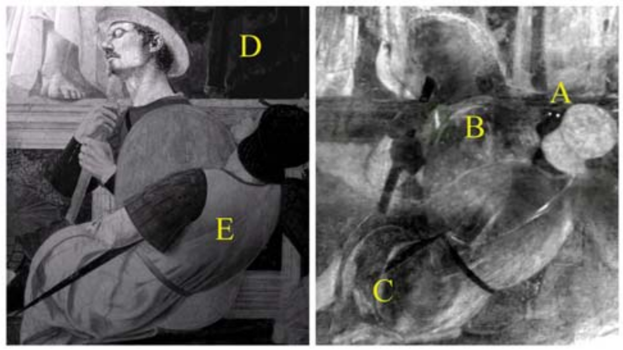
together as mini-Neptunes, and stellar irradiation preferentially eroded the lighter one's gas envelope. (J. A. Carter et al., *Science*, in press.) —BMS

A new imaging technique for analyzing art. Optical methods present powerful, noninvasive tools for artwork diagnostics, a central part of art conservation and forensics. For instance, interferometry with visible laser light can detect structural defects and changes over time, due perhaps to variations in ambient conditions. Near-IR radiation can penetrate beneath the surface of a painting, so reflectance imagery—also called reflectography—in that wavelength range can uncover such details as preparatory drawings and changes made by the artist. And thermography—imaging the thermal radiation emitted from the surface in the mid and far-IR—can detect variations in temperature and emissivity due to the presence of heterogeneous materials or subsurface defects.



At the other end of the spectrum, x rays are increasingly finding use in art forensics (see PHYSICS TODAY, January 2012, page 58). Claudia Daffara, Daio Ambrosini, Luca Pezzati, and Domenica Poletti have now demonstrated another technique for the conservator's toolkit. Termed thermal quasi-reflectography (TQR), the method maps the MIR radiation reflected by an object. The team worked in the 3- to 5-μm MIR band because room-temperature objects emit significantly less blackbody radiation at those wavelengths than in the FIR, so the background noise is reduced. For their light source, the researchers used halogen lamps that were underpowered so as to shift their spectra toward the MIR. The team showed that the reflected radiation is sensitive to surface composition and enables differentiation of surface materials. In this detail of Piero della Francesca's *The Resurrection*, for example, the letters label regions where the TQR image on the right reveals subtle features—including pigment variations, retouches, and differing execution techniques—that aren't seen in the NIR image on the left. (C. Daffara et al., *Opt. Express* **20**, 14746, 2011.) —RJF

Concentration gradients promote antibiotic resistance. To become resistant to an antibiotic a bacterium must end up with several favorable mutations. Acquiring them all is tough. If the drug concentration is too high, intermediate mutants won't have enough competitive advantage to survive the drug. If the drug concentration is too low, the mutants will be overwhelmed by the much larger wild-type population before they can acquire the next mutation. Yet *Mycobacterium tuberculosis*, *Neisseria gonorrhoeae*, and other pathogenic bacteria continue to defy antibiotics. How? Rutger Hermsen, Barrett Deris, and Terence Hwa of the University of California, San Diego (UCSD), have proposed an answer. Their approach embodies two basic and plausible ideas: First, drug concentrations vary within a host; second, bacteria can move back and forth between zones of different concentration. Conceivably, bacteria, having acquired one favorable mutation in a zone of low concentration, could establish colonies in a zone of slightly higher concentration, where they could subsist—unlike their more numerous unmutated cousins. The mutants could go on to proliferate in the new zone without competition. If repeated, the process of range expansion and selection could engender full resistance. To assess that possibility, the UCSD team built a stochastic model in which the gradual acquisition of resistance depends on how readily each generation of bacteria mutates (favorably or unfavorably), proliferates, dies, or migrates to a new zone. Assigning plausible probabilities to those processes, the researchers found that their simulated bacteria did indeed acquire resistance—and rapidly. Their next step is to test the model in a microfluidic experiment. (R. Hermsen, J. B. Deris, T. Hwa, *Proc. Natl. Acad. Sci. USA* **109**, 10775, 2012.) —CD

Plutonium-239 yields to nuclear magnetic resonance. An appropriately tuned RF wave will excite a nucleus whose energy levels have been split by an externally applied magnetic field; that's the basis for nuclear magnetic resonance (NMR). The precise excitation frequency gives information about the nucleus's local magnetic environment, which perturbs the field experienced by the nucleus. For more than 50 years, ^{239}Pu stymied efforts to probe it with NMR, but Hiroshi Yasuoka and colleagues at the Japan Atomic Energy Agency and Los Alamos National Laboratory have now coaxed a signal from the iconic nucleus. The group had to overcome two principal difficulties. First, the hyperfine interaction between electron and nuclear spins is unusually strong in ^{239}Pu, which means the NMR signal decays extremely quickly. Second, the gyromagnetic ratio γ of ^{239}Pu, which relates external field and resonance frequency, was poorly known; the Yasuoka team had only a rough idea where to look for the resonance. The first problem was solved by preparing the oxide PuO_2 (see the figure) and maintaining it at 4 K to force the Pu^{4+} ions into their electronic ground state. That state is nonmagnetic, so there's no hyperfine interaction. The second problem was solved by care and patience; the group set a specific radio frequency and swept the magnetic field from 3 to 8 tesla. Once they found the resonance, experimental refinements yielded a precise value for γ. The group also observed two distinct signals for a sample in which the ^{239}Pu exists in two oxidation states. That environmental sensitivity, say Yasuoka and company, could be particularly useful for understanding the consequences of long-term ^{239}Pu storage. (H. Yasuoka et al., *Science* **336**, 901, 2012.) —SKB