

Can the methodology of physics be applied to the study of social and natural sciences and thereby tell us more about the world we live in? Joaquín Marro believes that the great leaps that physics made in the twentieth century were just the beginning

The world can be seen as the sum of many parts, from groups of galaxies and ecosystems to human beings and molecules. Each has numerous elements that influence each other constantly. Around the universe, galaxies collide; within a galaxy, interstellar gravity generates streams of stars that are, after all, no more than electrons, neutrons, and quarks, whose form is dictated by the fundamental interactions.

The same principle can be discovered on many different levels and in many different contexts. The brain, for example, has the same elements as a star, but in the brain, instead of collaborating in order to emit radiation, they cooperate in a way that produces emotions and intelligence. Our communities and economies are shaped by friendships and business relationships; biological evolution is the result of genes interacting; and trophic relationships – or what eats what – determine ecosystems.

So, is it possible to understand natural disasters, social behavior, the origin of life, and other such puzzles simply by knowing how the elements of each of these systems work together? Does a principle determine how these elements are organized?

Recent scientific research has shown that concepts and methods used in physics for more than a century to understand the properties of matter – which we know to be due to cooperation between electrons, nuclei, or molecules – can help decipher some basic aspects of social and economic systems, as well as the worlds of nature and human behavior. For instance, Kai Nagel and Michael Schreckenberg have produced a mathematical metaphor based on the assumption that traffic jams are governed by simple local rules that drivers obey unconsciously. Studying the outcome of this model on a computer shows that the

transition from free flow to congestion has similarities with the way that water changes into ice. In other words, when vehicles have to coexist with many others in a limited space, they follow structured and restrictive patterns of behavior just as molecules do when water temperature falls.

Another reliable similarity has been found between the movement of molecules in a fluid and the way crowds behave in situations of panic. Certain psychological tendencies and interaction between the people closest together come into play. (As the Nobel Prize winner Richard Feynman pointed out, a fluid is no more than a collection of “particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.”) When this model was reproduced on a computer, researchers were able to design the most effective exits and the best conditions for evacuating a crowd from an enclosed space. They discovered that they were able to characterize crowd behavior by monitoring simple parameters, in the same way that researchers predict the movement of turbulent water.

It is surprising that as independent, rational people, we sometimes adopt the kind of herd mentality that works against both individual and collective interests. Nevertheless, there is no denying that our individual brains are superb pieces of machinery. We still don't know how to build a computer capable of carrying out the brain's normal tasks, such as coordinating the nervous system or recognizing a childhood friend we haven't seen for years.

Even before we are born, our brain is producing as many as a quarter of a million immature neurons a minute. These cells specialize and migrate to their permanent

locations, resulting in a surplus of neurons, which develop multiple synapses to fulfill various functions. While some of these connections just wither away, others are strengthened by electrical impulses that ensure efficient transmission of information, leading ultimately to increased intelligence. The most capable brains are those most able to neutralize superfluous connections.

Santiago Ramón y Cajal, the Nobel Prize-winning scientist, described neurons as “mysterious butterflies of the soul, whose fluttering of wings would someday – who knows? – explain the secret of mental life.” In the same way that the twentieth century saw great developments in physics, we can foresee that the present century may satisfy Ramón y Cajal's curiosity and find answers to the many questions that our current knowledge of neuroscience raises.

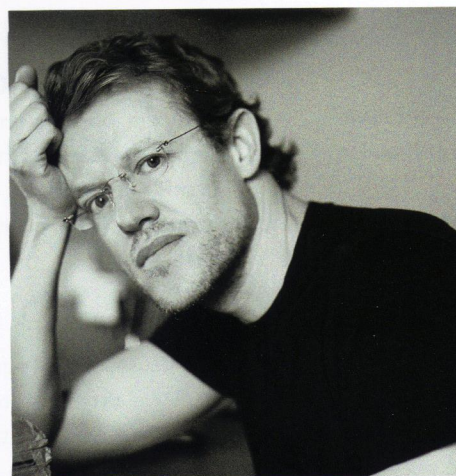
Mathematical metaphors based on the cooperation between neurons and synapses may well reveal the detailed mechanisms behind our consciousness, and what are the essential differences, if any, between the human brain and that of underdeveloped primates. In fact, if we had not devised this method of studying the brain, we would be as incapacitated as an extraterrestrial scientist abandoned in front of a modern computer as he tried to understand how it works, let alone how to interpret data measured on tens of billions of terminals.

Whether in the realm of physics, biology, or sociology, these models, in which the properties of a system emerge as a result of cooperation between its elements, form the basis of a still developing scientific discipline. Perhaps, this collaboration between scientists from different fields will result in a deeper and more coherent understanding of the world we live in. ♦

Translated by Isabel Varea

CONTRIBUTORS

London-born photographer **Jason Bell** is renowned worldwide for his portraits. His photographs of celebrities such as Nicole Kidman, Johnny Depp, Paul McCartney, and David Beckham have been featured in *Vogue* (U.S. and U.K.) and *Vanity Fair* among other leading publications. Bell's work has also been used in international advertising campaigns and on posters for major films, such as *The Golden Compass* and *About a Boy*. He has won the New York Photo Awards' Best Advertising Image and the Royal Photographic Society Terence Donovan Award for an outstanding contribution to photography, as well as many other prestigious prizes. Three books of his work have been published, with a fourth scheduled for 2010. As Thierry Stern succeeds his father as president of Patek Philippe, Bell helps commemorate the historic transition with exclusive portraits of the two men (page 14) for *Patek Philippe* magazine.



Professor **Joaquín Marro** is the author of *Physics and Life – the relationship between physics, nature, and society*, a guide to the strategies and concepts that help us understand the boundaries between physics and sociology, economics, and biology. Marro is the head of the department of electromagnetism and physics of materials at the University of Granada in Spain. He also teaches at the Institute Carlos I for Theoretical and Computational Physics, which he co-founded. Marro's thoughts on how physics can be applied to enhance the understanding of our lives appear on page 72.



Turkish-born **Ferit Kuyas** began his photographic career in 1986 and has since received many awards for his work. His most recent project, *City of Ambition – Fast Forward in China*, in which he observes the fast-evolving cityscapes of Chongking, was widely acclaimed and has now

been published as a book. A former architecture student, Kuyas photographed the Bauhaus in Dessau for *Patek Philippe* (page 54). He says, "It was good to see that piece of history, having influenced so many architects, still alive and filled with teachers and students."

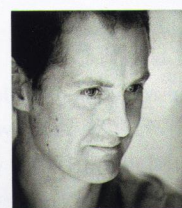


David Scheinbaum is head of the photography department at the College of Santa Fe, New Mexico. His book *Beaumont's Kitchen: Lessons on food, life, and photography with Beaumont Newhall* (Radius Books) celebrates the renowned photographic historian who wrote cookery columns in his spare time. The book also includes culinary-themed photographs by Beaumont's friends – masters such as Henri Cartier-Bresson and Ansel Adams. On page 60, Scheinbaum, in collaboration with **Kristin Barendsen** (pictured above), recalls his friendship with Newhall.

Audur Jonsdottir, granddaughter of Halldór Laxness (who won the Nobel Prize for literature in 1955), is fast carving her own reputation as a great writer. She won the Icelandic Literature Prize in 2004 and was nominated for The Nordic Council Literature Prize in 2005. Her latest novel, *Vetrarsól* (*Wintersun*), to be published internationally in 2011, sparked a bidding



war. Exclusively for *Patek Philippe* magazine, Jonsdottir recalls her childhood experiences with the horses that share her beloved homeland (page 20).



Photographer **Tim Flach** is best known for his unique and insightful portraits of animals. His first book, *Equus*, celebrates the physical dynamics and the spirit of the horse "from ass to zebra." Flach journeyed to Iceland to photograph the country's legendary horses for *Patek Philippe* (page 20), and says he was touched by the animals' gentle inquisitiveness and astonished by their agility, which enabled the horses to negotiate even the most challenging of landscapes.

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