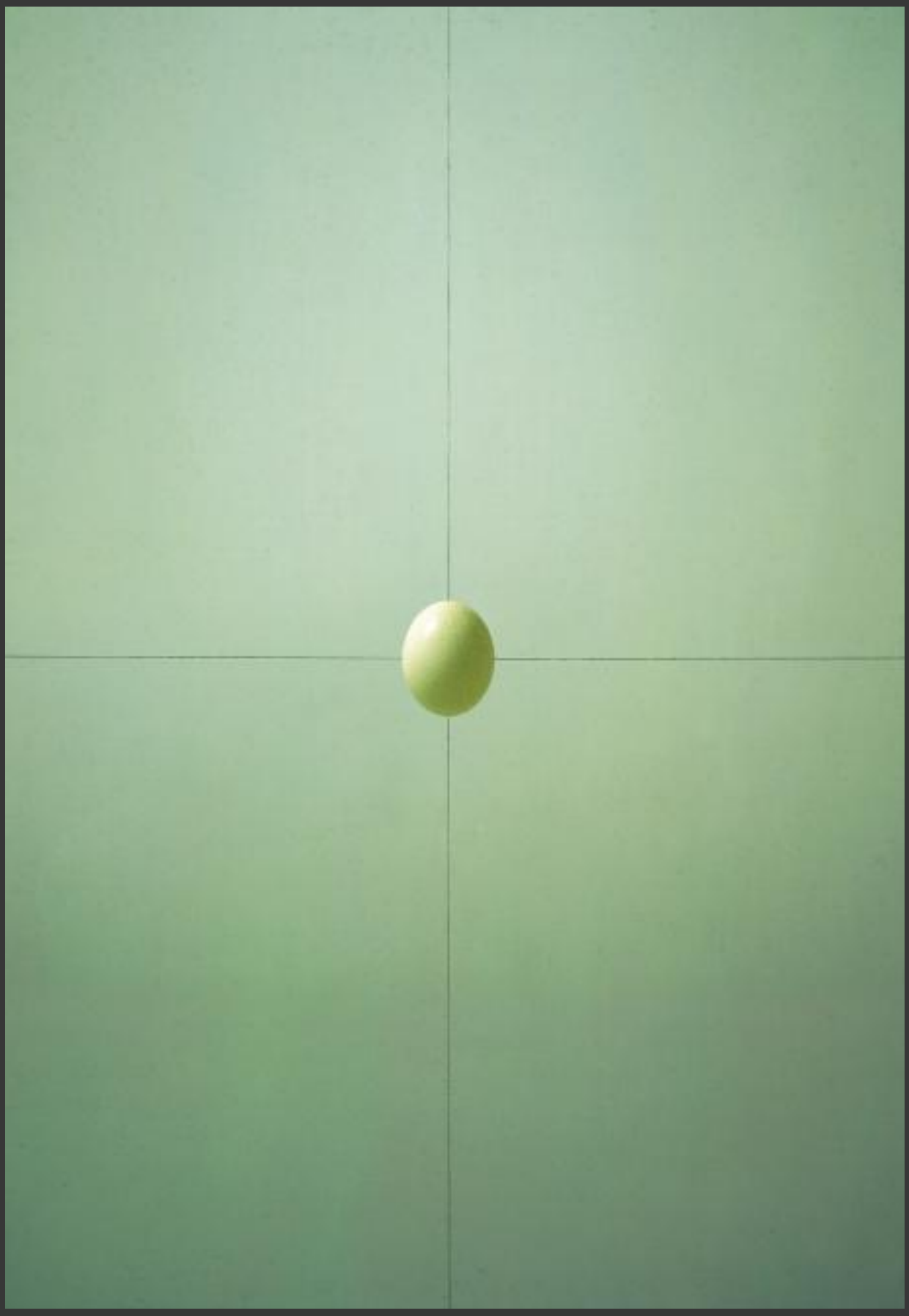

Claudio Parmiggiani, *Uovo*, 1967, Collection du Musée d'Art Moderne, Marseille

"I am grateful to certain artists for helping me step back and achieve the essential critical distance which techno-science requires today." This 'saying' of Jean-Marc Lévy-Leblond dates from 1996, but it has not lost one iota of its truth to this day. Theoretical physicist, 'experimental epistemologist', lecturer at the University of Nice, director of publisher Seuil's scientific collection, and the driving force behind the *Alliage* magazine (see box), he is constantly questioning science which he likes to 'put to the test of thought' and to confront with other human activities, like artistic creation.

Science and the world, art and the ego

Traditionally, people have spoken of a scientific spirit and an artistic sensitivity. Are these expressions meaningful to you?

I would like to turn them the other way round. One could equally well speak of an artistic spirit and a scientific sensitivity. But traditionally, science tends to be identified more with a rational approach and art more with an emotive approach. I do not believe we should attach much importance to such vague categorisations. The real differences between art and science do not lie at this general level of terminology.

Where then should we begin to situate their differences?

The social reality of these two professions is radically different today. The scientist is part of a powerful institution – in most cases publicly owned – which pays him. He belongs to a team and is part of a collective effort. The artist works alone, with a much higher degree of personal risk. His personality and subjectivity are truly committed and non-recognition and failure can prove very painful. A scientist too can confront career difficulties, but he is protected by the group to which he belongs. This vital difference needs to be taken into account if we set out to promote dialogue between artists and scientists. Most of the time, the latter group are unaware of what separates them. Artists have an image of individual researchers, hidden away in their laboratories, in a creative pose similar to their own, whereas scientists – deluded by the large-scale mediatisation of a handful of artists – are unaware of the isolated and very special nature of the artist's profession. In short: a double misunderstanding which does little to promote real exchange.

Looking beyond this distinction, are scientific and artistic research driven by similar forces?

Here, too, I would insist on their differences. An artist never seeks to be exhaustive. When Bach or Modiano worked on variations, they were not interested in producing the greatest possible number, but rather those that appeared to them the most interesting. A computer can create an xth Goldberg Variation, but it will be a pastiche. The specificity of the work lies not only in what its creator does, but also in what he does not do.

Science, on the other hand, claims the – utopian – right to knowledge of the entire world. In this process of discovery, it may never limit its variations and it should extend its system with as few limits as possible. A naturalist will never say to you 'if I know 30 varieties of this species, I will know how it functions'. He will want to know every single variety.

Moreover, scientific researchers are driven by the desire to add another little stone to the edifice of science, not necessarily very different from other discoveries, modestly, and without a Nobel Prize in sight. Artists do not think in this way. They do not pay any tribute to the edifice of art. They tell themselves "I bring what I bring, which is myself".

An artist uses the first person singular, a scientist the first person plural. This vital difference conditions their ability to engage in dialogue. An artist speaks of his own position whilst a scientist has a lot of difficulty bringing his own subjectivity into play and always speaks, in a certain way, on behalf of the group, under the watch of others and, again, taking far fewer risks. Which often means that, when they do meet, there is no real dialogue – a very interesting juxtaposition of words, but no real exchange.

Do such meetings, when they do take place, strike you as being constructive? In other words, do researchers – mainly in the exact sciences – have anything important to learn from others?

As a scientist, my impression is that right now science is having a hard time. It is running up against a series of difficulties and contradictions. For me, the only way to confront this situation is to fall back on the cultural experience accumulated over the centuries by writers, artists and philosophers, which has remained foreign to scientists for many years. Science as we conceive it today, as an organised, specialist, professionalised

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Jean-Marc Lévy-Leblond: "An artist uses the first person singular, a scientist the first person plural. This vital difference conditions their ability to engage in dialogue"

Enlightenment from '*Alliage*

Alliage **Alliage has recently published its 52nd issue, dedicated to the topic of science and war. This out-of-the-ordinary review seeks to deepen reflection on the place of science in culture and the relationships between techno-science and society. The 'decoding' of contemporary art forms and of their relationships with their environments is another common theme. One of *Alliage*'s greatest qualities is perhaps its aversion to everything banal. All texts are downloadable.**
www.tribunes.com/tribune/alliage/accueil.htm

social activity, has only existed for around 400 years.

It is one of the rare human activities not to include a historical dimension. You can be a physicist, a biologist, etc., and be locked into a very narrow contemporaneity, knowing absolutely nothing about the history of your discipline. Here again, scientists differ radically from artists who can situate themselves within a historical process, claim allegiance to one or other movement, or break with it and know what they are 'breaking' from.

Another particularity of scientists is the way they pride themselves on their critical spirit but, paradoxically, their production is always examined by their colleagues. The peer review system is a form of purely internal criticism. This is not the case for artists who expose their work to outside criticism. This is criticism in the noble sense of the term, which is not so much an evaluative judgement but an attempt to analyse the question of meaning.

But, beyond peer review, scientific popularisation is very much alive…

We are informed, abundantly, of its latest discoveries and latest state of knowledge. But the question of the significance of such work is rarely broached, or only very much later, when discoveries have political or ideological impacts. Take, for example, genetic manipulation. The real problem here is not that of knowing exactly which treatment cells are subjected to, but of questioning the meaning of such work from the viewpoint of the relationship of the human race to the rest of the living world. We need to step back sufficiently from a purely didactic approach and from immediate political criticism and show how our relationship with the living world changes once the subject of technology is life itself and not just the world of matter. It seems to me important to understand not only the replies that scientists give, but why they ask this or that question.

Could not the artistic endeavour be compared with that of the 'fundamentalists'?

The problem is that fundamental research is becoming increasingly ambiguous. Until a few decades ago, it was possible to uphold the idea of research undertaken out of curiosity, independently of any subsequent application. This separation between fundamental and applied research has weakened from the mid-20th century onwards. Its concrete symbol is the nuclear bomb, developed by the most fundamentalist theoretical physicists, driven by the curiosity to know how the nucleus of an atom works. Hiroshima and the nuclear arms race mark the beginning of a fusion between the fundamental and applied sciences which today makes the demarcation line increasingly difficult to draw.

Astrophysics is probably one of the few areas where science can boast it retains a certain original purity. But the impressive images that have made this science known to the general public are the fruit of space technologies. Probes would never have been sent to photograph Saturn without the communication satellites that industrialists are interested in…

We have spoken a lot of the differences between arts and sciences. But, when in the same context, they must share a certain number of questions.

People have often quoted the symmetry, in the 1910s and 1920s, between the physicists who invented the theory of relativity – which totally overturned our conception of time – and the work of the cubists who revolutionised the representation of space. The artists themselves, however, do not make the slightest reference to Einstein. What we have is rather a historical situation in which a whole series of representational structures were beginning to become unstuck. The traditional conceptions of time and space were being called into question by the historical upheavals – market globalisation, colonial empires, the widespread movement of goods – which were shattering traditional stable conceptions. This widespread impact affected every sector, both in science and art. It is quite possible that comparable phenomena are taking place right now. In any event, we can point to the increasing merchandising of both science - major companies buying and selling know-how and applying the criterion of profitability to scientific discoveries - and art, where the market potential is particularly powerful.

Today, we see scientists open their laboratories to artists working on living objects, for example changing the design of butterfly wings or using pig stem cells. How do you react to this type of encounter?

In a world in which technology is raising a host of problems – even if it resolves some of them – I would see rather a trend in scientists seeking to use one or the other art form to legitimise their research, on the lines of 'this can even create art' or 'what we are doing in our laboratories is not only real but is also beautiful'. This can be pretty gratifying self-justification, and it is no accident that biotech art has appeared just when the impact of genetics on industry is, rightly or wrongly, being called into question.

Artists, in turn, can find a sort of guarantee of modernity in this relationship with contemporary technologies in today's highly technological and

Claudio Parmiggiani, *Deiscrizione*, 1972
"I do not believe that we have any other message to pass on than the sign, the trace of our path and of what we are, that is: comets. Advancing like blind men, we have only our solitude to hand down." (Parmiggiani).

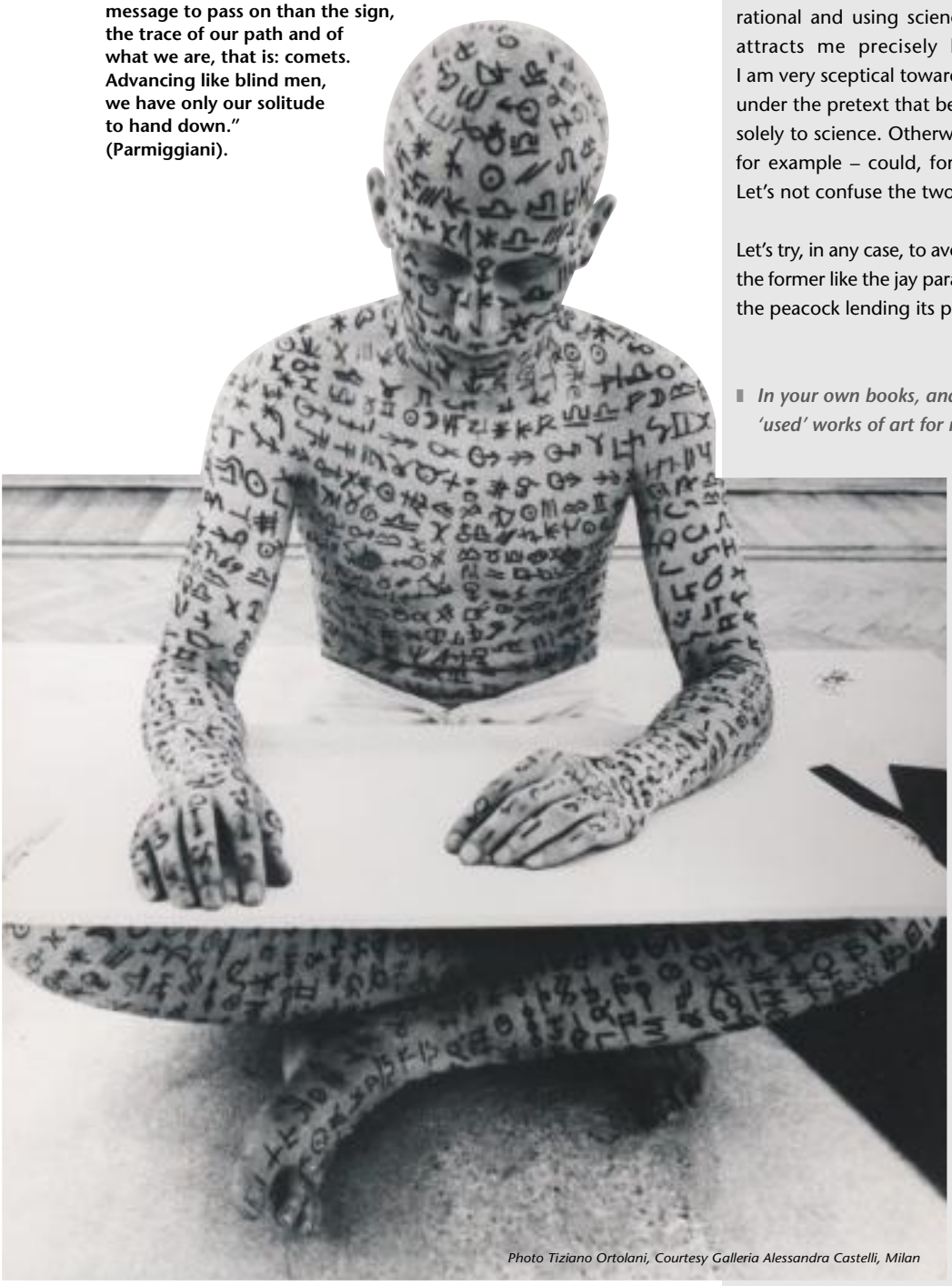


Photo Tiziano Ortolani, Courtesy Galleria Alessandra Castelli, Milan

scientific era – though not enough of course to explain the contemporary world. The works of artists like Joseph Beuys have long drawn our attention to the development of science and technology and questioned the roles they play in our lives.

Indeed, it can be asked whether the current insistence on a purported syncretism between art and science does not reflect the period of uncertainty in which we live. Science is adopting a human face. Through art it is entering the world of culture and sensitivity. Art is becoming rational and using science as a badge of modernity. Personally, art attracts me precisely because of its differences with science. I am very sceptical towards seeking any new alliance between the two under the pretext that beauty does not belong solely to art, nor truth solely to science. Otherwise, beauty – 'the splendour of an equation', for example – could, for certain scientists become proof of validity. Let's not confuse the two.

Let's try, in any case, to avoid science and art making fools of themselves, the former like the jay parading in a peacock's plumes, and the latter like the peacock lending its plumes to the jay.

In your own books, and in the publications you manage, you have 'used' works of art for many years. What role do they play?

Certainly not that of illustrations. A work of art cannot be reduced to illustrating a concept or a theory, which it generally has nothing to do with. Contradictions of this type abound, for example when people link elementary particles with Kandinsky. When I use a work of art, it is always with a certain caution and a slight sense of unease. What I seek to find is a work that can resonate, in a sort of temporary and fugitive way, a distant, diffused echo. This distance is very important. For example, for the cover of a book on Galileo, we took a work by the Italian artist Parmiggiani who has developed a profoundly metaphysical system, but in an entirely different context. Not a figurative representation of the Earth, but rather a poetic counterpoint which distances us from the purely historical scheme of things. Not a face-to-face encounter between art and science, but a relationship hinted at by this shared philosophical background, which imbues both of them with meaning and enables them to communicate. ■

The enigma of knots

In mathematical terms, a knot is a closed curve. It can intertwine, crossing over or under itself. A simple circle is also a knot. Knot theory is a field of topology – or the study of the geometrical properties of an object which remain unchanged by continuous changes in shape or size, providing nothing is severed. Mathematicians seek to discover whether or not an apparently complex knot can be simply untied, whether two apparently different knots are the same, and how to classify knots. It is an area of research that is also of interest to biologists who frequently observe knotted molecules through the lenses of their electronic microscopes.
The physical and concrete knot has long been a subject of fascination for the artist. Unlike the abstract knot, given a little patience it can always be untied. It may take some time to unravel its mysteries, discover the loose end and follow it through its many twists and turns. But a solution can always be found. The Peruvian artist Jorge Eielson has been working on the knot for the past 40 years. For him it is the metaphor for life itself – from the DNA sequence to the tangle of nerves and neurons. "Our whole existence," he writes, "'is the story of a structure which, to survive, must continually invent a network of information and interactive relationships to widen its horizons."

Jorge Eielson, Quipus vert, 1971
Courtesy Galleria d'Arte Niccoli, Parma (IT)

Jorge Eielson, Omaggio a Leonardo, 1996
Courtesy Galleria d'Arte Niccoli, Parma (IT)

Two ways of presenting the Borromean Rings, the heraldic symbol of the Borromea family at the time of the Renaissance, at the Castello Sforzesco in Milan (IT). On the left, the interlacing is wrong; the 'real' rings are on the right. No one ring links with any other within the Borromean Rings, yet the group that they form cannot be unknotted. If one of the three rings is cut, three separate rings are obtained. These rings can also be seen on stone sculptures in Gotland, an island off the coast of Sweden, which are believed to date from around the ninth century. They can also be found in the form of a triangle in northern Scandinavia.
A representation of the Borromean Rings in the form of 'Odin's triangle' or 'the knot of the slain' can also be found in this region.
Matemilano exhibition, Milan

"It gave me great pleasure to learn that some recent cosmological theories conceive the universe as a nodal structure, or an infinite web of knots which are constantly tying and untying."
(Jorge Eielson, *El dialogo infinito*).

Jorge Eielson, Nodo, 1973
Courtesy Galleria d'Arte Niccoli, Parma (IT)

The beauty of maths

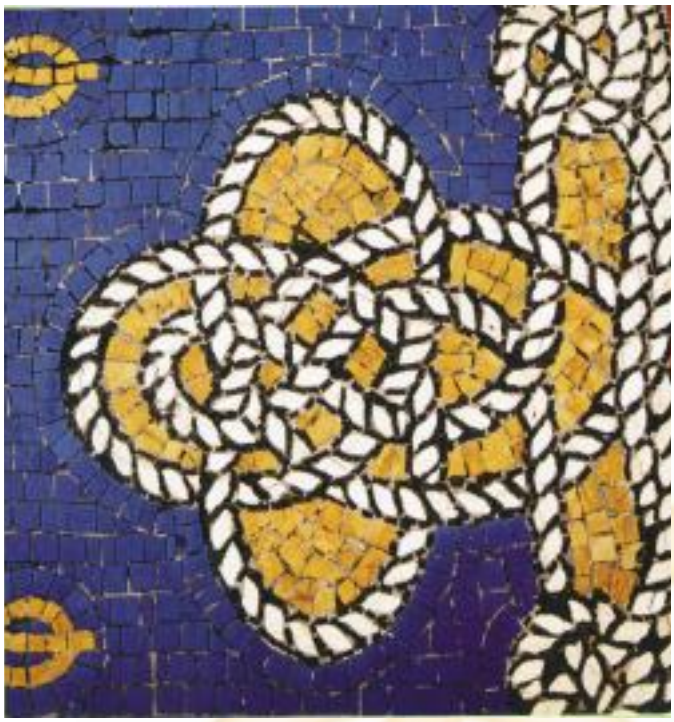
"Many mathematicians see their discipline as an art. They work according to their specific methods, but also using aesthetic theories that can be applied to artistic creation. Conversely, some artists are attracted and/or stimulated by mathematics and use ideas developed by scientists." That is the opinion of Michele Emmer, a mathematician and film-maker in whose company – among others – we take a look at the relationship between art and maths, images and visualisation, and aesthetics and education.

"The sense of beauty in maths must go back at least as far as Pythagoras. There is no lasting place for ugly mathematics. The elegance of a demonstration or the beauty of a formula can, in itself, be a pointer to the truth," believes Osmo Pekonen, a Finnish mathematician from the University of Jyväskylä, who is also a writer. When Pekonen speaks of maths, his enthusiasm is immediately evident – and contagious. "In mathematical physics, there are currently some mind-boggling predictive theories, such as String Theory and its most recent form, M-Theory. They allow us to dream of the existence of superior dimensions in the universe, dimensions which go beyond our usual perception of time and space where the fundamental interactions of contemporary physics – gravity, electromagnetism and nuclear interactions – would be unified. This may seem fictitious, and it remains experimentally unverifiable, but theorists want to believe in it because they are inescapably drawn to the beauty of equations." Such sentiments would have undoubtedly been shared by Henri Poincarré for whom "All mathematicians experience a genuine sense of aesthetics. It is a question of sensitivity."

Whether it is considered as art or not, mathematics plunges us into a world of balance and harmony – its links with music have long been the subject of study for example - and also of form. Do we not speak of mathematical objects – and of 'objets d'art'?

Plasticity

When rendered visible or palpable, equations become less obscure. Felix Klein (German mathematician, 1849-1925) was one of the first to understand this and, back in the 19th century, produced a collection of plaster models of complex functions that form the collection of the University of Göttingen (DE). The campus of Bangor University (UK) is also the site of James Robinson's *Symbolic Sculptures*, inspired in particular by the famous Borromean Rings – an idea that came from the mathematician Ronnie Brown, founder of the university's Centre for the Popularisation of Mathematics. For Professor Brown, "the major problem of teaching is converting mathematical reality into mathematical objects". His exhibition on knot theory, based on an exhaustive and fascinating presentation of knots, also proved a resounding success.



Detail from Roman mosaic tiling in the Hall of Columns (second to third centuries) at the Museum of Brescia in Italy.
Civici Musei d'Arte e Storia di Brescia

But sometimes the initiative comes from artists rather than mathematicians. Max Bill, an artist who worked with plastics and member of the Bauhaus school, spent many years investigating these abstractions – and sculpting, in his way, another life (see *Emmer's lens*). "Is it necessary to say that a mathematical approach to art has nothing to do with any ingenious system of calculation based on ready-made

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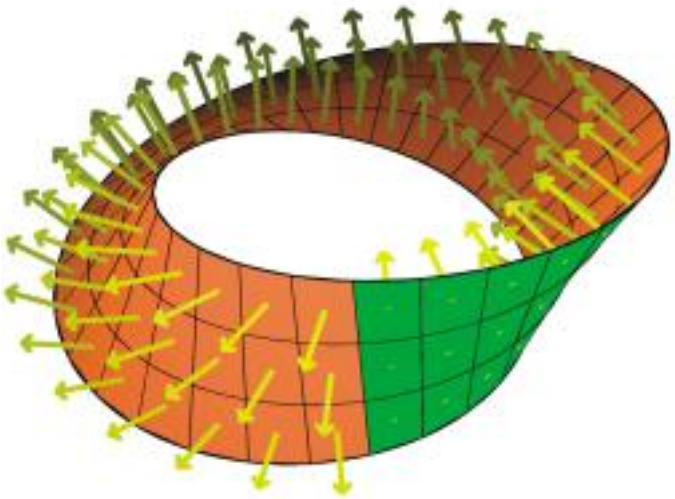


The *Möbius strip* (1790-1868) is one of the most famous and easily understood geometric paradoxes. It simply involves joining the two ends of a strip together after first twisting one end through 180 degrees. This produces a 'non-orientable' surface. In moving along it, one moves from one surface of the strip to the other without any transition.
©Konrad Polthier, T-U Berlin

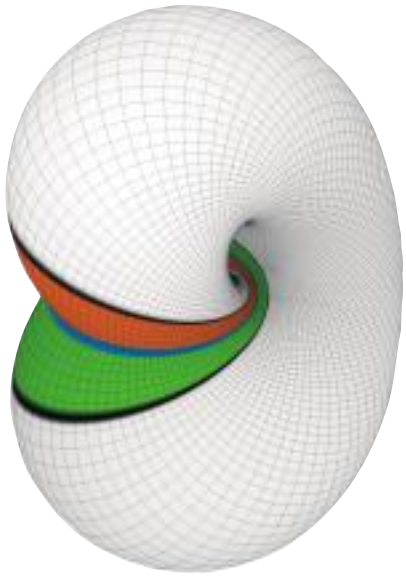
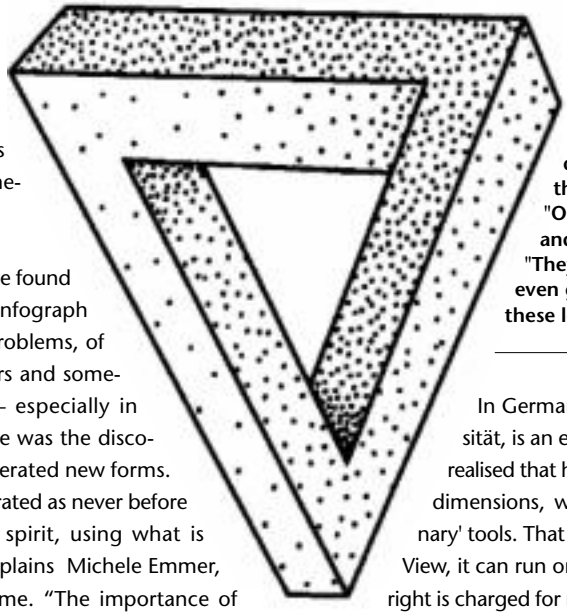


Illustration of another topological shape known as the *Klein bottle*, named after the mathematician who first described it in 1882. This surface, with no inside outside or edge, resembles a bottle whose neck has been stretched and then twisted back into itself through to the base.
©Konrad Polthier, T-U Berlin

formulas?" he wrote in 1949. "As regards composition, however, we can affirm that all schools of art have had, more or less, mathematical foundations."



The tribar, the "impossible triangle" dreamt up by the English mathematician and physicist, Roger Penrose, in 1958, only exists in two dimensions. It has frequently been used by the Dutch artist Maurits Cornelis Escher. "One of my greatest pleasures is the company and friendship of mathematicians," he said. "They have often given me new ideas, and I have even given them a few. How playful they can be, these learned men and women!"

More recently, mathematicians have found a new media in computing. The infograph is a means of visualising known problems, of understanding how to solve others and sometimes of helping new research – especially in geometry. "The point of departure was the discovery of new algorithms which generated new forms. Mathematicians and artists co-operated as never before with a new kind of Renaissance spirit, using what is known as visual mathematics," explains Michele Emmer, professor at the University of Rome. "The importance of these virtual images and the possibilities for animating them are increasing all the time in mathematics. It seems only natural that all these new visual aspects should also interest artists. After all, at certain times, during the Renaissance for example, it was not easy to distinguish between an artist and a mathematician."Hence the name of the official journal of The International Society for the Arts, Sciences and Technology, of which Emmer (and formerly Max Bill) is a member of the editorial team: *Leonardo*.

In Germany, Konrad Polthier, of Berlin's Technische Universität, is an enthusiast of mathematical visualisation. He quickly realised that his research on shapes and surfaces, in three or more dimensions, were too complex to be represented using 'ordinary' tools. That is why he created his own software. Known as Java View, it can run on any PC with an Internet browser – and no copyright is charged for non-commercial use. Java permits on-screen visualisation of the widest range of calculations. A simple 'mouse click' is all it takes to 'manipulate' the virtual object – twisting or stretching it, flipping it over to show other surfaces, etc. "This software is designed to enrich scientific publications through visualisation. I would be happy to see many researchers use it," comments its creator. We know that multimedia technologies are set to become increasingly important in the world of publishing. In some cases, it may seem like a gadget but, when discussing multidimensional mathematical problems or describing complex processes

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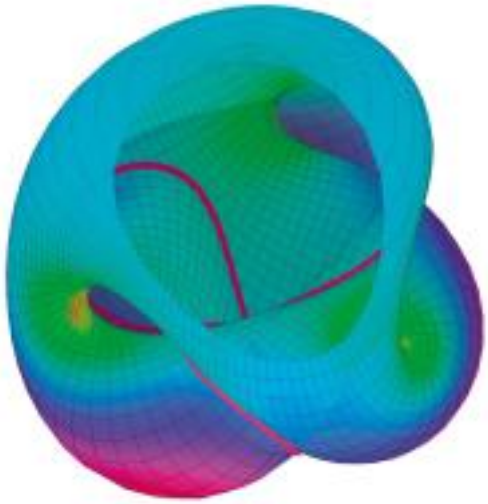
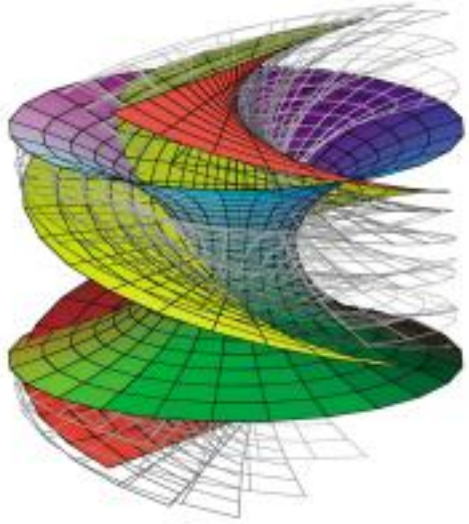


Computerised visualisation of the triple point *Boy's Surface* concept, discovered in 1922. This strange mathematical object with a single non-orientable surface (like the Möbius strip, of which it is an extension) is a model of what mathematicians call the 'projective plane'. It may be compared, intuitively, with a plane representation of all the straight lines converging from all the points on a sphere towards an 'eye' located at its centre. It can be understood as an analytical resolution of the famous geometric problem of the inverted sphere (its internal surface having been interchanged with its external surface).



***Transformation of a catenoidal surface into a helicoidal surface.* Already conceptualised by the mathematician Euler in 1740 and then by Joseph Plateau in the 19th century, this geometric form is by definition a so-called minimal surface, in the form of a 'diabolo' consisting of two superposed circles. In physical terms, it is equivalent to the stable form acquired by a film of soap stretched between the two circles so that the tension energy applied to the film is minimised. The complex mathematical analysis of the minimal surfaces was not formalised until 100 years later. In this way, a given surface is transformed from a catenoidal surface into a helicoidal surface.**

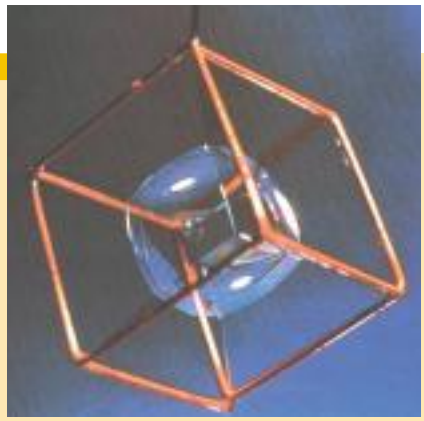
Emmer's lens

"In mathematics and in science we can perhaps speak of progress, but in art it is totally absurd to do so. Technology is in the service of art as it is in the service of mathematics, but creativity and inventiveness are vital to both," believes Michele Emmer.

This Italian mathematician has had many opportunities to experience relationships between art and science through his work as a film-maker and his friendships with artists. For the past 20 years he has been engaged in the project entitled 'Art and Mathematics' which is seeking to gather together the results of his research linking these two fields, in the form of films, books, exhibitions and conferences.[1]

Still from *Moebius Strip*

The son of Luciano Emmer, the maker of fiction as well as documentary films – most notably Picasso (1954) – Michele found himself immersed in this environment from a very young age.



Still from *Soap Bubbles*

"When I wanted to make a film on Max Bill, I simply wrote him a letter. He promptly opened the doors to his home – and to his incredible collection of modern art. We made two films together, he stayed in the studio for three days and we became friends."

"My personal experience with artists is very interesting because I discovered many similarities in the way we regard shapes and forms. Their approach to visual and plastic questions is clearly different, but there is such scope for a genuine exchange of ideas and experiences. These were not just brief encounters."

[1] *His films include* Moebius Strip, *on which he collaborated with Max Bill,* Soap Bubbles *with the mathematicians Fred Almgren and Jean Taylor, and* Geometry *with the Japanese architect Koji Miyazaki. His books include:* The Visual Mind Art and Mathematics *(ed. Leonardo – MIT),* The Fantastic World of M.C. Escher *(Springer), and* Mathematics and Culture *(Springer, 2003).*

How can a form imagined by an artist help in the understanding of a mathematical concept? *Genesis*, a sculpture by James Robinson which stands on the campus of Bangor University (UK), is one such work. The university's Centre for the Popularisation of Mathematics was an active participant in several of the European Science Weeks supported by the European Commission.

in science and technology, visualisation will become an essential tool."

These new shapes are sometimes very surprising and the images fascinating. "Some of these structures are so harmonious that it is almost impossible not to view them as works of art," adds Konrad Polthier – who, by the way, denies any pretentions to being a creative artist himself. He sees the beauty of these forms as absolute, comparable to the natural beauty of plants and minerals, rather than a subjective expression or message.

Communication

Visualisation can also be useful in enabling a better understanding of mathematics by bridging the gap between abstract concepts and their practical applications, most notably through revealing the underlying fundamental notions. Very often it is the educational applications of mathematical images that are cited by scientists rather than the aesthetic ambitions. Manuel Arala Chaves of the Faculty of Sciences in Porto (PT) distinguishes two aspects. "First, beautiful pictures attract the attention, arouse interest and can subsequently lead to investigations into concepts and mathematical results. But, in addition to this, sometimes the pictures themselves may already suggest mathematical ideas or make it possible to illustrate them geometrically."

Manuel Arala Chaves has initiated a number of exhibitions, in particular Matematica Viva, in Lisbon in 2000. "An important point is the target public. This exhibition was aimed at everybody and succeeded in its goals. Schools and individual visitors visited who wanted to investigate their discoveries further." The modules were designed so that they could be appreciated and understood at various levels, depending on the interests and mathematical background of the individual.

"When I was young I often visited the Deutsches Museum in Germany and the Palais de la Découverte in Paris. They made a big impression on me, but I always felt that they did not pay enough attention to mathematics and that this oversight was not due to the specific nature of mathematics as such," he explains.

Fun and games

Manuel Arala Chaves also worked on and adapted the exhibition Symmetry and the play of mirrors, designed by the team from Milan University's Department of Mathematics, for exhibition in Portugal. The same team has since launched the particularly original Matemilano exhibition, which investigates four principal themes (topology, *massimi e minimi*, vision and symmetry) with reference to the city itself. Architecture, sculpture and painting serve as a gateway to geometry, perspective, knot theory, etc. The Roman mosaics, Renaissance painting, the layout of the city, the Gothic rose windows of the Duomo… all the periods in the city's history play a part. "In these exhibitions we gave a lot of space to images and we are firmly convinced that this beauty plays an important role in communicating mathematics, especially to young people and people of different cultural origins," believes Maria Dedo, one of the key players in this initiative. In addition to beauty, the exhibition also incorporates the notion of play in connection with mathematics. With its problems and its enigmas, maths can take us on some exciting new journeys. All it takes – as Matemilano shows – is some paper, a length of cord or a few matches to have some fun and games with maths. ■

To find out more

- **CPM Bangor**
  http://www.cpm.informatics.bangor.ac.uk/centre/
- **Visualisation – Java Script**
  http://www-sfb288.math.tu-berlin.de/~konrad/
  polthier@math.tu-berlin.de
- **Milan exhibitions**
  http://specchi.mat.unimi.it
  A catalogue entitled "*Il ritmo delle forme*" was published for this exhibition and translated into English under the heading "*Symmetry and the play of mirrors*" (Pole, 2002)
  http://matemilano.mat.unimi.it
- **Leonardo Journal**
  http://mitpress2.mit.edu/e-journals/Leonardo/home.html





Roman Opalka

or time measured

His life counts in a different way - or rather he counts his life in a different way - since that day in 1965 when, on a 195 x 136 cm canvas, with a No 0 brush, dipped in white paint, on a black background, he painted the number 1 right in the top left. And then he carried on - 2, 3, 4... - until he reached the bottom right. On a second canvas, he continued the sequence of numbers from where he had left off. And the counting never ends. So as not to lose the thread, Opalka says the numbers out loud. The tape recorder records them , as well as the occasional silences (dead time). After each session, he sets up the camera and photographs his face, always in the same way - same light, same frame, same expression, same shirt. Some numbers have great beauty, such as 55555 which came up after 7 years. Opalka calls this work his life plan. On each canvas the black background is lightened by 1%. Opalka's works therefore become whiter, just like his face. The passage of time leads to the illegible, the invisible, destiny.

"To master time, death needs to be taken as a real dimension of life. Existence is not fullness, but rather a state where something is missing: human beings are defined by their unrealised death."

The mysteries

Biotech artists' studios are laboratories and their materials are cells, DNA molecules and living tissue. The life sciences can be a vehicle for ethical, as well as, aesthetic inquiry. We take a look at a special coming together of 'art and science'.

Art or science? It is sometimes in the culture section and sometimes on the science pages (as here) that journalists write about *Alba*, Eduardo Kac's fluorescent rabbit which has brought the notion of biotech art to the attention of the general public.

Alba is a white rabbit which, when placed under ultraviolet light, emits a greenish glow. Born at an Inra laboratory in Jouy-en-Josas (FR), she received a jellyfish gene which enables her to synthesise a fluorescent protein. Although, generally speaking, there is nothing really extraordinary about such transgenic animals for researchers, on this occasion, *Alba*'s creator, the American-Brazilian artist Eduardo Kac, used the mutation for a unique purpose. It is the starting point for a work which is structured around everything that has been said, written or organised on the subject of this 'fluo' rabbit, including exhibitions, the artist's comments and reactions by the critics and general public. The living creature as creative material, art interacting with science, the inevitable shadow cast by the biotechnological industry, the ethical issues raised by genetic engineering – it is in such terms that Kac, a pioneer of this new "biotech art" movement, sees the meaning and implications of his own transgenic art.

Living art

But bioartists are not only interested in genetics and DNA. "The first of these artists appeared in the 1980s and the approach gained considerable significance over the next decade. But our work is very diverse. Today, we consider as bioartists all those who explore the body, cultivate new flowers, or whose work uses organic matter," explains the Slovenian artist Polona Tratnik. The common element in all these works is that the point of departure is life itself, rather than its representation, its metaphor or its digital simulation. Wings designed for pigs, unique butterfly specimens, hybrid irises, genetically modified bacteria and tattooed skin cultures are all 'living objects' which – while not always particularly spectacular in themselves – serve rather as the point of departure for multi-dimensional works, encompassing often very provocative artistic expressions in the form of installations, words or performances. Rather than glorifying or rejecting *en masse* human engineering of living creatures, the way these artists present these sometimes 'monstrous' creations causes us to question science and technology, as well as the ambiguity of our own reactions.

Art in the lab

To work in this way, artists must use the tools and the methods of biologists. This is why they must work together. This collaboration takes many forms. Some artists act as guinea pigs, such as the French duo Art Orienté Objet (AOO). Others, such as the Portuguese artist Marta de Menezes, use a number of techniques which they mould to their own designs. The Symbiotica group even founded, at the University of Western Australia in Perth, a laboratory which is subject to the same rules as the research units proper, in particular the practice of subjecting projects to the scrutiny of the university's ethics committee. Symbiotica investigates such subjects as the body's capacity for repair, organ culture and industrial animal rearing techniques. It creates so-called 'semi-living' entities by installing genuine mini-laboratories for cell culture at exhibition sites.

# of a mutant art

At the other end of the spectrum, George Gessert, the plant magician, works in total solitude: "I almost never work with researchers, or anyone else for that matter, just the plants."

Initially surprised by these requests for collaboration, scientists now view the experiences as positive. "Co-operation with an artist improves public knowledge of science. That said, I do not see how I could justify the use of my time and the subsidies I receive for purely artistic purposes,"points out Ana Pombo of the Centre for Clinical Sciences at Imperial College (UK), who has worked with Marta de Menezes.

In linking up with science in this way, these creations can themselves be the subject of controversy. "It is hard to see how artists can be allowed to carry out experiments at the very time when scientists are prohibited from doing so, or are at least very closely monitored," believes the philosopher Yves Michaud(1). Although the reality is that the artists are subject to the same laws and respect the same precautions as scientists, the point made does relate to a frequently asked question: have we got the right to manipulate living creatures for non-scientific purposes? Then there are the socio-economic concerns: are these artists not the secret spokesmen of the biotech industry? "Scientists work with living creatures, children play with them, businessmen buy and sell them, we eat them and politicians determine the destiny of the entire species. Why can't artists also work with living creatures?" asks Gessert. The plant magician readily admits that certain processes do raise ethical questions. As to the supposed link with industry, he believes that "if there is a danger of exploitation, that is a risk to be run. The alternative would be an enforced silence that would benefit only the most mercenary scientists and big business."

Ironically, Eduardo Kac's famous *Alba* has been described both as an "act of resistance" against and as an "act of collaboration" with the biotechnological industry. Could it be that the fluorescent rabbit also symbolises ambiguity? ■

(1) Art and biotechnologies, *in the Biotech Art exhibition catalogue, Le Lieu Unique, Nantes (FR), March-April 2003.*

George Gessert : Nature and solitude

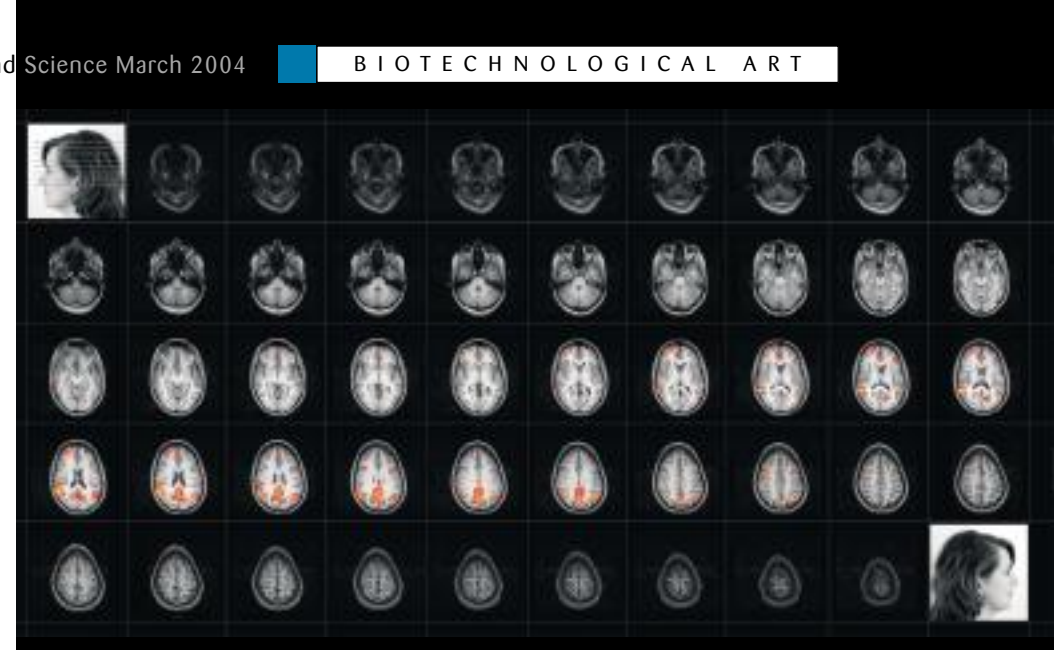
"In the early 1990s, I was chiefly interested in auto-organised patterns, such as the spread of ink in non-coated paper. Working with living organisms, which are supremely auto-organised, was a logical extension of this approach. I have always been fascinated by plants, for example, as aesthetic objects as well as life forms," says George Gessert.

He practises a biotech art in which technology plays very little part. He cultivates, crosses and selects flowers without any contact with scientific institutions. A former student of horticulture, he has an extensive knowledge of biology, chemistry and entomology. He views gardening almost as a fine art and works in the tradition of the German Edward Steichen who exhibited his hybrid flowers at the New York Museum of Modern Art in 1936.

Gessert also makes a very specific selection, deliberately creating flowers unlikely to meet with much success on the horticultural market. Adopting a kind of 'Darwinism in reverse', he takes up a stance in opposition to the prevailing taste. His number one enemy is kitsch.

His work can seem purely aesthetic and in fact seeks to be precisely that, but it also includes reflections on death, time and eugenics. Gessert never forgets this sinister use made of genetics during the 20th century. "We can only fully appreciate a work of art if we recognise the issues that it raises," he explains.

> "Walter Benjamin thought that mass-produced works of art lost their aesthetic force. Ornamental plants prove the contrary." (G.G.)



***Functional Portraits*: Self-portrait by Marta de Menezes. "My objective is to revisit the tradition of portrait painting. Artists have always sought to go beyond the physical appearance of the model to show the subjectivity. Medical imaging allows us to visualise directly the areas of the brain which are active at a given moment. This means you cannot only show a person's appearance, not only their body, but their mind as well."**

PRESENTING AND DEBATING

All the artists presented in this article participated in the Biotech Art exhibition, organised by Jens Hauser at Le Lieu Unique in Nantes (France) in the spring of 2003. A debate between philosophers, researchers, artists and members of the public was the occasion to raise questions on "this art which disturbs, which portrays our fears and our contradictions".
www.lelieuunique.com/SAISON/0203/2/ArtBiotech.html

To find out more

The artists' sites

- **Symbiotica:** www.tca.uwa.edu.au/
- **Eduardo Kac:** www.ekac.org
- **Marta de Menezes:** www.martademenezes.com
- **AOO:** http://artorienteobjet.free.fr

Virtual space bridging art and science

- **Scicult:** www.scicult.com/

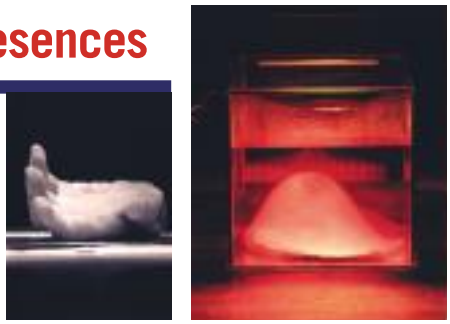
Marta de Menezes: Poetry and art

"I first began to investigate biology when I realised that it was a field I knew very little about. It was a time when important decisions were being taken about transgenic food, genetic engineering and the use of stem cells. I decided to learn by immersing myself in the latest developments in research and, in so doing, I discovered extraordinary possibilities for artistic expression," says Marta de Menezes, a painter born in Lisbon. She joined the laboratory for evolutionary biology at Leiden University in the Netherlands where a team of researchers, headed by Professor Paul Brakefield, were working on butterflies. The result of this collaboration was Nature? De Menezes changed the patterns on one of the wings of an insect about to be born by pricking the chrysalis at very precise points. Butterflies treated in this way produced one wing with a pattern modified by human intervention and the other with the natural pattern. These works, obtained without genetic engineering and therefore non-transmissible, were deliberately transitory. After producing 'DNA paintings' (Nucleart) at a British laboratory, in 2002 the Portuguese artist moved to Oxford University (UK) where she worked with Dr Patricia Figueirdo. Her attention there focused on functional magnetic resonance imaging. She used this technique – which makes it possible to visualise the brain's activity – to produce a series of 'functional' portraits of a pianist while playing and of herself while painting. These illustrate her innovative approach to representing the invisible 'essence' of models which painters have always sought to capture.

***Nature?,* A butterfly with modified wings developed at Leiden University (NL). "My main aim was to create works of art in which art and life are simultaneously present by using the possibilities of biology as a new medium for artistic creation."**

The DNA molecule – the billions of nucleotides just a tiny proportion of which is enough to contain all our genetic information – has always held a fascination for de Menezes, for whom they represent a kind of internal universe. This inspired her series entitled 'Inner clouds'. By precipitating an individual's DNA in a test tube, she obtained an opaque mass which she perceived as that person's "inner cloud".

Polona Tratnik: ambiguous presences



37° C: Kapelika roka, kapelica poglde, kapelica josk

"It was the desire to capture a certain presence of a living organism, of a body, that brought me to bioart," writes the Slovenian painter Polona Tratnik in her installation entitled 37°C. The presentation consisted of three 'aquariums' each containing small wax and latex statues covered in a skin cell culture taken from the artist at the Ljubljana Cell Type Differentiation Centre. In one, the cells are dead and decomposing. In another, they are lying dormant in a glass refrigerator. In a third, they are continuing to multiply at body temperature. The visitor is constantly faced with the contrast between the welcoming nature of the installation (familiar furniture, warm lighting) and an awareness of the artificiality (scientific devices, cold materials) of the living exhibits. A system which amplifies the sounds produced by the visitor serves as a constant and disturbing reminder of his or her own existence.

Before using this cell culture, Polona Tratnik already sought to provoke the strange sensation – a mixture of attraction and repugnance – one experiences when touching the skin of a stranger. At that time, she was working with latex as a first step towards using laboratory skin, a tissue that is both artificial and living.

Science? She uses it, and that is all. "I am much more interested in provoking these emotions than in becoming a scientist."

The artists' skin deposited on a pig's dermis which is then tattooed. A human skin culture is too fine for this kind of operation. "We present genuine pieces of ourselves, submitted to biotechnology. In this way, we are working with ourselves and no other living organism. This role as guinea pig is essential to our personal ethic."

Art Orienté Objet: Frontiers and symbols

"Hybridation" and "poésie". These are the two key words for Art Orienté Objet (AOO), the Parisian duo Marion Laval-Jeantet and Benoît Mangin. "The basis of all our work is the consciousness of the living creature and its manipulation by science and society," they explain. Logically, it is themselves which they 'manipulate' to produce their strange creations.

For *Cultures de peaux d'artistes*, for example, they allowed a reputable US skin production laboratory (its products are used in treating burns) to take biopsies of their epidermis. In return, they were given samples deposited on a pig's dermis which they then tattooed with animal motifs, usually of endangered species or those used in biology. The skin, as the barrier of the self, thus becomes the site of a symbolic alliance and a questioning of the 'species barrier'. Their latest project, entitled *Que le panda vive en moi*, will consist of injecting themselves with panda's blood which has been rendered compatible.

Born into a family of researchers and herself a scientist by training, Laval-Jeantet has had to "reconcile her sense of the logic of reality subject to physical laws with that of the world of vision." The duo have frequent meetings with scientific teams in the belief that it is impossible to envisage the mental, social and ecological impact of biotechnologies without a command of the tools. As a result, their work becomes the focus of an extremely precise and articulate discourse.

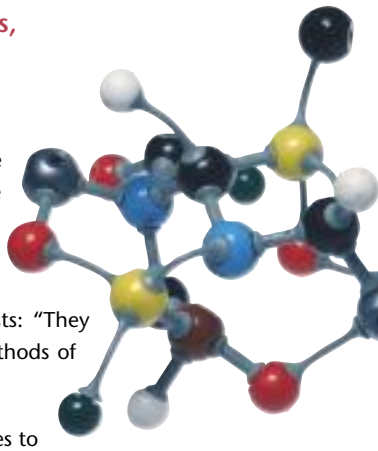
"The general public is shocked to see hybrids of our skin, but, in fact, what shocks is not so much the skin culture – even a hybrid one – as the fact of imagining the kind of world that such techniques imply," believes Marion Laval-Jeantet. Her final comment? "Art will have proved revelatory, and increasing our awareness of any issue is generally beneficial," she concludes.

George Gessert - *Homage to Steichen*, Steptocarpus hybrid, 1998



Research in all its aspects

Artists express their unique inner self. Scientists discover a pre-existing, unbiased reality. Their objectives, methods and results differ. But are they not all researchers whose paths cross on occasion?



Being 'scientifically correct' requires that research results be presented without reference to the author's state of mind. Science is, after all, a logical, objective, rational pursuit. This façade can, nonetheless, be shattered, and some scientists show their passion, or even the chaotic aspect of their activity at times. Watson, the co-discoverer of the structure of DNA, caused a scandal by publishing *The Double Helix*, in which he stated that "science, as I hope this work will demonstrate, rarely proceeds with the logic laymen attribute to it". Far from the linearity of manuals, ongoing science is made up of doubts, mistakes, zigzags and confusion. This reality is the same as that of artistic creation. To poet Kenneth White, "chaos and the indiscriminate are at the source of all new creation". In this he was echoed by mathematician Bark Kosko who rose up against the modesty of science: "There is no shame in admitting to what extent scientific progress depends on intuition. This needs to be taught in schools as much as mathematics," whilst physicist Ludwig Boltzmann felt that "the cradle of theory is always *fantasy*".



Pleasure and wonder

Just like artists, scientists can be rewarded by intense jubilation which, to some of them, appears to be the principal reason for their passion. "I am overcome by intense joy, a wild pleasure," noted biologist François Jacob, whilst chemist Michael Polyani spoke of the "feeling of extreme exaltation that a scientist can feel at the moment of discovery".

If artists and scientists share passion as a driving force, they also share the same energy: emotion, a sense of wonder at the universe, this endless source of question marks. Both are able to tear down the walls erected by a process of socialisation which teaches us not to be surprised at anything. Observing nature is to rediscover a sense of wonder. Physicist Richard Feynman spoke of his "child-like fascination for the world as it is," of the "pleasure of contemplating water in bathtubs or puddles on the pavement". Poet Saint-John Perse had also perceived this convergence between scientists and artists: "They are probing the same abyss, only the methods of investigation differ."

From this sense of awe, one indeed decides to study nature, and the other starts working in its image, thus extending creation. Leonardo da Vinci recommended to his students that they draw inspiration from patterns observed on old dilapidated walls. "Do not imitate nature, but work with it. Feel the branches grow," according to Picasso. Painter Dominique Maraval explained his paintings as a "series of supposedly hazardous or unconscious proposals, alternating with a series of consciously selections observing laws that are beyond me".

Fate and imagination

In other words experimenting is as important to artists as it is to scientists. Both multiply physical configurations that can potentially offer new insights or heady concepts. Both are equally open to a sudden twist of fate that can sometimes unexpectedly shake up the experiment. Mozart was able to draw inspiration from birds singing in the street to compose the theme of a concerto, and John Cage made fate his major source of inspiration. Numerous visual artists also use fate or suggestions taken from matter to forge ahead.

Scientists, too, depend on fate. Many discoveries – among which America, radioactivity and fossil radiation – have been the result of error, clumsy movements or coincidence. In the words of composer John Cage, an experiment is "a net that serves to catch the fish we do not yet know".

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But to scientists, fate's helping hand does not serve to create new structures, but to discover those that already exist. Scientists spend their life decoding what nature has coded and what artists likewise continue to code.

A testimony to this symmetry that unites them is their recourse to imagination, vital to both. To Baudelaire "imagination is the most scientific of faculties," and, if Einstein could be believed, it is "the true soil of scientific germination". The creator is one who sets out on an adventure, guided by intuition and attentive to fate. It is often by veering off the course, which is only outlined on the map, that he makes the greatest discoveries. But red herrings are numerous. In both art and science, culture and experience enable us to 'guess' which of our intuitions is likely to open up new avenues.

***Helix Nebula*, captured by the Hubble telescope** – **"Art is an abstraction. Derive it from nature while dreaming before it." (Paul Gauguin)**

©ESA

Abstraction and reality

Another essential mechanism to both approaches is the capacity for abstraction. "At the outset, the perception of things involves a choice within reality, itself conceived as an immeasurable unit, the totality of which we will never grasp," is how mathematician Pierre Lelong perceived it. Gauguin also said: "Art is an abstraction. Derive it from nature while dreaming before it." It is an abstraction that is accompanied by an interpretation that allows it to give meaning to reality, and even to exceed it. To Einstein, science arbitrarily draws certain groups of data from the labyrinth of sensorial information, attributing concepts to them which go well beyond sensations. In this sense, scientific theories are free creations. In this effort to recompose what has been isolated, the scientific approach is for that matter sometimes more audacious in its representations than art itself.

While creation can be broken down into a selection process followed by extrapolation, it is particularly sensitive to certain kinds of stimuli. What attracts the attention of creators and is then 'taken out' of context is often the ordinary (structure, order, repetition) or else the unexpected (rupture, exception, what is atypical). In this way, the scientist's mission is often to explain both regularity and anomaly. Artists echo this theme: to author Jacques Roubaud, "a familiar path is conducive to poetry, arousing recognition. A road never seen before creates another sentiment, that of surprise, also favourable to the capture of words. But differently."

The death of truth, the end of beauty

Apart from these underlying structural trends which bring together artists and scientists to the extent that we could swap their quotes, certain developments also tend to reduce the gap between them. In particular, the quest for beauty or truth as absolute references has been seriously questioned during the 20th century.

In science, quantum physics has undermined the status of reality and its independence from the observer. On a small scale, nature becomes impossible to grasp. "We started with traditional science that was concerned with details. We are now moving towards a science that is analogous to Impressionism," says physicist Pierre-Gille de Gennes, whilst for philosopher Michel Bitbol, "science is more than ever identified with the deployment of what is possible, and less than ever with an immediate capture of numbers". Was it not Nietzsche who described the idea that truth is the goal of science as the 'noble metaphysical illusion' of scientists? In art, creators have long ceased believing in the existence of beauty in its own right. Today, they explore creative space for itself and for the satisfaction they can derive from it.

At the same time, artists have always found a major source of inspiration in scientific discovery. In the 19th century, poet Coleridge attended lectures at the Royal Institution in order, in his words, to update his inventory of metaphors. Nowadays, artists continue to take over the concepts, vocabulary and techniques of research. And scientists, albeit more rarely, turn to literature to extend their vocabulary, like the term quarks, borrowed from James Joyce. This use of scientific knowledge appears to respond, in a reflexive loop, to the creative capacity scientists observe in artists. In the words of science historian Michel Serres, "myths are full of knowledge and knowledge full of dreams and illusions". ■

It was in 1623 that the German astronomer Johannes Kepler wrote Somnium, a detailed account of a journey to the moon. He noted how "agreeable it is to anticipate what is going to happen years in advance". This venture by a man of science marked the beginning of a new literary genre: science fiction. Today, we find the European Space Agency (ESA) collecting texts, taking the measure of 'futuristic' ideas and organising a science fiction literary competition. Who knows – one day this pursuit of the imagination may even serve to inspire our scientists and engineers.

Intuition & fantasy

Chromolithograph produced by the Liebeg company in the early 20th century.
© Agence Martienne

As technical progress accelerated, it increasingly fuelled the imagination of writers as they anticipated the technologies of the future. Yet the world of fiction can often be far removed from reality, and only a very small percentage of works of science fiction describe feasible inventions.

But is that any reason not to make a more serious study of certain visionary ideas? NASA recently carried out a detailed study of the concept of the space elevator which Arthur C. Clarke imagined in his novel *The Fountains of Paradise* (1979). They concluded that 50 years from now it could well be the best mode of transport in geostationary orbit.

ESA scouts the field

David Raitt, project leader at the European Space Agency, has a maxim: stay realistic without putting the blinkers on the imagination. "I am not a scientist or an engineer and I don't read science fiction. But that does not stop me having certain ideas. One of these was simply to look at old works of science fiction to see if some of the concepts they describe could be feasible today, using our more advanced technology. For example, a number of authors described tools which involved what they called miniaturisation – and miniaturisation has recently become a possibility." So, David Raitt suggested that the ESA should look for ideas in the vast pool of science fiction literature. "The scheme did not meet with such a favourable reception at first. The fear was that people might conclude that the Agency lacked imagination and was turning to science fiction as a last resort. But in the end I managed to persuade them to allow me to make the study and, when announced, it was welcomed by the general press and scientific journalists as an innovative and refreshing idea."

The experts investigate

Two partners embarked on the adventure: the Maison d'Ailleurs (The House of Elsewhere), a Swiss museum which houses more than 400 000 works of science fiction, and the OURS Foundation, also Swiss, which promotes cultural activities on space-related subjects, such as conferences and exhibitions. Following an Internet appeal, some 600 people (including engineers and scientists from various space agencies) expressed an interest in the project. They divided up the work, studied the literature and gave their opinions on what they thought might and might not be possible. They identified 250 concepts or technologies which are currently being studied by a group of experts. The proposals are grouped into categories: techniques of propulsion, space colonisation, energy, communications, robotics, materials, etc. "When the process is complete, there may be just five or six concepts remaining for an in-depth study. But that is more than enough," believes the project promoter.

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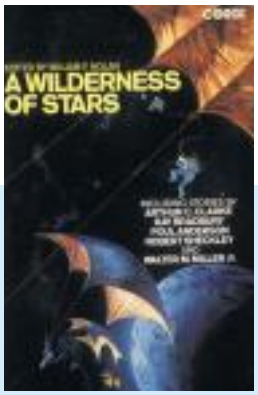
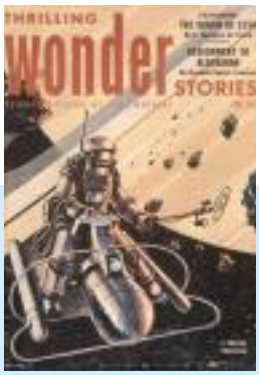


Propulsion by means of solar sails. Cover of *A Wilderness of Stars*, an anthology of short stories edited by William F. Nolan, Corgi Books, 1972.

Spacecraft fleeing a merging star. Illustration by J.Coggins - *Thrilling Wonder Stories*, 1954.



Astronaut taking measurements on rocks which form the rings of Saturn. Illustration by J.Coggins - *Thrilling Wonder Stories*, 1954.

Belgian poster for the film *Tobor the Great* by Lee Sholem.

***Special Interplanetary Issue*, Amazing Stories, June 1940. Illustration by Julian Krupa.**

Drawing by Emsh for *Galaxie science-fiction.*

Illustration by Manuel Orazi - *Quest for Fire* by J.H. Rosny, *Je sais tout* n°55, August 1909.

Encouraging literary creation

The ESA also organised The Clarke-Bradbury International Competition, an SF literary competition that awarded first prize to Lavie Tadhar, a 26-year-old living in the United Kingdom, for his short story *Temporal Spiders, Spatial Webs*. "We received many interesting stories from 36 countries, about 50 of them written by women. Lavie's story was chosen for its excellent writing, underlying technological concept and poetic qualities. The impression it creates is of a strange and very different future. We will probably hold a similar competition again next year."

Literary creation has the merit of immersing us in the realm of the feasible. Space exploration is an excellent example. Patrick Gyger, director of La Maison d'Ailleurs, believes that science fiction prepares the public to accept – or challenge – science. "I think that one of the secondary effects of science fiction – secondary to the extent that it is not necessarily sought by the authors – is to make people dream. As innovative

Hergé. Intuition and the mood of the times

Tintin set foot on the moon 17 years before Neil Armstrong. The adventure related by Hergé (Belgian author and illustrator, 1907-1983), certainly contains some sound ideas, although he does not always get it right. The effects of weightlessness that cause Captain Haddock's whiskey to escape from the bottle in the form of a bubble demonstrates his excellent insight. The reporter and the captain subsequently discover sheets of ice and a cave indicating the presence of water on the moon at some time in the past. And, he was right in his own way. Recent observations (Lunar Prospector, 1998) suggest that the surface of the moon has absorbed at least 6 billion tonnes of water in the form of ice. However, this water could never have existed in liquid form and, as to lunar caves, they are unlikely to exist outside Hergé's imagination.

Hergé was also passionately interested in the human sciences (Egyptology, ethnography, archaeology), chemistry and nuclear physics. The French physicist Nicolas Witkowski[1] points out that Calculus's pendulum, which never works properly, 'caused him to make a number of discoveries while he was searching for others'. He adds that this phenomenon 'which occurs frequently in the history of science and is known as serendipity, shows that Hergé had good notions of epistemology'.

Nicolas Witkowski sees Hergé's attitude to science as evolving in three stages, paralleled by the changing way in which the West in general came to regard it. Up until the 1940s there was a certain indifference – and Calculus had not yet appeared on the scene. From the 1940s to the 1960s there was enthusiasm for the sciences and a faith in technical progress – an interest which subsequently seems to have waned.

[1] *See* Alliage *n°47 - www.tribunes.com/tribune/alliage/47/Witkowski_47.htm*

Space station and solar sail, Amazing Stories, 1962. Illustration by Alex Schomburg.

Individual space scooter designed by Alex Schomburg for *Rider in the Sky*, by Raymond F. Jones, Amazing Stories, 1964.

Giant robot frightening an astronaut on the moon. Drawing by Robert Fuqua - *World without Women* by Thornton Ayre, Amazing Stories, 1939.

The tomb of Jules Verne, Amazing Stories, 1934.

First on Mars, Ace Books, 1957.

technologies are the key to some of these dreams, it leads the public to be more ready to accept them. However, science fiction also warns us against the uncontrolled use of techniques such as cloning or genetic engineering. It can therefore motivate certain researchers to work in a particular field and at the same time make them more aware of the use they or others could make of their discoveries."

Prehistory, or SF in reverse

However, the future is not the only unknown terrain explored by writers. The past can be similarly murky, especially if you travel back to the time before man appeared on the scene. Geologists, palaeontologists and archaeologists painstakingly seek to reconstruct history from the vestiges of the past. But what about the gaps in our knowledge? In his presentation of the novel by Jean-Pierre Andrevon, *L'homme aux dinosaures*, the palaeontologist Stephen Jay Gould argues on behalf of the imagination. He states that "fiction can add a great deal to scientific inquiry, providing interesting intellectual insight that the scientists themselves, given the norms that govern their profession, are not enabled to envisage in their publications." Gould also expresses the regret that researchers "are denied this rewarding approach to scientific questions".

The meeting of Neanderthal and Cro-Magnon man is one example of a fascinating period in human history which still holds many mysteries. It therefore provides excellent raw material that writers have turned to for some very well thought out scenarios.[1] In addition to speculating freely on the actual events of the past, novelists are able to use another ingredient that is normally out of bounds to the scientist: the reconstruction of the subjective world of human beings in these distant times, complete with their emotions and interactions. Here, too, the imagination can make a significant contribution to scientific knowledge. Jean Auel, for example, began writing his trilogy *The Earth's Children* by asking how prehistoric man ate, drank and 'prayed'. In his novels, Björn Kurtén, a palaeontologist as well as a novelist, brings together the white-skinned Neanderthals and black-skinned Cro-Magnon. To each author his scenario, and to each novel its universe – time itself will provide the necessary elements to support or dismiss their hypotheses, as indeed is the case for scientific theories. ■

To find out more

- **The ITSF Study carried out by the ESA**
  www.itsf.org/
- **La Maison d'Ailleurs**
  www.ailleurs.ch
- **The OURS Foundation**
  www.ours.ch

When the imagination paves the way

Portrait of Jules Verne by S. Le Nain.

Jules Verne is perhaps the most famous of visionary writers. But he has some illustrious companions. Arthur C. Clarke imagined communications by satellites in geostationary orbit as early as 1945. Isaac Asimov formulated laws of robotics in 1942, well before robots were part of everyday life. In 1988, C.J. Cherryh explored the possibilities of cloning ten years before the birth of Dolly, the first cloned sheep (1996-2003). The many technical devices that first appeared in works of fiction include super-fast missile launchers (1865), retrorockets (1869), spacecraft landing modules (1928), aerodynamic stabilisers (1929), high-rise buildings (1929), auxiliary thruster clusters (1929), pressurised suits (1929), manned orbiting space stations (1945), solar sails (1951), multi-fuel reservoirs (1954), and manned space modules designed for re-entry into the earth's atmosphere (1954).

[1] *In particular, William Golding* (The Inheritors), *Björn Kurtén* (Dance of the Tiger), *Joseph-Henry Rosny Aîné* (Quest for Fire), *Pierre Pelot* (The Clay Eaters), *or Jean Auel* (The Earth's Children).

Science in fiction

In addition to science fiction, which fantasises about the future of science, there is also just fiction. A genre in which the novelist can give free rein to his imagination and – whether situating the events in the past, present or future – present the adventures of science to fascinating effect.

The physicist Richard Feynman, when asked to sum up his research in just three minutes of radio airtime, replied that if that were possible he would not have been awarded a Nobel Prize. It is in the nature of scientific discourse to be complex and protracted. So how can novelists work with a subject matter which can be so difficult to discern? The solution lies in the fact that writers are free to treat subjects as they see fit: selecting what suits the purpose, giving it a particular slant, and presenting it in a context of his or her own creation. Novelists do not demonstrate, but simply present, reconstituting elements of reality in line with laws of their own making. Subjects are chosen according to the imagination and they are then processed or 'digested'. Did not Marcel Proust, who had a taste for metaphors taken from science, once say that "To include theory in a novel would be like leaving the price tag on an ornament"?

Ulterior motives

When a writer turns to the scientific world, it is usually with an ulterior motive. According to Christine Maillard, professor of German literature and civilisation at the March Bloch University (Strasbourg, FR), two principal types of motivation can be identified. A first group includes writers seeking to make a social, ideological or individual criticism of science. In their works, ecological balances, ethical choices or the mental health of individuals are analysed in terms of their social impact. The scientist is often presented as an individual suffering from serious psychological problems who is unable to form relationships with others. The novelist sounds a warning against the excesses of a certain form of scientism. Writers such Michel Houellebecq (*Elemental particles*), Zadie Smith (*White Teeth*), Bernard Werber (*The Ultimate Secret*) and David Lodge (*Thinks…*) all write of the 'dehumanising' effects of a science taken to the extreme.

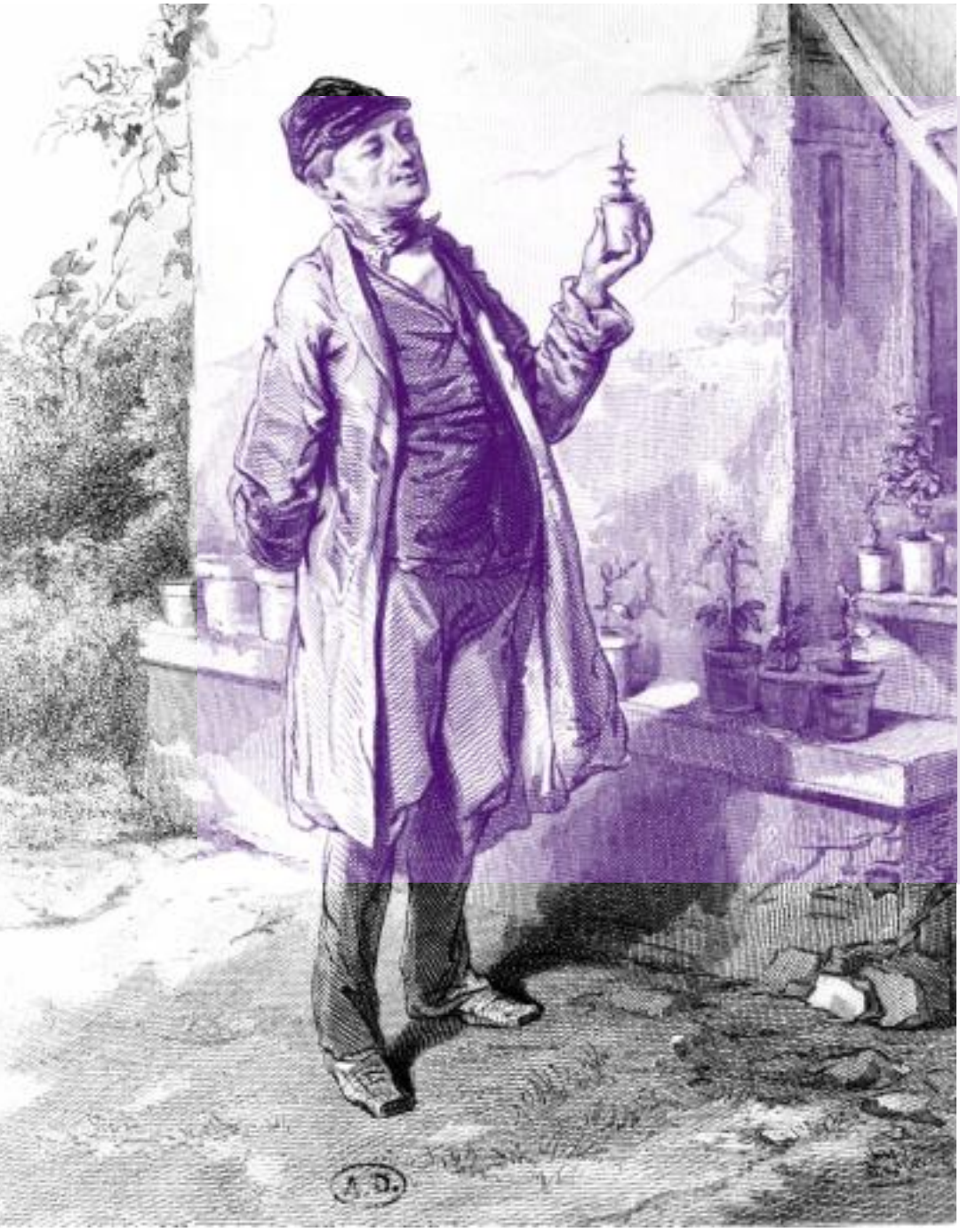
A second group includes writers who are engaged in a more philosophical approach to the nature of scientific knowledge and its limitations, its links with other types of approach – even with nature and reality itself – its unity or its 'knowability'. These writers call into question the very legitimacy of the scientific approach as well as its status in relation to other human activities. Some very major writers fall into this category, notably Robert Musil (*Man Without Qualities*), Thomas Mann (T*he Magic Mountain*), Hermann Broch (*The Sleepwalkers*), Georges Perec (L*ife, user's manual*), Raymond Queneau (*Petite cosmogonie portative*) and Umberto Eco (*Foucault's Pendulum*).

Freedom of association

In both approaches – critical or epistemological – the novelist brings into play knowledge taken from various sources. The same narrative space can bring together disciplines which academic organisations may keep totally separate. The English writer Percy Shelley considered the writer's task as absorbing new scientific knowledge to transform it into a new basis for human thought. "That is to say," continues Christine Maillard, "that the novel is perhaps, by vocation, the transdisciplinary space which scientists need when they advance even more into specialisations.""Since science has grown wary of general explanations, as well as any solutions other than the sectorial or the specialised, literature must pick up the challenge and learn how to weave together various forms of knowledge and codes to create a vision of a plural and complex world," observed Italo Calvino, a renowned Italian author.

This is what certain contemporary novelists seek to do in major works which present a multi-faceted fresco. In *Habitus*, James Flint links mathematical and computing concepts to ideas from the realms of spirituality, games of chance, biology and psychology, while Harry Mulisch, in *The Discovery of Heaven*, mixes archaeology, astronomy, music and religion. Literature also confronts scientists with an image of themselves, providing criticism where self-criticism may be lacking and questioning scientific knowledge in the wider context of human thought rather than against its own criteria.

What is true of the various disciplines is also true of the different levels of thought. Whereas the sciences separate out, sort, rationalise and simplify in a manner which is in fact artificial, the novel remains true to the inextricable interlocking of the real. This is what Jean-François Chassay of the University of Quebec in Montreal has to say: "The activity of scientific thought does not consist of *reason* alone, but also of other ingredients,



The uncompleted novel *Bouvard and Pécuchet* is Flaubert's last work. Based on a vast amount of documentation, full of scientific references, summaries of treatises and extracts from encyclopaedias, the novel presents two anti-heroes who are passionately interested in all fields of knowledge. When they suddenly inherit a house in Normandy, these Paris clerks set up a chemistry laboratory, engage in agronomic experimentation, study geology and palaeontology, and seek to acquire medical knowledge. Everything fascinates them, but not for long. As they move from failure to failure, from disaster to disaster, Flaubert is able to present, to quote his own words "a critical encyclopaedia in the form of a farce". In a century in which science and progress are never free of doubt, Bouvard and Pécuchet, as absurd as they are touching, overturn – without wanting to – all certainties.

often very difficult to grasp, sometimes particularly trivial. Switching from Schrödinger's equations to Yvonne's legs is no doubt not very *noble*. But triviality is an ingredient of the functioning of thought which cannot exist without intermingling." In other words, the novel is sufficiently 'confused' for knowledge and emotions to be able to communicate freely within it. As such it is rather like a common trunk from which the various branches of organised knowledge shoot off, at the risk of being lost from sight.

"It is easy enough to believe there is a common root," continues Jean-François Chassay. "Any scientific approach is constructed around the notion of a hypothesis which could be viewed as a fiction, until an experiment can adequately prove or disprove it. In this sense, one could say that science is the daughter of fiction. It takes specific paths to explore its intuitions, but the fact remains that a scientist without a hypothesis is as lost as a writer without an imagination."

Lives and adventures

Compared with specialist publications, the novel has the advantage of being able to reach a much wider public. A good example of this is the way Jostein Gaarder's *Sophie's World* 'popularised' philosophy. Similarly, the writer who is able to relate science in words, stories and intrigues is in a position to help overcome resistance and generate a passionate interest in the subject – be it the life of ants or the exploration of Mars – on the part of the very people who may have discarded their science books. When one looks at it closely, science can be seen as a novel, but the practices of communication and education very often go no further than to transmit anaesthetised results. Reading the works of writers such as Bertolt Brecht (*The Life of Galileo*), Michael Frayn (*Copenhagen*), Daniele Del Giudice (*Western Atlas*), Michael Paterniti (*Driving Mr Albert*) – and many others who communicate the passion of their characters, can help in the rediscovery of a passion for science – a passion without which science – as reasonable as it may claim to be – would be nothing. ■

The seventh art

Marey's chronophotographic gun camera – the forerunner of today's movie camera – was designed to film the flight of birds. Ever since, motion filming has been used to capture and conserve scientific phenomena or information in the same way as written documents, photographs and sound recordings do. Research, with its heroes, myths and ethical dilemmas – whether real or imagined – is also a field rich in dramatic potential to which scriptwriters have often turned for inspiration. We focus on a number of cases where film has drawn inspiration from science, or where science has used the camera to communicate its discoveries.

1

Exemplary lives

A number of famous scientists have been celebrated in film biographies, which are often romanticised for dramatic effect. The big screen clearly favours the big names. The French biologist who 'pasteurised' our milk and developed the first vaccines was played by Paul Muni in William Dieterle's *The story of Louis Pasteur* (1936, USA). That most famous investigator of the subconscious, Sigmund Freud, was portrayed by Montgomery Clift in John Huston's *Frued* (1962, USA). Among the Nobel prizewinners, John Nash and Richard Feynman were the respective heroes of Ron Howard's *A beautiful mind* (2001, USA) and Matthew Broderick's *Infinity* (1996, USA). As to Marie Curie, she has been given the big screen treatment on at least four occasions. She was played by Nicole Stéphane in George Franju's *Monsieur et Madame Curie* (1953, FR), by Olga Gobzeva in Elmira Chormanova's *Mysli o radiatssi,* and by Greer Garson in Mervyn Le Roy's *Madame Curie* (1944, USA). More recently, Isabelle Huppert played Curie in *Les palmes de M. Schultz* (1997, FR) by Claude Pinoteau, which departs from tradition in that the heroine is not portrayed as dying from the effects of radiation.

Jean Painlevé, film-maker and scientist

"Jean Painlevé, armed with the surreal eye of his camera, peered into an aquarium, a studio without troubled waters. Glass walls and a diffuse light which revealed no starlet with tempting thighs, no young male lead, no independent director, but an octopus, a daphne, a spirograph and other players commensurate with our dreams," wrote Jean Vigo. "On the basis of sound scientific knowledge, Jean Painlevé deflates our lazy anthropomorphism and presents films which combine technical excellence (the lighting, the shooting angles, the editing) with visual poetry, doing justice to the mystery or the miracle."

A master of the cinema of 'scientific theory', Painlevé made almost 200 films, all magnificent lessons in balance and clarity. The director classified them as films of pure research (using blow-ups, slow motion and other techniques to enable his camera to capture phenomena invisible to the naked eye), educational films (montages of the former for students), method films (systems of investigation revealed and illustrated by the document), as well as films of scientific popularisation for a wider audience.

2

"One of the tasks of the scientific world is to find a suitable form to render, in simple terms, its discoveries understandable to all," believes British scientist Stephen Hawking. Could cinema be one of these forms? Errol Morris' big screen adaptation of Hawking's bestseller *A brief history of time*, which examines the birth of the universe, seems to have achieved this goal.

(1) *For all photo captions please turn to page 29.*

Frankenstein and other made-to-measure scientists


3


5

The myth of Frankenstein's monster, created by the pen of Mary Shelley, is, in itself, sufficient to express all the ambiguities of what we expect from science. What reader of the original novel or viewer of the many films based upon it – most famously Boris Karloff in the film by James Wales (1931, USA) – does not, in a sense, want Professor Frankenstein's experiment to succeed? Who does not hope, paradoxically, to see his monstrous, yet ultimately pitiful, creature break free of its master and wreak revenge?


6

Written in an age of puritanism, the story could not leave unpunished the man who dared to rival the Creator. As genetic engineering remains a controversial subject to this day, the debate is clearly far from closed and the novelist effectively put her finger on a key issue.


4

The cinematic portrayal of the scientist takes varied forms. There is the harmless eccentric, living in his own world but endowed with a certain common-sense –such as Jerry Lewis' *The nutty professor* (1963, USA), Fred McMurray in Robert Stevenson's *The absent-minded professor* (1961, USA) or *Dr Dolittle* (of which there are many versions, including one by Richard Fleischer).

Then there is the researcher-turned-sorcerer's apprentice. Among the pioneers of this genre, Fritz Lang's *Dr Mabuse* (1922, DE) and Robert Wiene's *The cabinet of Dr Caligari* (1920, DE) use their know-how for particularly evil personal designs. Later, Ingmar Bergman presented his vision of the gestation of Nazism in the eminently expressionist *The serpent's egg* (1977, SE). Through an alter ego of Mabuse, Dr Vergerus, the Swedish director delves into the role of science under a politically perverted regime. Vergerus drives the subjects of his experiments to madness and suicide before finally taking his own life. Taking the scientist's mania for observation to the extreme, he grabs a mirror to see the effects on his own person of the poison he has just swallowed.

Kubrick's eye

American film-maker Stanley Kubrick made three films which gave shape to his very unique view of the future and which he sought to render as realistic as possible. Each one is a major work: *Dr Strangelove* (1964, USA) is a superb comedy on the nuclear threat, *A clockwork orange* (1971, UK) is a sociological exploration of youth adrift in a dehumanised society without moral values. Of course, *2001: a space odyssey* (1968, USA). In this dizzying epic, the viewer is presented with a theological thriller examining human destiny. Having acquired the means to explore the universe, humanity is betrayed by its own inventions in the form of Hal the computer.


7

Robots: good and bad

In delegating their powers to technology, are people exposing themselves to danger? In a certain vision of the future, any progress, discovery or invention ultimately turns against its creator. Robots are no exception. Together with the docile R2D2 and C3PO in George Lucas' *Star wars* (1977, USA) and David in Steven Spielberg's *Artificial intelligence* (2001, USA), there are many examples of androids which escape the control of their masters. Among the most famous are the rebellious victims of Michael Crichton's Westworld (1973, USA) and the 'replicants' of Ridley Scott's *Blade Runner* (1982, USA). Above all, there is the supreme computer of James Cameron's *Terminator* (1984, USA), installed to manage the planet but which immediately concludes that the first service it can render is to cleanse the world of the human species. Its weapon? Implacable superhuman robots cast in the mould of Arnold Schwarzenegger.


8

Wild and beautiful


9

Some documentary film-makers have made films for a mass audience which show exceptional aesthetic qualities: Frédéric Rossif's *Le monde sauvage, sauvage et beau*; Paul Calderon's *Attaville*; and Jacques Perrin's *Migrants*. More boldly, François Bel and Gérard Vienne moved further towards abstraction while, at the same time, encouraging the viewer simply to observe without any supporting commentary in *Le territoire des autres* (1970, FR) and La *griffe et la dent* (1976, FR). The makers of *Microcosmos* (1996, Europe/USA), Claude Nuridsany and Marie Pérennou, used modern studio techniques to reveal entomological realities to dramatic effect. As for Barbet Schroeder, it was with camera in hand that he set off to record the communication experiences of Penny Patterson in *Koko, a talking gorilla* (1977, FR).

Oceanography has also been the subject of some major films: *The Great Barrier Reef*, produced by Liège University (BE), and *The silent world* by Cousteau and Louis Malle, winner of the Cannes Film Festival's Palme d'Or in 1956. Vulcanology inspired Werner Herzog to take some major risks to film *La soufrière* just before the eruption of the volcano on the island of Guadeloupe. Two major documentaries, brought to the big screen by Haroun Tazieff, dealt with the same dramatic subject: *Le volcan interdit* and *Le rendez-vous du diable*.

Star Trek and the Trekkies

First shown more than 30 years ago during the Cold War era, the entertaining 1960s TV series Star Trek was based on the philosophical and politically committed vision of its creator Gene Roddenberry. To get round the censor, he opted for the space opera. In it, he expressed his views through the utopia of an atheistic world in which scientific knowledge underpins harmonious relations between people of different planets who prefer the virtues of diplomacy and negotiation to shows of force. The series was so successful that the message lives on to this day thanks to the activities of its worldwide network of fans (*Trekkies*). It is they who ensure that each new sequel respects the coherence of the universe imagined by Roddenberry, down to the very last detail. To date, the series has inspired no fewer than ten feature films.


10

The scientific adventure

For the scriptwriter, scientific research offers the dramatic attractions of suspense plus exploration of the unknown. A number of authentic events from the world of science have been brought to the big screen, including the Mercury programme in Phil Kaufman's *The right stuff* (1983, USA), a US space fiasco in Ron Howard's *Apollo XIII* (1995, USA) and episodes in the making of the first atom bomb in Roland Joffe's *Shadow makers* (1989, USA).


11

Medicine too has provided compelling cinematic material. The determined struggle of two parents in search of treatment to help their son, who is suffering from Adrenoleukodystrophy (ALD) – a rare genetic disorder – is presented in George Miller's *Lorenzo's oil* (1993, USA). The gripping *And the band played on* (1993, USA), by Roger Spottiswood, depicts the race between French and US laboratories to isolate the AIDS virus while, at the same time, condemning the politicians for being slow to react.

Much more originally, the theories of Henri Laborit on the subconscious urges which drive our behaviour were the inspiration for Alain Resnais' *Mon oncle d'Amérique* (1980, FR). This cinematographic experience – which many consider to be unique – is a psychological fiction situated in a scientific environment. "What interests me is not the characters or even the story. It is the dramatic construction. A form. On the one hand, the theoretical discourse of the scientist; on the other the individuals who act and to which the theories may or may not apply – because they retain their freedom," Alain Resnais once said.

A question of time: SF and nostalgia


12

Travel in time and space is the stuff – among other things – of science fiction. However, unlike in literature, and for complex reasons, cinema has often failed in its renderings of the genre. Few directors and scriptwriters have used its potential to explore the many speculative or utopian possibilities. When it is not limited to heroic fantasy that lacks all realism, the genre today no longer conveys the enthusiastic curiosity of the characters of the 19th century French novelist and father of science fiction Jules Verne, but rather a sense of anxiety when faced with the uncertain future or unfathomable vastness of the cosmos. Often, in seeking to discover the infinite, a person, such as Icarus, courts countless dangers in the form of undesirable encounters, or alien concepts which defy his understanding. Among the many space operas on confronting such belligerent aliens as those in British novelist HG Wells' *The War of the Worlds*, Ridley Scott's *Alien* (1979, USA) is one of the most pertinent because it is situated in a much more plausible context. The crew of a space cargo vessel carrying minerals picks up a strange signal on the return trip. Seeking to decode it and shed light on the mystery, the space travellers encounter an unknown life form, which is terribly aggressive and has a worrying ability to mutate.

Another futuristic current has its origins in fear of nuclear conflict. Nuclear war and its aftermath offer rich material for film makers, from Nicholas Meyer's *The Day After* (1983, USA) to George Miller's *Mad Max II* and *III* (1982, 1985, AUS), and including Peter Watkins' *The war game* (1965, UK). *Soylent Green* (1973, USA), on the other hand, is difficult to compare with anything else. The inspiration for this nightmare vision of the future by Richard Fleischer lies in the warnings by 1970s futurologists about ecology and population growth.

As to travelling back in time, remorse seems to be the rule. The "what would happen if?" of travelling into the future becomes the "if I could have done it differently". These time machines tend to be used for personal purposes: Robert Zeugmes' *Back to the future* (1985, USA), Jeannot Szwarc's *Somewhere In time* (1980, USA), Alain Resnais' *Je t'aime, je t'aime* (1968, FR). They only rarely tell stories that could have changed radically the course of history, such as Don Taylor's *The final countdown* (1980, USA). What is more, the cinema has never adapted Wells' *Time machine* for what it is: a highly sceptical fable of the destiny of man and the planet. ■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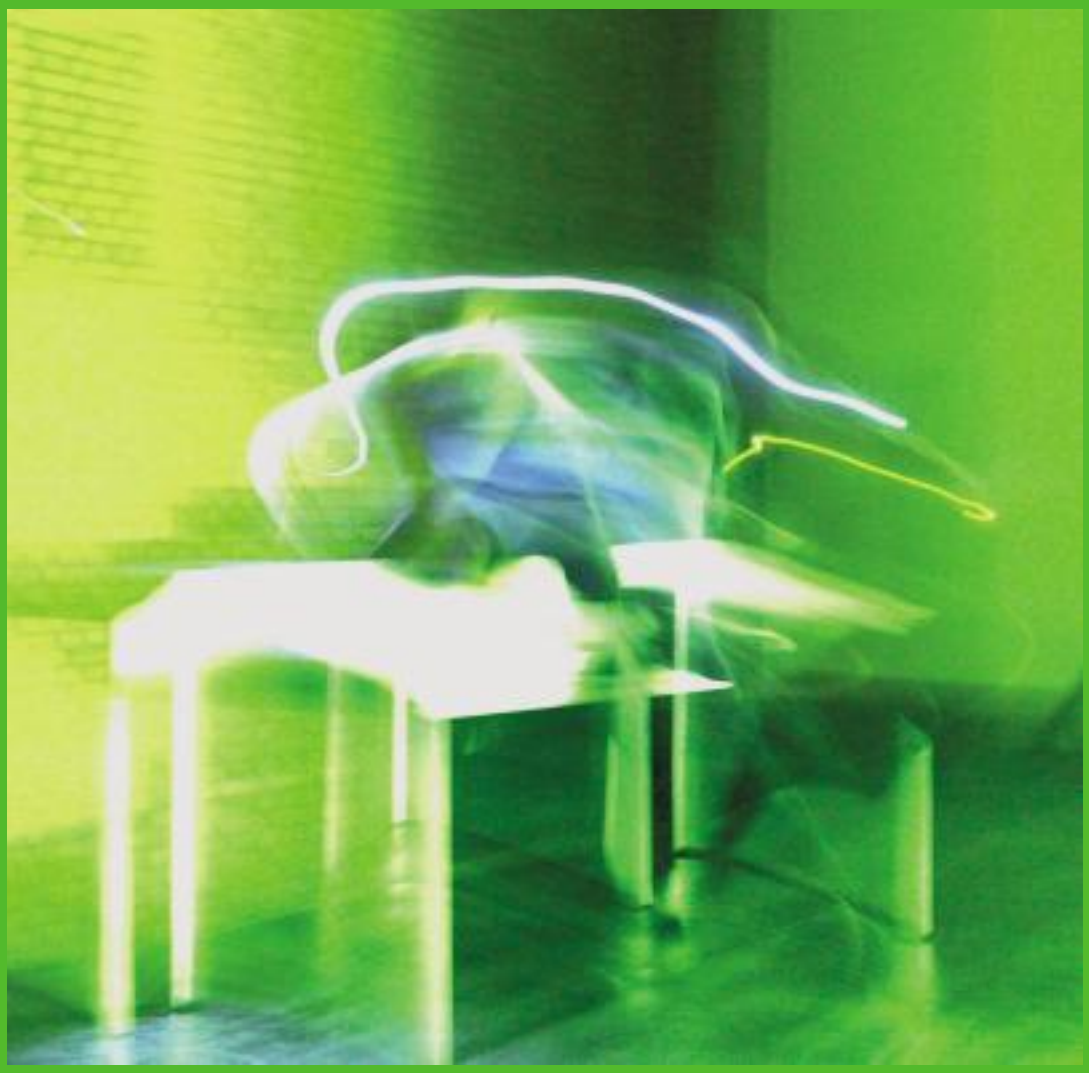
SOUNDS AND NOISES SOUNDS AND



The Catalonian Assumption – Munich, novembre 2003 © Franz Kimmel

Crossed ideas

"Should we resign ourselves to viewing science as simply a machine for producing truth or formulae that work? Or rather shouldn't we see in both its theoretical and practical aspects an incessant quest for intelligibility and creation?" asks mathematician Luciano Boi. "Once again, we need to think of beauty in all its temporal and timeless, tangible and intelligible, natural and artificial complexity," says art theorist Roberto Barbanti. Together, the two men have launched the Pharos centre at a former convent, heavy with silence and memory, near the Italian city of Urbino. It is a place where scientists, philosophers and artists of every discipline can discuss, reflect and ask one another questions.

Montefeltro Valley lies 40 kilometres outside Urbino, where the four regions of Emilia, Tuscany, Umbria and San Marino meet. The little town of San Leo, built on a rock guarded by a granite fortress, lies close to the cathedral, with a few palazzi also around. This is archetypal – or postcard – Italy, a peninsula traversed from end to end by history. Leaving the town by a rough-hewn track that leads to the convent of Sant'Igne, the sense of history continues. "We wanted somewhere that was quiet and intimate, not institutional; a relaxed place where people can come to think, work, create and rediscover their own sense of time." This site forms part of the Franciscan heritage. "There is an extraordinary cultural history here. The monks respected and developed a relationship with nature which they discussed, contemplated and explored. We felt it was an ideal place to recreate this dialogue between thought that reflects and seeks to understand, and the type of thinking that contemplates and rediscovers the value of things." (1)

Meaning and meaninglessness

A few buildings surround a cloister at the heart of the Pharos centre, the brainchild of two long-time accomplices, Luciano Boi (2) and Roberto Barbanti (see box). Their objective was to bring together scientists,

➥

(1) Quotations by either Roberto Barbanti or Luciano Boi. To simplify reading, and since they are not contradictory, the author is not specified here.

(2) Pharos would never have come into being without the efforts of founder members Simona Capra, Angela Gorini, Simonetta Piscaglia and Sabina Raggini. Enzo Tiezzi, Giuseppe O. Longo, Pino Paioni and Pascal Gabellone have also inspired and encouraged the development of this project.

The Franciscan convent of Sant'Igne, which houses the Pharos centre, close to San Leo, in Italy. 'We wanted to create a relaxed environment where people can think, work, discover, be creative and recover their own sense of time.'

philosophers and artists who were keen to undertake a critical discussion on the meaning of their work and the "destiny of human knowledge". "Many of us sense a lack of meaning in our work, whether it's in life sciences, the humanities, or artistic creation. Interests and motives that are alien to the very *raison d'être* of our disciplines increasingly dictate our efforts. The sciences are becoming less and less a form of creative, detached knowledge. Why? Because they are becoming increasingly dependent on economic, political and social interests which obscure their original intent."

For Barbanti and Boi, this erosion of meaning, which affects all forms of knowledge, is accompanied by the danger of a much greater loss. Entire fields of culture are disappearing (languages, or Buddhas massacred in Afghanistan), human artefacts disfigure the coasts and mountainsides, biodiversity is constantly in retreat. Such desertification and reduction to the lower common denominator also have social effects. "The less shape and harmony we encounter in our environment, the more limited our perceptive and intuitive potential. If you live in surroundings devoid of all aesthetic sense and a certain organisation, your understanding and sensitivity can disappear. Socio-economic problems also stem from this. We believed we had found a nodal point that we needed to draw the attention of researchers, politicians and economists, architects, etc. to.

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To learn more

- www.centrostudiricerche.org/entry-en.htm

Beauty and form

The first interdisciplinary symposium that Pharos organised was on the subject of beauty, both as an intrinsic factor of knowledge and as a criterion of style and life. The second symposium examined the genesis of shapes in science, nature and the arts. Each time, these meetings went beyond their strict – and *prima facie* elitist – topics, crossing the artificial frontiers separating the various disciplines, and suggesting new points of rapprochement between theoretical research and the practice of knowledge.

Boi and Barbanti believe that reflecting on these subjects is also a way of entering into the fight to preserve the Earth. "It is a fight, not for any old development or progress, but for the valorisation and respect of all natural, vital and human resources. All from the perspective of a new humanism that is able to reconcile science – as the creator of concepts and not as an appendage to technology – with philosophical thought and aesthetic imagination."

This calls on us to develop qualitative science without trying to dominate nature – of which we ourselves are an integral part. "Imagine the grandeur that we can still aspire to if we dare to envisage Nature differently, to reorganise our economic, social and cultural life in line with our current knowledge of the complex and interdependent relationships within the biosphere and the environment, of the self-organising and evolving capacities of nano-biological and nano-chemical structures, of land and marine biodiversity, and of alternative and renewable energies. Taking this risk would give us back our true human and cultural dimension. We need more scientific imagination, philosophical questioning and more artistic creation if we are to recover beauty and truth in our lives. We need to learn to marvel again in order to make the word an enchanting place once again."

Concordance and discordance

The latest Pharos project clearly reflects this ambition. It seeks to examine the new frontiers between art and science, to contribute to reflections on Europe's cultural identity. Various Italian, French, British and Belgian universities, together with a German research centre, are involved in the analysis of the relations between artistic and scientific approaches, with their various analogies and similarities. These include the concept of experimentation (increasingly present in contemporary creativity), the new dimensions of technology (memorisation, data processing and transmission, visualisation, cognitive modelling), the common use of certain working tools, questions concerning space and time, etc.

This approach refers us back to certain traditional conflicts between art and science, such as rationality/irrationality, consciousness/unconsciousness, causality/chance and truth/beauty. Analysing the frontiers between these two universes enables us to measure both what separates them but also what they have in common. "Artistic creation, for example, is opposed to every procedural or protocol-based methodology, whereas the validation of science is based on the ability to verify. Science integrates a certain concept of progress, for which art has marginal room. But discordances go hand in hand with concordances, and we would like, through discussion and reflection, to reveal the existing relationships between these scientific, aesthetic, philosophical, anthropological and other fields of research."

Beauty and truth

But is the truth-beauty duality transmitted by positivism and scientism open to questioning? From the scientific viewpoint, beauty can be seen as a driving force of knowledge. "One talks of a beautiful theory. Elegance, simplicity, economy of means, symmetry, the relationship of the part to the whole, and intelligibility are all elements connected to beauty that form part of abstract thought. We also believe that science can no longer be identified with Truth. At the same time, from an artistic point of view, the concept of beauty has been shattered, "ever since Duchamp and the Dadaists revealed the instrumentalisation of beauty". Other artists have worked counter to beauty as a focus, with some intentionally seeking ugliness. But this latter trend concerns, in particular, the visual, 'retinian' area, i.e. the most abstract of the senses, favoured by Western culture to the detriment of other forms of perception. It would be like a cook seeking to create 'inedible' recipes. Coming to biotech art, Roberto Barbanti believes that we have entered an era of chimeras, requiring a new approach to aesthetic questions. "The problem of beauty becomes a fundamental issue in this new framework where reality can now be shaped by a human project. Seen from this viewpoint, every aesthetic question immediately becomes an ethical issue." ■

Mathematician and philosopher Luciano Boi (left), and artist and art theorist Roberto Barbanti (right).

The two voices of Pharos

Roberto Barbanti and Luciano Boi have talked together for many years. Mathematician and philosopher, Luciano Boi is the author of many research works and articles on mathematics, theoretical physics, philosophy and the history of science. He is currently working on demonstrating the importance of geometric and topological methods for developing an understanding of biological processes. His publications include *The Human Problem of Space* (Springer-Verlag, 1995), *Science and Philosophy of Nature* (Peter Lang, 2000) and *Geometries of Nature, Living Forms and Human Cognition* (Springer-Verlag, 2003). He is also a director of the collection *Philosophiae Naturalis and Geometricalis*, published by Peter Lang.

Art theorist and practitioner, Roberto Barbanti's books include *20th century art and Utopia* (L'Harmattan, 2000 – with Claire Fagnart) and *Francis of Assisi and Marcel Duchamp – Rudiments for an aesth-ethic* (Danilo Montanari, 2001). He explores the evolution of the consciousness of time and space, as expressed in both science and art. He questions the ethical consequences of an art which experiments with new technologies and tackles a whole range of questions about life, evolution and consciousness. As a practitioner, Barbanti has completed several multimedia works of expression (performances, environmental music, installation, and 'communication aesthetics' events).

The paradoxes of perception

For the past 40 years the musician Jean-Claude Risset has been exploring the possibilities of synthesising and digitally processing sound. As a physicist, he is also engaged in research into the characteristics of auditory perception. As a composer, his musical creations are inevitably linked to his research work – with the recognition he receives coming in equal parts from both the scientific community and the world of music.

"Art and science are distinct in terms of their goals, tempo and criteria. But my scientific and artistic activities nourish each other. The driving force behind science, as well as creativity, is a kind of emotion and desire." Jean-Claude Risset was awarded the CNRS(1) gold medal in 1999 for his work as a theoretical physicist. As a composer, he has received many awards, most notably the Prix Ars Electronica (1987) and the Grand Prix National de la Musique (1990). To succeed in these two equally difficult worlds, considerable tenacity, a twofold talent, and a little luck are required.

The latter first took the shape of Pierre Grivet, the young Risset's boss at the Institut d'Electronique Fondamentale (Paris). He suggested to Risset that he should explore subjects that could bring science and music together, rather than abandoning one for the other. He gave him an article by Max Mathews published in *Science* magazine, entitled "The digital computer as a musical instrument".

> "My scientific work on the synthesising of sounds and perception has brought me new possibilities for composing. And my work as a musician has raised stimulating problems for my research."

The 'Bell Labs' musicians

Max Mathews, John Pierce and Newman Guttman were producing computer sounds across the Atlantic in the early sixties. They were conducting their experiments at the Bell Laboratories in Murray Hill, just outside New York – a hotbed of imaginative researchers. Pierce, an acoustician, was also the inventor of satellite communication and the progressive wave electronic tube used in radar systems. Bell Labs is the birthplace of the transistor, satellite communication, solar cells, the Unix system and C language – as well as being the location where the background noise of the Big Bang was discovered. At the time, Max Mathews was in search of a music fan with sound scientific knowledge. France, for its part, needed top-level computer scientists. Risset applied to the 'electronic calculators' committee and obtained a grant to go to the United States.

(1) The gold medal from the National Centre for Scientific Research (CNRS) has been awarded annually since 1954 to people who "made an exceptional contribution, in various fields, to the dynamism and influence of research in France".

CAREER PATH

In 1969, after three years at the Bell Laboratories (United States), Jean-Claude Risset published a *Catalogue of synthesised sounds* for use by researchers and musicians. On his return to Europe, he developed this type of work by computer at the Institut d'Electronique Fondamentale d'Orsay and at the Faculté de Luminy, Université de Marseille (1970) before heading the Computer Music Department at the IRCAM (Institut de Recherche et de Création Acoustique-Musique), under Pierre Boulez (1975-1979). 'Mediterranean by adoption', he then returned to the CNRS as director of research at the Laboratoire de Mécanique et d'Acoustique (Marseilles), where he is now emeritus professor of research. In 1998, Jean-Claude Risset was charged by the French Ministry of Education with drawing up a report on 'Art-Science-Technology' which analyses the scope for synergy between these three areas in the field of education. His very varied musical works are available on over 20 different CDs.

www.lelieuunique.com/SAISON/0203/2/ArtBiotech.html

"It seemed to me that the precision and complexity of the computer could produce flexible musical material more rich and lively than electronic music. "The work of serial composers, the latter is characterised by sounds which are precisely controlled by oscillators but lack resonance. During this same period, champions of the almost divergent school, concrete music, were achieving some very rich sounds but finding it difficult to give them any kind of form. "For me, concrete music largely involved an artistic mix, while the effects produced by electronic music lacked warmth. Therefore I tried to explore sound synthesising – the digital equivalent of electronic music – by attempting to introduce life into artificial sounds."

At Bell Labs, a giant computer and modular software designed by Mathews (Music4 and Music5) made possible the use of digital coding to produce some unique sound effects. Risset himself devoted his energies to the complex task of imitating brass instruments. In 1965, while working on the relationship between the spectrum and intensity, he succeeded in simulating the trumpet. This initial result caused quite a stir among experts.

Auditory illusions

The computer not only makes it possible to 'sculpt' sound, but it can also analyse the listening experience. What is the relationship between the sounds made (via objective parameters) and the sounds heard (their perceived effect)? Why do some sound structures not resonate as expected? Why do some imitations of instruments remain unconvincing? "To manufacture synthesised sounds, we give the computer a precise digital description, a 'complete' score which will be translated into sounds. A schematic representation is not enough. Certain sounds, even very simple ones, do not sound as expected."

In analysing the peculiarities of perception, Risset combines physics and music to produce 'paradoxical sounds' and 'auditory illusions'. These unique constructions seem to defy common sense. "They are sounds which seem to become lower when you double the frequencies, or rhythms which become slower when you double the speed of the tape recorder they are played on. Some sounds seem to rise and fall at the same time, or to continually become slower, despite being faster at the end than at the beginning."

These paradoxical interpretations by the senses – comparable to perspective tricks played on the eye – reveal truths about perception. Risset was the first, for example, to create the illusion of an indefinitely descending spiral in 1968 for the work by Pierre Halet, entitled *Little Boy*, which reconstructs the bombing of Hiroshima. A descent into hell, it illustrates the despair and madness of Eatherly, one of the pilots who flew on the nuclear attack.

Computer Suite for Little Boy and *Mutations* (1969) are considered as the first 'major' works totally synthesised by computer. Jean-Claude Risset later created combinations of synthesised sounds and performing musicians (*Dialogues, Inharmonique, Moments newtoniens, Passages*). This was followed by Sud, in which Nature makes its appearance. Sud is presented as a musical landscape, complete with waves, birds, insects and frogs, and is the result of recordings made near Marseilles, Risset's adopted home for the past 30 years. "I was crouched at the end of a rocky inlet. It was the sound of silence, the impalpable, the crackling of grains of sands, and the scraping of pebbles." Electronic sounds were then mixed in with these echoes from the natural world. "These two elements – or *characters*, in a sense – didn't merge, but created a hybrid. It was the interpenetration of two worlds, one of which was initially foreign to the other. I often quote Cézanne who said he wanted to unite feminine curves with hilly shoulders."

Inner multi-disciplinarity

Sound research involves physics, data processing, signal processing, psychoacoustics and music. "People often talk about multi-disciplinarity. It is a question of specialists from different fields working on the same project. But the level of dialogue remains low if each one doesn't venture into the world of the other at some level. I believe that multi-disciplinarity often takes place inside the individual. Pasteur was not a biologist, but a chemist and physicist. A lot of scientific progress has been achieved by outsiders who are not a part of the normal establishment."

Art or research, if Risset had had to abandon one of the two which would it have been? Music would no doubt have won the day – but it would not have been the same music. ■

To find out more

- **Biography, research, compositions**
  http://www.olats.org/ ('pioneers and precursors' section)
  http://composers21.com/compdocs/rissetjc.htm
- **Discography**
  http://www.electrocd.com/bio.e/risset_je.cat.html
- **Risset Report**
  www.edutel.fr/rapport/risset
- **Laboratoire de Mécanique et d'Acoustique de Marseille**
  http://omicron.cnrs-mrs.fr

Experiencing science through art

A nuclear physicist abandons a career mapped out in advance to devote his time to multimedia performances. A musician and doctor of biochemistry translates into sound the beauty which fascinates him in the science of biology. Two German researchers, Dieter Trüstedt and Jörg Schäffer, have chosen a career as artists – but it was science that led them there.

Dieter Trüstedt: "I organise sounds and noises like a painter uses colours and lines." ©Franz Kimmel

Jörg Schäffer: "'Science often remains blind to some of its aspects, such as beauty" ©Franz Kimmel

The Catalonian Assumption – Munich, November 2003 ©Franz Kimmel

Fluctuating, echoing sounds, like distant harmonies, contrast with the amplified strains of string instruments – projections of often abstract visual images. In the midst of it all is a dancer whose movements interplay with sounds, shadows, shapes. *The Catalonian Assumption* is one of the latest creations of Dieter Trüstedt, a nuclear physicist who preferred art to science. The title is a reference to a mathematical problem – sequences of squared numbers, such as 8 or 9. "That is simply an inspiration which helped me to structure the material when designing this performance," explains Dieter. "The public does not need to know this to appreciate the beauty."

From the simple to the complex

This scientist's passion for the arts is long-standing. It was first aroused when he was a student in the sixties and attended a performance by a very original puppet show. "There was an abstract image, consisting of shadows and shapes, and I was haunted by it." Trüstedt decided to join the group, where he met the artist who was to become his wife. Together they sought new modes of expression and experimented with the projection of images accompanied by electronic music. It was complex work due to the limited availability of suitable material. Finally, the physicist, who was both practically minded and familiar with laboratory equipment, built his own synthesisers and laser projectors which he used to create his own performances.

With his science doctorate behind him, Trüstedt opted firmly for art. "Clearly, it was a difficult decision, but I had experienced the intellectual pleasure of creating, of giving birth to something and sharing it with an audience." But that did not disprove the old adage that "once a scientist, always a scientist". "This dimension always stays with you; you cannot drive it out. There is always the curiosity to know how things work, the desire to experiment, to first explore simple phenomena and then arrive at a greater complexity."

This is an analysis that can be applied equally to his creative work which is austere and free of ornamentation. "I am not a real musician. I can't even sing a melody. I simply organise sounds and noises rather like a

painter uses colours and lines." The visual aspect is, moreover, a very important element in his performances. The tension originates in the combination of simple geometric shapes – with the emphasis on pure colours and from which there sometimes emerges the photo of a real but deformed object – and the movements of a dancer as a counterpoint.

Variations on DNA

While Trüstedt was presenting his latest performance at the Munich School for Music and Performing Arts, Jörg Schäffer was playing one of his compositions on piano in a neighbouring room. The clarity and linearity of this music initially brings Bartok to mind. It consists of a cycle of 26 short pieces, called Viroids, which were inspired by DNA sequences. Each of them corresponds to between 200 and 300 nucleotides. "I am trying, through the medium of sound, to reveal the harmony of this molecular structure and the beauty of DNA."

A doctor of biochemistry with a degree in musicology and a composer, Schäffer says he grew up "between a chemistry lab and a piano room, one almost next to the other". Science and music: he feels equally at home in both these worlds. He sees his compositions as an attempt to analyse scientific compounds through aesthetic elements. "In musicology or in the theory of art, it is normal to analyse the arts through the medium of science. I do the same thing in musical creation, but in the other direction." Although passionately interested in science, nevertheless Schäffer regrets that it "often remains blind to some of its aspects, such as beauty, of molecules for example. It is a question that is asked only rarely, when I believe that research would benefit enormously from such an approach."

The Catalonian Assumption – Munich, November 2003

The sound of an atom

Schäffer could imagine deciding to return to his laboratory one day, but on one condition: "If I made a new discovery, I would probably want to publish it in the form of a composition."

"What could the sound of an atom be like?" he wonders. It is a question he has never been able to answer – "yet everyone can tell me what an atom looks like" – and his music is an attempt to provide one. This is no doubt why after his studies at the famous Max Planck Institute this young biochemist studied musicology and the history of art. It was at this time that he discovered experimental music, began to compose and was subsequently appointed musical director at several German theatres. He composed a number of piano works and also an opera, the latter inspired by the piece by the Hungarian composer Peter Nadas, entitled *Housecleaning*. Schäffer has also been commissioned to write certain works, always keeping in mind his scientific inspiration. He wrote *Fusion* (a work symbolising nuclear fusion and the transformation of hydrogen into helium) for the Fraunhofer Research Institute and *Caenorhabditis elegans*, based on the flow chart of cellular development, for the Max Planck Society. Schäffer is nevertheless at pains to point out that his music is not for or about physical phenomena or the development of living organisms, but always an attempt to capture the internal and secret harmonies of science and to translate them into musical forms.

"Echtzeithalle"

About a decade ago, Trüstedt founded the Arts Centre at Ulm University where he taught "artistic strategies" to science students. He was putting into practice the idea that "the very notion of university implies a universal education" and was trying to demonstrate in his lectures that a whole world of inquiry lay behind the sciences. This concept was applied to the *Echtzeithalle*, a 'real-time' centre founded by Trüstedt and Schäffer in 1999 and dedicated to exploring the various artistic fields which embrace the dimension of sound – innovative music in all its forms, sound sculptures, performance art, experimental choreography, videos, etc. About 50 artists, engineers and scientists from various disciplines work at this institution which is in the open tradition of the Bauhaus. Their general aim is to explore the new media and new forms of expression which often have their roots in an interaction between art and science. By a strange coincidence, the *Echtzeithalle* (that has since also become a virtual 'multiple use' space) is situated on Einstein Street – named after the man who said that "the imagination is more important than knowledge".

But do art and science actually have anything in common? Yes, reply Trüstedt and Schäffer in unison. You have to devote your whole being to them. You cannot be a part-time scientist or part-time artist as that can never work. You need inspiration and enthusiasm to stay the course. You must have a very clear idea of what you are looking for and of the result you are seeking. All of these apply to both fields. ■

To find out more

- www.luise37.de/2003/katvermut/katalanischevermutung.htm
- www.luise37.de/
- www.echtzeithalle.de/echtzeithalle.htm
- www.echtzeithalle.de/kuenstler/schaeffer-j.htm

Museums of the digital age

With two museums, three institutes, a centre for artists and a full programme of cultural events presenting contemporary – if not avant-garde – works, the Centre for Art and Media in Karlsruhe (DE) is unique in Europe. Defining itself as a "culture factory for the digital age", this versatile space provides scope for research, artistic production, reflection and public debate.

"Listen to the imperceptible voice of the sand." This line by the French poet Annie Salager is the inspiration for the latest work (*Voices of the sand)* by the British artist Pippa Murphy. Whispering and jabbering voices, rustling sand and crackling pebbles fill the space with a music which invades the whole body. The computer which controls the 36 loudspeakers is the composer's accomplice. At the mixing desk, Murphy orchestrates the whole piece. She defines this new work as "acousmatic" because the source of the sound is invisible. "Ten years from now," she says, "it could be the popular music of the day."

A member of the Birmingham ElectroAcoustic Sound Theatre and a lecturer at the Universities of Edinburgh and Aberdeen, Murphy created *Voices of the sand* during her time as resident composer at the Center of Art and Media (ZKM). Housed in a listed building, formerly a munitions factory, the centre occupies a vast space nearly 300 metres long. It was founded in 1989 with public money provided by the City of Karlsruhe and the Land of Baden-Württemberg. The plastic arts, dance, literature, music and reflection all have their place here, with the new media as the unifying theme.

The Blue Cube

The ZKM pays particular attention to the creation of sound. Its **Institute for Music and Acoustics** is housed in a structure known as the *Blue Cube*. This transparent module was designed to meet the most demanding requirements in terms of the quality of its acoustics and its recording equipment. As a result, it enjoys a reputation as one of the world's best pilot centres for electronic music and computer composition. An extensive range of professional recording, creation and sound engineering programmes are available on the majority of its computing platforms.

The Institute's director Lothar Brümmer, himself a composer, presides over the activities of this unique facility where technology is permitting the exploration of new dimensions of sound in which the computer is master. A number of the composition programmes were developed by researchers at the ZKM in co-operation with centres of excellence of world-wide renown, such as Stanford University (USA) and the Institut National de l'Audiovisuel (FR).

The ZKM and the Institut de Recherche et Coordination Acoustique/Musique (Ircam) in Paris (FR) are currently planning to combine their sound archives, while possibilities are being explored for closer links with the Association pour la Création et la Recherche sur les Outils d'Expression (ACROE) in Grenoble (FR).

More than 90 artists from all over the world have produced 180 works at the Blue Cube. Martin Schüttler, who teaches composition in Frankfurt, is currently at the centre working on advanced technologies and sees music as "a sculpture or time puzzle". But can it be described as difficult music? "To the extent that it departs from the usual expressions of sound, this type of music does surprise," admits Brümmer. "The public must be educated and guided to appreciate it, but that is what we are trying to do here." ■

THE ZKM PUZZLE

In addition to the Institute for Music and Acoustics, the ZKM also has an **Institute for Net Development**, which provides communication tools and strategies for artists and cultural institutions; and an **Institute for Research**, which concentrates on the investigation of complex systems, especially in the field of cognition and aesthetic perception. The Centre also houses the very interactive **Media Museum** which presents technologies in all fields and a **Museum of Contemporary Art** which showcases the principal movements in European and American art since the 1960s. Its **Media Library** has one of the largest collections anywhere of videos, CDs and books on 20th-century art. It can be accessed on-line at http://on1.zkm.de/zkm/e/.

To find out more

- http://www.zkm.de/

MEMORY MEMORY

Europe, researchers & cultural heritage

Civilisations are built up over centuries and millennia. The tangible traces they leave behind enable future generations to find their roots in a shared past. With its historical cities, grandiose remains and more modest historical vestiges, Europe is particularly rich in reminders of our shared history. It is no accident that Europe is the continent for the growing business of art and culture tourism. But this culturally – and economically – valuable heritage is also fragile. It is literally crumbling away, not only from age, but also from the effects of climate, pollution and human negligence. The meeting of science and technology with art and culture includes the provision of invaluable assistance towards conserving and restoring these riches.

Given the necessary resources, researchers can help curators understand the causes, mechanisms and consequences of this deterioration in our cultural heritage. They can develop practices and technologies to control it and offset its harmful effects. For this reason, for the past 20 years or so the European Union has wholeheartedly supported projects focused on these objectives. Over 200 partnerships involving researchers from many different disciplines and origins have helped save a host of such testimonies from destruction.

Manuscript by Galileo (1564-1642), National Archives of the Netherlands.

This European approach – working in networks and comparing buildings, materials and objects from different parts of the continent – has advanced research into our heritage and improved its conservation.

On the following pages we present examples of 'young' projects, often in midstream, which the Commission is currently supporting. Involving many countries (often acceding states) and very different fields – manuscripts or architecture, the condition of historical organs and monuments, the poor state of tapestries or stone – the very number and diversity of these projects reflects the richness of Europe's treasured memories.

Contact

- johanna.leissner@cec.eu.int

For further information:

- www.cordis.lu/eesd/ka4/home.html

Less sulphur, more nitrogen?

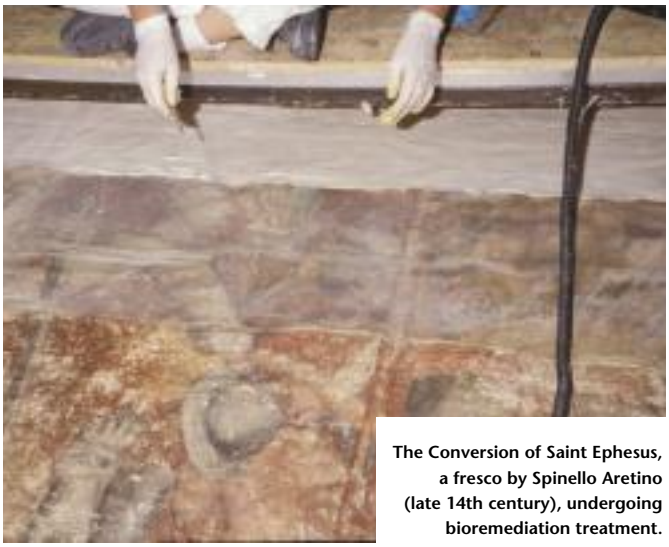
One long-time enemy of our architectural heritage is sulphur dioxide (SO_2), coming mainly from industrial emissions – even though these have been cleaned up considerably in recent years – and coal-fired domestic heating systems. Increases in automotive traffic have also introduced a range of more complex pollutants, including nitrogen derivatives (dioxide and nitric acid) and ozone. This atmospheric cocktail attacks the surface of materials in different ways depending on their exposure to sunlight, air humidity levels, pH, etc.

The Parthenon is one of the masterpieces of our global heritage which has been most affected by urban pollution.

Diagnosis and prevention call for much more sophisticated, multi-factoral analyses and standards than currently exist –the pan-European ***Multi-Assess*** project addresses such needs. With the help of sensors placed in various urban areas, researchers are undertaking an extensive campaign to identify and sample toxic components, and to model new "dose-response" functions to combat the corrosion and soiling of different materials by complex combinations of pollutants and atmospheric factors. With participants from 14 countries, ***Multi-Assess*** has set out to propose new reference "threshold levels" for implementing the *Convention on long-distance cross-frontier atmospheric pollution* adopted by the United Nations Economic Commission for Europe, as well as the Union's own directives in this area.

Detail of a sculpture on a gateway in the old city of Stockholm.

Multi-Assess
(Model for multi-pollutant impact and assessment of threshold levels for cultural heritage)
16 partners – 14 countries
(SE-AT-DE-CH-IT-GR-UK-CS-NO-PL-LV-FR-EE-BE)
Started: January 2002 – 40 months
Contact: vladimir.kucera@corr-institute.se
www.corr-institute.se/MULTI-ASSESS



The Conversion of Saint Ephesus, a fresco by Spinello Aretino (late 14th century), undergoing bioremediation treatment.

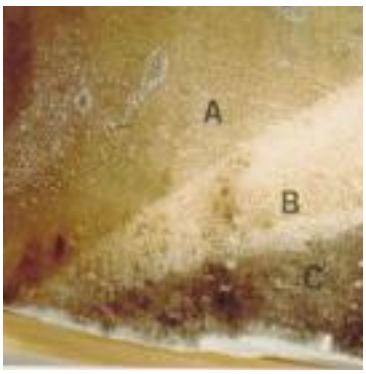
Biomedicine to heal stones

Urban monuments have undergone regular cleaning for several decades, either with chemicals, which can cause environmental problems, or with lasers, a method limited by the danger of physical damage to the materials.

Detailed microphoto of the marble structure covered in black dust – Freedom Monument, Riga (LT).

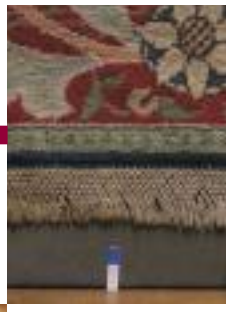
Without pretending to actually look for a substitute for these traditional methods, the six universities and one industrial partner in ***Biobrush*** are exploring a non-aggressive alternative approach known as bioremediation. The idea is to identify bacterial micro-organisms that can decompose the mineral and organic deposits encrusted on the stone or brick. Test sites currently include the Tholos Dome at Epidauros (GR), Matera Cathedral (IT) and Riga's Brethren Cemetery (LT).

Biotreatment has produced excellent results on this 13th century marble column:
A. untreated area;
B. 36 hours after treatment;
C. 46 hours after treatment.



Biobrush
(BIOremediation for Building Restoration of the Urban Stone Heritage in European States)
7 partners (UK-DE-GR-IT-LV)
Started: February 2002
36 months
Contact: eric.may@port.ac.uk
www.biobrush.org

Soft lighting



Any curator will tell you that the colours of works of art are as sensitive as flowers to sunlight. The harm caused by lighting is, however, difficult to analyse. This depends on the light source – artificial or natural – and, in the latter case, to a large extent on the state of the sky, the season and the time of day, and on the properties of the light itself. In general, the shorter the wavelength (closer to ultraviolet), the more energetic the photons are and the more aggressive the light. This harmful effect also increases after a certain period of exposure. Sophisticated and reliable measuring and surveillance apparatus already exists, but is expensive and often bulky. To fill this gap, five European research teams set to work on the ***LiDo*** project, with three of them tackling specifically the problems of conserving works of art. The objective was to design a practical and user-friendly 'light dosimeter'. The result is the *LightCheck®* mini-sensor with a photosensitive covering that changes colour, indicating the 'accumulated' exposure to light. A spin-off from space technology, it won a European Space Agency award in December 2003.

Evaluating the *LightCheck®* principle on a tapestry at London's Victoria and Albert Museum. ©V&A, London

LiDo
7 partners - 5 countries (DE-FR-IT-UK-CZ)
Contact: roemich@isc.fhg.de
www.lido.fraunhofer.de

Church welfare

The outwardly simple mountain church of Santa Maria Maddalena at Rocca Pietore is decorated with frescoes and houses a very beautiful 16th-century carved wooden panel behind the altar. In winter, during church services, a 'complete' heating system is switched on and runs continuously for several hours. "This is an enormous waste of energy. The entire building is supposedly heated, but worshippers are cold and the art works suffer from variations in temperature and relative humidity," explains Dario Camuffo, the Italian climatologist who is coordinating the Friendly Heating project. Santa Maria Maddalena is currently a pilot site where a team of European researchers is testing a radically different heating system – based on common sense. Heating is concentrated uniquely on the space occupied by worshippers. Radiant heat and occasionally forced warm air are provided by low-temperature infra-red sources placed among the pews. An extraction system removes excess moisture from respiration. Over 80% of the heat remains concentrated in the first few metres of the nave, whereas previously 93% of the heated air was dispersed throughout the building.

The church of Rocca Pietore (IT), a pilot site which is experimenting with new heating systems that are effective, economical and respect the works of art.

Friendly-Heating
7 partners (IT-BE-FI-NL-PL)
Started: April 2002 – 36 months
Contact: d.camuffo@isc.cnr.it
www.isc.cnr.it/friendly-heating/default2.htm

Sampling, assessment and testing of a tapestry from Hampton Court (UK).

Tapestries: analysis without destruction

Heavy but fragile, Europe's tapestries are sensitive to humidity and light. The ***Modht*** project has set out to analyse the condition of certain examples in order to develop conservation methods based on scientific evaluation. But how can we analyse these tapestries without damaging them? "Part of our work consists of producing small model tapestries, using traditional materials and dyeing techniques, then artificially ageing them. What we have discovered is that the dyeing process affects the sturdiness of the object," explains project coordinator David Howell. These models also help define the resistance of the tapestries, the largest of which could take the weight of a double-decker bus.
Other tiny samples are also taken from the tapestries themselves. Conserved in Belgium, Spain and the United Kingdom, and representative of both northern and southern European schools, these works are all the more interesting to researchers as their history is well documented (original workshop, successive locations, etc.). "Our analyses are already producing very interesting correlations, and the results are due to be presented this July at the University of Southampton's Textile Conservation Centre," says David Howells.

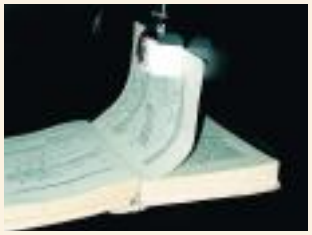
Modht
(Monitoring of Damage in Historic Tapestries)
7 partners (UK-ES-BE)
Started: April 2002 – 36 months
Contact: david.howell@hrp.org.uk
www.hrp.org.uk/webcode/content.asp?ID=706

Across the world, hundreds of miles of books are abandoned to their fate – and slow deterioration.

Paper's strange radiation

As it ages, paper gives off a very feeble light which can be captured. This phenomenon, known as *chemiluminescence*, is not unlike the light given off by glow-worms. It is caused by the ultra-slow oxidation of cellulose – the natural polymer which is the main component in paper – which, at the end of the cycle, results in the irreversible degradation of the medium.

Researchers in the ***Papylum*** project have set themselves the goal of developing a prototype hypersensitive *chemiluminometer* which can both pick up and measure the 'signal'. This new instrument will enable researchers to explore the complex conditions (temperature, air humidity and pH, ambient light, etc.) which encourage or slow down the paper-ageing process. It will also make it possible to evaluate ways of optimising the conservation of this fragile material. Once developed, it will provide the curators of our main 'library treasures' with an easy and direct method of analysing the 'state of health' of their documents – as well as taking a series of preservation measures. A prototype chemiluminometer will be presented at Ljubljana in November 2004 (see website).

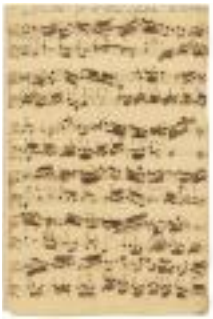


The operating principle of the prototype chemiluminometer which should enable librarians to assess paper degradation.

With the ability to analyse and diagnose other media (textiles, resins and paints), this apparatus could have potential uses in totally different research areas, including pharmaceuticals and foods.

Papylum
5 partners (SI-SK-NL-FR)
Started: July 2001 – 40 months
Contact: matija.strlic@Uni-Lj.si
http://papylum.uni-lj.si

The evil effects of iron-gall ink



Score by Johann Sebastian Bach (1685-1750), Berlin Library Collection (DE).

Used throughout the Middle Ages and into the 17th century, in particular for landscape drawings, iron-gall ink continued to be used for manuscripts into the 20th century. But whilst its scriptural or pictorial quality is undisputed, the corrosive properties of its components 'self-deteriorate' the works and writings of which it is the lifeblood. "A recent inventory by the Boijmans van Beuningen Museum (NL) shows that more than a quarter of its collection of 17th-century Dutch drawings are affected by this phenomenon. The manuscripts of Victor Hugo's works, conserved in Paris, have seriously deteriorated, as have 60 to 70% of Leonardo da Vinci's works," according to Jana Kolar of the University of Lubljana, a coordinator in the ***InkCor*** project. "This project has been set up to learn more about this corrosion phenomenon and to establish the best ways of conserving and preserving documents," Jana Kolar explains. "European co-operation has made it possible to bring together experts from different fields – art historians, curators, physicists and chemists – to tackle the problem."

Their research has shown that three parameters come into play in determining the degree of deterioration of the documents: the thickness of the ink layer, that of the paper, and the acidity of the ink. "Once we know these variables, we can foretell the future behaviour of the documents and, where necessary, apply conservation treatments. ***InkCor***'s work on degradation mechanisms should also help us to improve certain existing conservation processes." A patent for an 'antioxidising treatment' for commercial use has recently been registered jointly by the ZfB (Zentrum für Bucherhaltung), the National Library and University of Slovenia, and the University of Ljubljana.

Landscape with Bridge, Rembrandt (1606-1669), Telyers Museum collection (NL).

Antioxidising treatment being carried out at the ZfB, in Germany.

Projet InkCor
8 partners (SI-SK-NL-FR)
Started: March 2002 – 36 months
Contact: jana.kolar@nuk.uni-lj.si
www.infosrvr.nuk.uni-lj.si/jana/stran.html

Battling with salt

Salts erode stone, eat away brick, and encourage mould. The damage can be caused by the crystallisation of the salts in the pores of the material itself, or as a result of a chemical reaction with the components of the mortar. Heritage restorers have to choose between modern industrial products or traditional methods. What are the advantages and disadvantages of these different approaches? When should one be preferred to the other? Are modern-day materials, in particular mortars, compatible with the damaged materials, for example substrates containing salts?

Venice: salt damage to brickwork and plaster.

Partners in the European projects ***Compass*** and ***Asset*** are seeking to understand better the deterioration processes caused by salts, and the technical demands of restoration. In particular, ***Compass*** is studying the problems posed by coatings and plasters applied on top of brick masonry (type of damage, causes, quantity of salts, diagnosis, etc.). The ultimate objective is to develop an expert system – an assessment assistant tool – for choosing the most suitable rehabilitation option in individual cases. ***Asset*** is a huge project aiming to validate restoration products and methodologies, based on on-site studies in Zeeland (NL), Venice (IT), La Rochelle (FR) and the Island of Rhodes (EL).

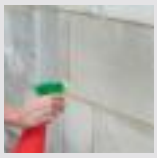
As well as its decorative function, plaster protects masonry against humidity.

Compass
(Compatibility of Plasters and Renders with Salt-loaded Substrates in Historic Buildings)
7 partners (NL-FR-ES-PT)
Started: March 2002 – 36 months
Contact: R.vanHees@bouw.tno.nl
www.kcbs.nl/hm/compass.php

Asset
(Assessment of suitable products for the conservative treatments of sea-salt decay)
7 partners (IT-NL-FR)
Started: February 2001 – 36 months
Contact: zezzaf@iuav.it
www.assetproject.com

Regenerating marble 'materials'

Water, heat, atmospheric pollutants and living organisms all 'prey' on historic monuments. The complex interactions between the material itself and these various elements produce degradation, the causes of which we still do not completely understand. For years, experts have been using various materials in an attempt to reinforce stone, few of which have proven truly satisfactory. A new and totally different approach is to treat the stone with 'biological' BIMS (Bio Inducing Macromolecules Solutions). These provoke the formation of calcium carbonate crystals using technologies inspired by bacterial genetic engineering methods (*B. Subtilis* and *B. Cereus*). Two types of stone, bioclastic limestone and Carrara marble, are currently being tested. ***Bioreinforce***'s partners are seeking to develop natural, water-applicable and more user-friendly products.



Château of Champs-sur-Marne: this early 18th-century castle in the Île de France, close to Paris (known to film fans), is one of the sites where BIMS treatments are being tried out.

Church of Santa Maria at Angera, Lombardy (IT).

Bioreinforce
(Biomediated calcite precipitation for monumental stone reinforcement)
7 partners (IT– UK – ES – BE – FR – IL)
Started: February 2001 – 36 months
Contact: p.tiano@icvbc.cnr.it
www.ub.es/rpat/bioreinforce/bioreinforce.htm

Wheezing organs

"With its unique architecture and tones, the organ was a high-technology object well before this concept was invented, combining expert knowledge of the properties of wood and metal with the art of working these two materials. Ingenious remote-control systems are used to operate the mechanisms and bellows," explains Carl Johan Bergsten, a researcher at GOArt (Göteborg Organ Art Centre) of the University of Göteborg (Sweden) and the enthusiastic coordinator of the ***Collapse*** project. Europe's organ landscape presents many common features, but also fascinating differences of construction, style and sound, reflecting the social and economic development of the various regions. All this knowledge and skill are put to the service of music."

Designed by organ builders who signed their instruments with inimitable tones, organs suffer problems of ageing, and certain of their most famous voices have started going hoarse with age. The first case was discovered in 1992 in the famous *Stellwagen* at the St-Jakobskirche in Lübeck, Germany, the oldest parts of which date back to 1467. Little corrosion holes had appeared in the lead-tin alloy tubes. But the St Jakob's organ was not the only case of its kind, and it was soon observed that a number of instruments, in many cases from the 15th, 16th and 17th centuries, were also panting and wheezing. Under GOArt's baton, the ***Collapse*** project was launched in 2002, bringing together the Swedish institute, the parish of St Jakob in Lübeck, a Danish SME specialising in organ building and restoration, chemical researchers from Chalmers University (SE) and archaeometallurgy specialists from the University of Bologna (IT).

"We selected seven organs for reference, all suffering from corrosion, in Italy, Germany and the Netherlands. We also compared them with 'healthy' instruments, housed in similar conditions in the same regions. One year into the project we realised that certain of the corroded instruments showed a high and unexpected concentration of acetic acid, a known metal corroder. This acid comes from the wooden parts and gets into the bellows."

But where exactly does it come from? The acid is found in oak which is used for restoration, although many organs repaired in a traditional way with this material do not demonstrate this problem. Could it be young oak? Could it be that central heating encourages the migration of acetic acid from newly used wood?

These are not the only enigmas posed by these impressive instruments. All the affected organs studied here were built in the German way, with only a very small percentage of tin in their pipes. In the United Kingdom, where tin is mined locally, it can represent up to 20% of the alloy ... and corrosion is almost non-existent. This looks like a serious avenue of investigation, and the Italian researchers' initial results seem to indicate that corrosion is inevitable in alloys containing less than 2% of tin. But specialists are not stopping here and are evaluating the impurities that slip into the metal and could possibly change its microstructure, and once again encourage corrosion.

Collapse's researchers are not just looking for causes – they also want remedies. Methods for treating corroded pipes and preventing this degradation are currently being studied and tested. At the end of the day, the European partners wish to propose a new vision of organ restoration and maintenance methods. "We hope that the results of this study will be useful in particular in the Central and Eastern European countries with their enormous heritage of around 10 000 instruments," Carl Johan Bergsten concludes.

Organ in the basilica of Santa Maria di Collemaggio in L'Aquila (IT). Built in the second half of the 17th century, this is one of the reference instruments in the Collapse project – 90% of its pipes are corroded.

One of 1 467 pipes with corrosion holes from the Stellwagen in the St-Jakobskirche in Lübeck, Germany. Magnification of the microstructure of the same element, by the University of Bologna Metallurgy Institute (IT).

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Collapse

(Corrosion of Lead and Lead-Tin Alloys of Organ Pipes in Europe)
5 partners (SE-DE-IT)
Started: 2002 – 36 months
Contact: Carl.Johan.Bersgsten@musik.gu.se
http://www.goart.gu.se/collapse