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selves chiefly as Muslims and only more recently as a people whose ancestors were responsible for the pyramids. He seems to argue that because these identities are recent and nationalistic they should have no bearing on claims for antiquities, which he believes to be the heritage of all.

Neither book gives much attention to the perspective of archaeologists, who have played an important role in these developments. The clandestine looting of sites that is the source for the illicit art market results in the destruction of all factual information about the context of the particular artifact. Greek vases that appear on the market almost certainly originated in ancient tomb assemblages about which all scientific knowledge is forever lost. And even if we know the original location of the works of art, like the Parthenon sculptures or the Mogao murals, our understanding and appreciation are diminished by the incomplete nature of the ensemble.

What Cuno provides that Waxman's book lacks is excellent documentation of the various international agencies (such as UNESCO) and conventions (beginning with the 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict, which the U.S. Senate did not ratify until 2008) that have been drafted to protect and preserve antiquities. Many of the more recent conventions stress the rights and obligations of nations to protect archaeological sites and artifacts located within their borders, but according to Cuno these "nationalist, retentionist cultural property laws" fail to protect our ancient heritage and "conspire against our appreciation of the nature of culture as mongrel, overlapping, and a dynamic force for uniting rather than dividing humankind"—which is the mission of the encyclopedic art museum. What Cuno and most other writers on the topic fail to see is that museums in countries such as Egypt, China and Turkey are a different species altogether from our universal art museums; they are more akin to our historical societies, which seek to present the history and culture of a region in the context in which it was produced.

To the question of who owns antiquity, Cuno's answer is "all mankind." But today the artifacts on the market or those recently acquired by art museums are largely looted from archaeological sites and exported illegally from their countries of origin. Now that some of these countries—Italy, for example—have documentation obtained from dealers' papers that these artifacts are in fact stolen, they are having little trouble in persuading museums to return them. And these museums in turn are adopting new acquisition policies that are in accord with the 1970 UNESCO Convention on the Means of Prohibiting and Preventing the Illicit Import, Export, and Transfer of Ownership of Cultural Property.

Although Cuno states that this change has had no effect on the looting of sites, he offers no concrete evidence to back up his statement. Both authors unfortunately set up an either/or scenario: *either* universal museums filled with antiquities from the entire world *or* national collections of locally excavated antiquities. Other options, such as long-term loans, are possible and indeed have been generously offered by Italy to those museums that have returned looted Italian artifacts.

If one is looking for a good whodunit that deals with prominent and colorful personalities such as the current secretary-general of Egypt's Supreme Council of Antiquities, Zahi Hawass (who has called for nothing less than the return of the bust of Nefertiti from Berlin and the Rosetta Stone from London), then *Loot* is the book to read. In fact, a more apt title for Waxman's book might be *Looters*, because they, rather than the loot itself, dominate her text.

Cuno is a museum director whose writ is clearly to defend the acquisition practices of the major western museums in light of increasing pressure to refrain from purchasing objects of dubious or no provenance. The public might be better served by less atavistic museum professionals, ones who could address our changing times and evolving ethical standards and offer creative solutions for the enjoyment of our collective past.

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PHYSICS

QCD with a Light Touch

Alex R. Dzierba

THE LIGHTNESS OF BEING: Mass, Ether, and the Unification of Forces. Frank Wilczek. xii + 270 pp. Basic Books, 2008. $26.95.

On September 10 of last year, physicists at CERN (the European Organization for Nuclear Research in Geneva) for the very first time steered protons around the Large Hadron Collider (LHC), a truly gargantuan subatomic microscope with equally grand and ambitious physics goals. The LHC (now undergoing repairs) is the world's most powerful particle accelerator. It includes more than 1,600 superconducting magnets, used to bend and focus protons into a circular path, and 16 radiofrequency cavities, used to accelerate those protons. All this is housed in a tunnel whose circumference is 27 kilometers (17 miles), which is buried at an average depth of 100 meters on the border between France and Switzerland. The LHC has two counter-circulating proton beams—each with the energy of 7 trillion electron volts—which will be brought together at several points along the LHC tunnel, where large detectors will observe the remnants of the resulting collisions.

One of those particle detectors, named ATLAS, has a volume of about 23,000 cubic meters, weighs 7,000 metric tons, cost about 540 million Swiss francs and was built by a collaboration of 2,500 physicists, engineers and students from 169 institutions in 37 countries. Each second, ATLAS will electronically sort through one billion collisions to select a few hundred potentially interesting events for further analysis. This process will generate about 3 petabytes (3 million gigabytes) of recorded data each year, which are to be analyzed by an international team of hundreds of physicists utilizing thousands of computers communicating through the World Wide Web.

The goal of ATLAS and the other LHC detectors is to provide data that will help answer some profound questions of physics. What is the origin of ordinary mass? Why are some elementary particles heavy, whereas others are light?

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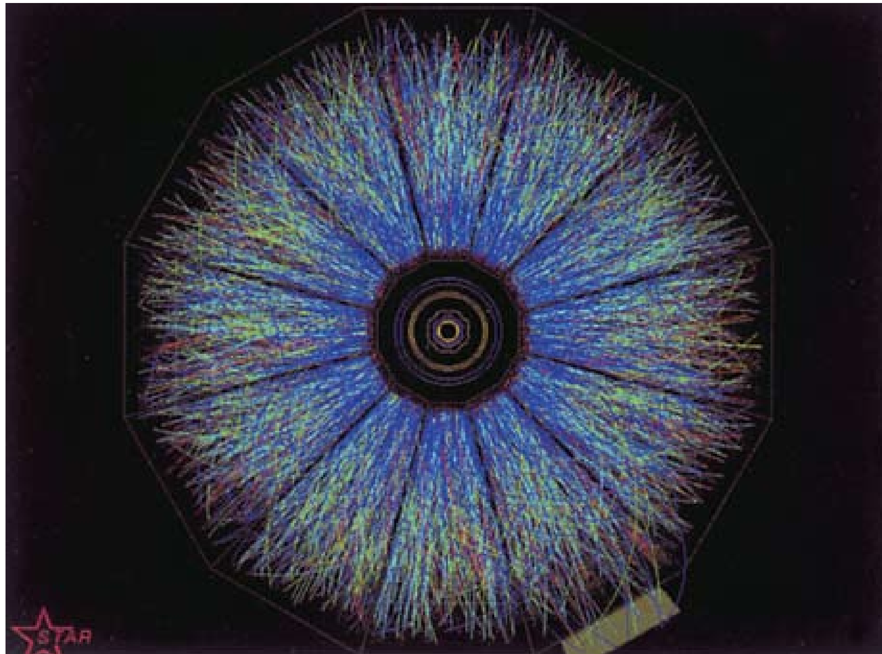

This image, which is based on the work of the STAR collaboration, shows the end result of a heavy ion collision: a miniature version of the big bang. From *The Lightness of Being.*

The answers will likely involve the Higgs mechanism, which predicts a new field, analogous to the electromagnetic field. This field should have at least one particle associated with it: the Higgs particle (which Peter Higgs postulated in 1964 and which Nobel laureate Leon Lederman famously dubbed the "God particle"). One goal of LHC experiments is to find the Higgs particle. Scientists are split on whether this is likely to happen, though. Higgs recently locked horns with Stephen Hawking, who has bet $100 that the Higgs won't be found.

Another goal of physics is to construct a theory that unifies all the fundamental forces, including gravity. If supersymmetric particles (massive relatives of the particles we now know about) are discovered at the LHC, this grand unification may be facilitated.

Astrophysical observations now indicate that all of the visible matter, or normal matter, accounts for only 4 to 5 percent of the mass in the universe. The 95 percent that is missing is thought to be in the form of dark matter or dark energy. LHC experiments will search for new particles or phenomena that could be responsible for this missing matter and energy.

This is all heavy stuff. A new book by Frank Wilczek, *The Lightness of Being,* does a superb job of introducing the reader to the aforementioned profound questions and to our current understanding of the nature of matter and the forces that govern the universe.

Wilczek played a critical role in developing the theory of quantum chromodynamics (QCD), which describes the strong interaction, a fundamental force of nature that acts to hold the nucleus together. For work he did as a 21-year-old graduate student, he shared the 2004 Nobel Prize in Physics with his Ph.D. mentor, David Gross (a professor at the University of California, Santa Barbara, and director of the Kavli Institute of Theoretical Physics), and with David Politzer (a professor at the California Institute of Technology).

The Nobel Foundation Web site (http://nobelprize.org) offers much background information on Wilczek, his prize-winning colleagues and their work, along with a video of an interview of Wilczek and Gross by Joanna Rose, a science writer. The two men share with Rose their thoughts about their theoretical discovery, the experimental work confirming it, and the importance of asking the right questions. What makes this video so delightful is the "lightness of being"—playfulness, even—that Wilczek and Gross exhibit in describing their work.

Wilczek also displays a "lightness of touch" in this book, as Frank Close notes in a blurb on the dust jacket. Wilczek takes a historical approach, beginning with what he characterizes as the "beta release" of the quark model, which Murray Gell-Mann and George Zweig postulated independently in 1964, bringing into some order the dozens of hadrons that had been discovered by that point.

Hadrons are particles made up of quarks and gluons. The subclasses of hadrons are baryons (a family that includes the proton and the neutron) and mesons. Baryons are made of three quarks, whereas mesons consist of a quark and an antiquark. The quark model did for hadrons what the atomic theory of electrons and nuclei did for the myriad of atoms in the periodic table.

In the 1970s, quantum chromodynamics took shape. QCD is modeled somewhat after the theory of quantum electrodynamics (QED), which brings together electrodynamics, quantum mechanics and special relativity in describing the interaction of electrically charged particles. However, there are important differences between QED and QCD. The force between electrically charged particles falls off with the square of the distance between them. That's why we can pull an electron away from its host atom. But the same is not true of quarks. If you try to remove a quark from its hadronic host, the force between that quark and its partners does not decrease, so infinite energy would be required to pull it away. Free electrons exist, but quarks cannot be isolated.

To account for this experimental fact, QCD contains the principle of confinement: When quarks are very close to one another, they move about freely, not feeling one another's influence. This feature of QCD is called *asymptotic freedom.*

QED describes the opposite sort of behavior. The underlying reason that the force from an electrically charged particle decreases with distance is the temporary existence of the many electron-positron pairs that spontaneously pop out of the vacuum. These pairs serve to screen the electric charge of the particle, which thus exerts a large force on a second charged particle only when it is positioned close by. The first particle becomes increasingly ineffectual when the second one is located far away.

In QCD, instead of screening there is an antiscreening, not of electrical charge, but of its analog, the color charge—which is in no way related to what we normally think of as color. The color charge is responsible for the strong force between quarks and gluons. Wilczek tells the story of how he and David Gross discovered this feature of QCD in 1973.

Wilczek also gives an account of the

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Nobel-prize experiments, the interpretation of which led him and Gross to their discovery. As Wilczek describes the "ultrastrobonanomicroworld" (his word!) of quarks and gluons inside the proton, he notes that

> Our eyes were not designed (ahem, did not evolve) to resolve such small distances and times, so any visual representation [of this world] must be a mixture of caricature, metaphor, and cheat.

It is writing like this, and there are many other examples, that makes this book so much fun to read.

Wilczek tackles such grand issues as the role of symmetry in physics, the nature of the vacuum, the origin of mass, grand unification, supersymmetry, dark matter and dark energy. His touch is indeed light: There are only a few equations. However, not every chapter is an easy read; some may have to be revisited a few times. The book also includes a very useful glossary, 16 pages of endnotes and three brief appendices.

The Lightness of Being is a wonderful program guide to what we can expect from the LHC in the coming years. Stay tuned.

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BIOGEOGRAPHY

The Sun Yet Warms His Native Ground

Rob Dunn

LOST LAND OF THE DODO: An Ecological History of Mauritius, Réunion, and Rodrigues. Anthony Cheke and Julian Hume. 464 pp. Yale University Press, 2008. $55.

Oceanic island chains built by volcanic activity are initially lifeless—dark spots on a lighter sea. But no matter how remote their location, eventually they are colonized. A bird flies in, bringing seeds in its gut or caught in its feathers. Other seeds arrive borne by wind or water. A lizard floats in on driftwood. A seal hauls itself onto the shore. Forests emerge and the islands slowly change color from gray-black to green.

On hundreds of islands, landscapes of rock have come to life in this fashion. The particular trajectories of the biota on any island depend on which species arrived first. In each set of islands, different lineages prosper. The radiation of species is happenstance, following Darwin's rules, with an infinite variety of possible ends.

When humans arrive on islands, new trajectories ensue (most of them unfortunate). Easter Island was once a subtropical island forested with a variety of tree species, including many palms. When humans first discovered the island remains a subject of debate, with estimates ranging from A.D. 300 to 1200 Yet by the time Europeans arrived in 1722, many of the island's native species, including nearly all the trees, were apparently extinct. Visitors now find a land of grassy hillsides punctuated by the island's famous stone heads.

The Galápagos Islands were not discovered until the 16th century. Early visitors included whalers and hunters, who diminished the populations of seals and tortoises but left much of the island life largely unaffected. When Darwin arrived in 1835, the islands were still home to nearly the full variety of endemic species that would have been seen thousands of years earlier. It was in these species that Darwin would, some years later, discern the mechanics of natural selection. In the beaks of finches and mockingbirds, he found the evolutionary consequences of competition for scarce resources. Today, along with salt-spitting marine iguanas and near-tame sea lions, one can still find 29 species of birds (22 of them endemic to the Galápagos), including flightless anhingas and wild hawks unafraid to alight on a visitor's head. The future of this wonderland is tenuous; invasive species have wreaked havoc on some of the islands, and humans (particularly those engaged in commercial fishing) have done additional damage. And yet the Galápagos remain the best living evidence of the sort of flowering of life that occurs on volcanic islands.

These contrasting stories raise the question of why we have been left so few islands where a great deal of diversity has been preserved, as it has on the Galápagos, and so many islands where diversity has largely been lost, as on Easter Island. However, Easter Island is perhaps not the best place to find the answer to that question. Much of what has

This painting by Julian Hume depicts both a female *(left)* and a male raven parrot *(Lophopsittacus mauritianus*, one of the world's largest parrot species, now extinct) at the base of a tree, extracting seeds from a *Sideroxylon* fruit. Alongside them is a smaller species, the echo parakeet *(Psittacula eques)*, which is the only surviving Mascarene parrot. From *Lost Land of the Dodo*.

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