

to liberty. Though his projected magnum opus on the history of liberty never saw the light of day, the ideas he expressed in his many essays, reviews, and lectures, as well as his notes and letters, continue to fascinate students of politics and history.

Acton's archival research and enormous historical reading forced him to conclude "that Catholics had committed many great evils for the sake of what they considered the higher interests of the church," notes Zagorin—evils that included the religious murders of the Inquisition and other authorized agencies of persecution. "Catholic historians and controversialists, moreover, had repeatedly distorted, concealed, and falsified the truth for pious reasons."

History persuaded Acton to strongly oppose the doctrine of papal infallibility entertained by the Vatican in the mid-19th century. "A man is not honest who accepts all Papal decisions in questions of morality, for they have often been distinctly immoral," he stated. The Vatican Council of 1870 nevertheless adopted the dogma. To avoid excommunication, Acton made some equivocal statements about the doctrine. But he came away convinced that Catholic churchmen and apologists of his day "were all too often

willing to disregard morality and to falsify or ignore the truth," Zagorin says, and this only fortified Acton's conviction that a historian must render moral judgments.

In the past, historians had to be sympathetic and impartial, Acton believed. Each age, he wrote, was "worthy of study [and] to be understood for its own sake, for the way in which it has met its problems, and its share in the suffering of mankind—not as a stepping stone to the present." At the same time, however, Zagorin says, Acton held that moral principles, based on the permanent, generally acknowledged standard of the sanctity of life, were everywhere and always the same. Murder, as the worst crime, provided what Acton called "our basis for measurement." Thus, after subjecting historical evidence and testimony to rigorous cross-examination, Zagorin says, "the conscientious historian" had the duty to make a moral judgment, one that "belongs to the domain of objective facts and becomes a part of historical science."

Most historians, in contrast, have not deemed it "proper as a rule" to make moral judgments, Zagorin says. Unlike Lord Acton, they believe "that they possess neither the power nor authority to speak as the voice of History and pronounce its verdict for all time."

SCIENCE, TECHNOLOGY & ENVIRONMENT

30,000 Tons beneath the Sea

"Burial of Radioactive Waste under the Seabed" by Charles D. Hollister and Steven Nadis, in *Scientific American* (Jan. 1998), 415 Madison Ave., New York, N.Y. 10017-1111.

When it comes to the disposal of nuclear waste, many Americans seem to prefer to bury their heads in the sand. A repository has been under development at Yucca Mountain, Nevada, for more than a decade, at least in theory, but no construction has begun and state officials and residents remain adamantly opposed to the facility. It may never open for use. Yet more than 30,000 metric tons of high-level radioactive waste now lie in temporary storage at U.S. nuclear power plants, and every year brings another 2,000 metric tons. Add to that at least 50 metric tons of excess plutonium, and hundreds of tons of highly



To gather data on conditions deep below the sea floor, European researchers have used devices such as these torpedo-shaped "free fall penetrators," laden with instruments.

enriched uranium taken from dismantled nuclear weapons.

Hollister, a vice president of the Woods Hole Oceanographic Institution, in Massachusetts, and Nadis, a science writer, have a different solution to the problem of radioactive waste: bury it beneath the ocean floor.

Marine scientists have identified broad zones of suboceanic terrain in the Atlantic and Pacific that have remained geologically inert for tens of millions of years in the dark and frigid depths. Three or so miles below the surface, note the authors, lie vast mudflats, with a clay-rich blanket, hundreds of meters thick, above the underlying rocky crust. Present evidence, they say, “suggests that mobile, multicellular life-forms inhabit only the top meter or so of the abyssal clays,” and that below that there are no organisms capable of transporting radioactive substances up to the sea floor. Employing technology that has been in use in the petroleum industry for decades, canisters of radioactive waste could be lowered into cylindrical shafts drilled hundreds of

meters deep in the thick sediment, well below the ocean floor.

The canisters themselves would last only a few thousand years at most, but “the muddy clays, which cling tenaciously to plutonium and many other radioactive elements, would prevent these substances from seeping into the waters above,” the authors say. Scientists have concluded from experiments that plutonium would not migrate from a breached canister more than a few meters, even after 100,000 years. Burial of the radioactive waste in the sediments “would most likely buy enough time for the radioactivity of all the waste either to decay or to dissipate to levels below those found naturally in seawater.”

Yes, more research is needed, but there has never been a serious challenge to sub-seabed disposal on technical or scientific grounds, Hollister and Nadis say. Persuading the public is another matter, of course, but sub-seabed burial, the authors observe, has at least this advantage: it won’t produce “not in my backyard” (NIMBY) opposition.

Wet Planets

“Surfing the Solar System” by Michael Milstein, in *Air & Space* (Dec. 1997–Jan. 1998), 370
L’Enfant Promenade S.W., 10th Fl., Washington, D.C. 20024.

Plain old water has long been regarded as one of Planet Earth’s distinctive possessions. But as astronomers in recent years have taken a closer look at the rest of the solar system and beyond, free-lance writer Milstein reports, “they are arriving at the conclusion that Earth is really not that special after all. Water . . . turns up almost everywhere.” [Including the moon, scientists announced in March.] Most of the extraterrestrial H₂O is in the form of ice, but—it increasingly seems—not all of it.

The sun long ago burned off most of the water and ice from the inner planets nearest to it, and most of the solar system’s water now “resides in the frigid outposts beyond the asteroid belt” that separates Mars and Jupiter, Milstein writes. “The gas giants of the outer solar system—Jupiter, Saturn, Uranus, and Neptune—are still loaded with the stuff, although under such astounding pressures and mixed with such a noxious stew of other compounds that it’s a stretch to think of it as water.”

However, Europa, one of Jupiter’s moons, may be a different story. Photographs taken by the Galileo spacecraft “show cracked ice plates that almost surely have slid apart,” indicating, Milstein says, that the visible surface “is probably no more than a frozen shell floating atop a massive global sea.” Tidal heating—generated by Jupiter’s gravitational pull, first strong as the moon nears the planet, then loosened as it moves away—could explain why the water doesn’t freeze. “Other moons, too, show external signs of liquid interiors,” Milstein adds.

Although Mars, which may once have had oceans as huge as Earth’s, probably “still has pockets of groundwater beneath its arid surface,” notes Milstein, Europa may offer what planetary geologist Jeffrey Kargel of the U.S. Geological Survey calls “the best chance that we have” to find an ocean resembling those on Earth. For that reason, the author says, more and more researchers are coming to believe that “Europa is more likely than Mars to hold signs of primitive life.”