GRACE KIM PUTTING MICROBES TO WORK: USING BIOTECHNOLOGY TO RESTORE ARCHITECTURE & ART IN ITALY

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Whether it is the yellowed varnish on a painting or the soft sheen on leather that appears after extended use, patina has long been credited—sometimes, controversially so—as a faithful sign of an object's history. In 1681, for instance, Florentine art historian Filippo Baldinucci compared patina to the harmonious and rich *pelle*, or skin, that develops on well-aged paintings.[1] In 2015, during anthropological fieldwork with Italian scientists in Milan, I heard people speak of patina in a different register—using the term "green patina" to describe the skin on cultures within Petri dishes. The Petri dishes in the laboratory where I conducted my fieldwork contained cultures of microorganisms that had been sampled from peeling frescoes, darkening marble statues, and disintegrating architectural facades. Scientists now study how these microbes, such as bacteria and fungi, thrive on and deteriorate what they consider to be the irreplaceable artifacts of Italy's history. In contrast to the cold verdigris of copper and bronze antiques, what these scientists call "green patina" signifies the vibrant layers of microbial communities that inhabit cultural heritage.

But there is a twist. Although conservators and scientists alike have commonly viewed microbes as destructive entities, many also argue that microbes—or, better, particular kinds of microbes—can be used to *repair* objects of cultural heritage—a process they call "biorestoration." If bacteria can promote gut health and help us to make wine, scientists contend, these organisms might also be harnessed to benefit objects of cultural heritage by intervening against their degradation. In redirecting the metabolic activities of these tiny creatures away from heritage's deterioration and toward the service of its restoration, microbiologists are redefining microbes as valuable workers and the surfaces of architecture and art as suitable workspaces for microbes.[2] In turn, the definition of patina is shifting to describe a product of "multispecies" work, a swarm of activity by humans *and* nonhumans.

1 Filippo Baldinucci, *Vocabolario Toscano dell'Arte del Disegno* (Florence: Accademici della Crusca, 1681), 119.

2 See Francesca Cappitelli, Lucia Toniolo, Antonio Sansonetti, Davide Gulotta, Giancarlo Ranalli, Elisabetta Zanardini, and Claudia Sorlini, "Advantages of Using Microbial Technology over Traditional Chemical Technology in Removal of Black Crusts from Stone Surfaces of Historical Monuments," *Applied and Environmental Microbiology* 73 (2007): 5671-75.

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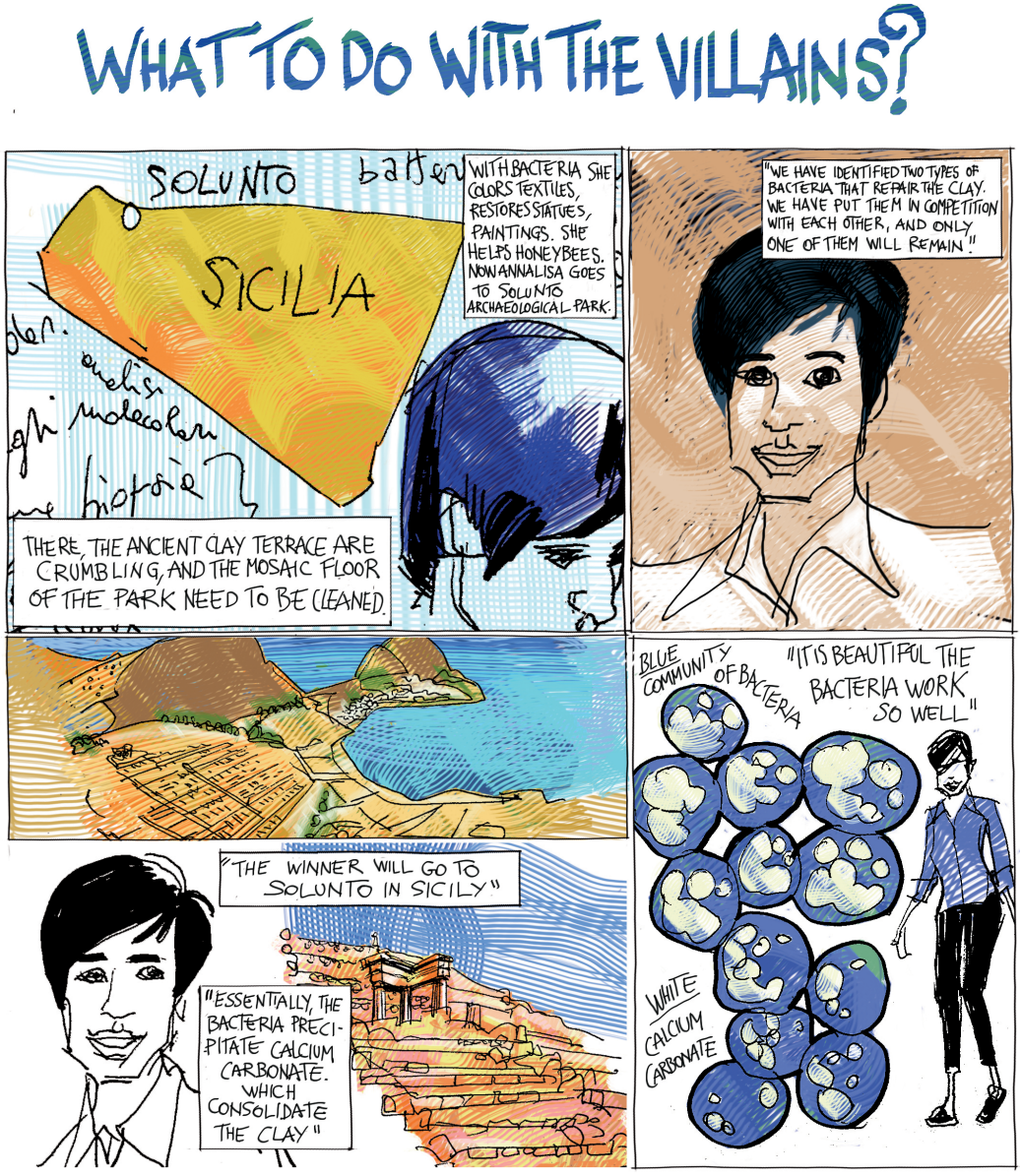

Fig. 1: Cartoon by Giancarlo Caligaris, 2015. Permission obtained from Giancarlo Caligaris.

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SPRAYING SOLUNTO'S RUINS WITH "OUR" BACTERIA

The ruins of Solunto, an ancient Phoenician settlement on the northern coast of Sicily, are fragile. Francesca Cappitelli, professor of microbiology at the University of Milan (UNIMI), tells me that Solunto's caretakers have reached out to her about using bacteria to reinforce what remains of its terrace walls. It turns out that a species of the *Bacillus* bacterium can be made to precipitate calcium carbonate and consolidate the crumbling clay. We are sitting in her office at the Department of Food, Environmental and Nutritional Sciences, and from across her desk, Cappitelli explains to me that the *terra cruda*, or "raw earth," out of which Solunto was made has rendered its ruins particularly vulnerable to water. As a result, she and her team will attempt to spray the bacteria directly onto the surface, rather than leave the architecture exposed to wet poultices, which are usually applied for hours at a time. I worry for the ruins after learning that a few days before my arrival thunderstorms wreaked minor havoc in southern Italy, bringing strong winds that tore trees from the ground and heavy rainfall that caused mudslides. However, as we drive up the side of Monte Catalfano toward Solunto—today an archaeological park that sits above the fishing town of Porticello—the autumn morning sky is clear and bright, and prickly pear cacti dot the landscape with their plump, fuchsia-colored fruit.

At the park's entrance, as the rest of us admire the panoramic view of the sea, Annalisa Balloi kneels down on the gravel and opens a plastic bottle full of an opaque, straw-colored liquid. She pours some of this nutrient-packed broth into a small test tube, which she then shakes vigorously to revitalize the small pellet of spores waiting inside. Balloi is co-founder and CEO of Micro4yoU, a startup that aims to develop green technologies by finding the right "microbe for your needs."[3] A University of Milan spin-off company, Micro4yoU often collaborates with Cappitelli's laboratory, and Balloi has traveled to Sicily to initiate the biorestoration project at Solunto. While working down the hall from Cappitelli as a PhD student and later as a post-doctoral fellow, Balloi perceived a growing need for commercial products that pair microbes with problems in environmental remediation. According to her, microbes—as objects of "nature" themselves—were the "natural" solutions to such issues. In addition to developing microbes for the restoration of cultural heritage, for instance, Micro4yoU investigates different mixtures of symbiotic bacteria that may help the honeybee's immune system to fight against American foulbrood, a widespread bacterial disease that targets bee larvae. In Solunto, I watch Balloi hold up her tube of high-tech nature to the hot sun, and I wonder at its unexpected relevance among archaeological remnants that date back to the eighth century BC.

Back in Milan, about a week prior, Balloi told me that an illustrator, Giancarlo Caligaris, had begun a cartoon about Solunto, her research, and her hope that her bacteria will change the relationship between humans and the environment. (Fig. 1) In the cartoon, Caligaris tracks Balloi's past work on compost in landfills and how bacteria respond to environmental stresses. Aiming to change the common view that all microbes are pathogenic, the

3 Micro4yoU, accessed January 3, 2016, http://www.micro4you.eu/.

cartoon echoes Cappitelli and Balloi's belief that "villains" can also be made to do good. Indeed, Caligaris explains, Balloi even aspires to use bacteria to produce paper—a feat that she dreams would save trees from being cut down. When Balloi spins her laptop around to show me the preliminary drawings, she points excitedly to one of the panels on the screen: "Look," she says. "The blue of the bacteria matches the blue of my blouse!" In this image, Caligaris had juxtaposed Balloi's scientific figure with microbes, and Balloi had fixed not on the juxtaposition as such, but rather on his use of color to draw out the likeness between them: they both work to restore Solunto.

A different panel stood out to me over the others: an illustration of Italy filled in not only with the colors of its flag but also the round and blue bodies of the bacteria with which Balloi sensed such affinity. The "bacteria-masons" that work on cultural heritage, it appears, gain integrity not only by repairing damage to objects of value but also by briefly assuming a *national* character—"our Italians," as Balloi jokingly calls them. And this prompts a question: through which practices do these microbes become *i nostri*, or "ours," and achieve their beneficent—and even Italian—qualities? In this case, I observe that treating the bacteria as part of the national landscape is central to how the bacteria are made to work. When in other contexts microbes are not nationalized but are generalized as "workhorses" whose "nature [is] to dumbly labor," it is worth noting the steps by which a bacterium is made to appear patriotic.[4]

The climb to the test site in Solunto is steep, and there are no other visitors at the park. Balloi and I slowly follow a group of local scientists and park employees to a set of three terrace walls, which are protected by miniature glass pavilions that slope down toward the Tyrrhenian Sea. (Fig. 2-3) Balloi chooses one of the walls to use for the experiment, and we gather around to observe her unwrap and assemble the laboratory apparatuses and solutions that she has brought from Milan.

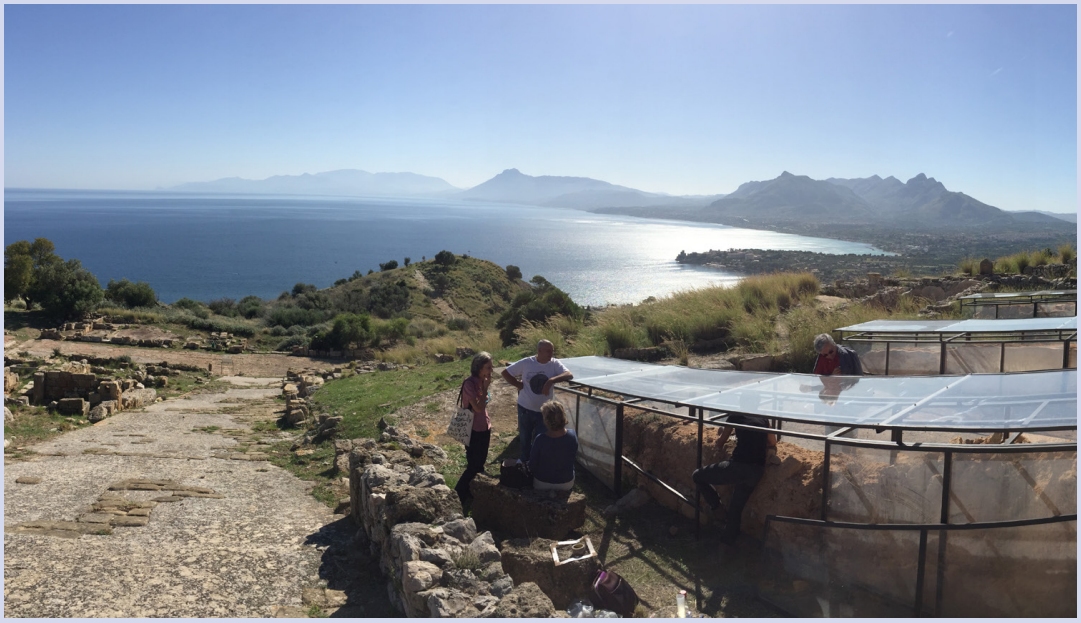

Fig. 2: View of Solunto. Photograph by author.

4 Stefan Helmreich, *Alien Ocean: Anthropological Voyages in Microbial Seas* (Berkeley: University of California Press, 2009), 126.

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On an area of approximately one square foot, Balloi will apply the test treatment, a mixture of calcite-precipitating bacteria and additional medium; on another, Balloi will apply the control treatment, which consists of the medium only. After she begins the applications, however, the initial wave of curiosity among her audience passes quickly. There is not much to see. Crouched in between the *terra cruda* and its glass roof, Balloi seems sheltered from the growing chatter above her. She "sprays" the bacteria out of a plastic squeeze bottle and feels around the moistened surface with the tips of her fingers. I imagine the activity that holds her focus: rod-shaped microbes consuming the free calcium ions in the medium to produce sheets of calcite, a stable polymorph of calcium carbonate, that fill in the miniscule pockets that endanger this ancient artifact's life.

In a sense, spraying Solunto was also a ritual of return, for the bacteria in Balloi's hands were sourced from the very *terra cruda* they would repair. Though calcite-precipitating *Bacillus* can be found on the market, Cappitelli tells me that using "indigenous" bacteria is crucial for this biorestoration project. "They are already accustomed to the environment," she says. In other words, the bacteria were likely to thrive and produce calcite under the particular environmental conditions present in the *terra cruda* of Solunto Archaeological Park because they already did so. From an ecological perspective, introducing a foreign bacterium runs the risk of disturbing the natural equilibrium of the local system and invites unforeseeable consequences: the bacterium may fail to grow and produce calcite, or worse, it may cause further deterioration. Thus, seven months before, the scientists of Micro4yoU obtained microorganisms from Solunto and, after identifying over fifty different species, they settled on the one that produced calcite most efficiently. Growing further cultures from this sample, they artificially produced *terra cruda* in test tubes and verified the bacterium's ability to consolidate other stones. Now, the scientists have moved out from the laboratory setting to test their agents in the field.

Remarkably, the bacterium's origin in the substance of Solunto itself makes the bacterium the right tool for Solunto's restoration. Conversely, the Hellenistic-Roman forms that have survived there are made to owe their continuing endurance to the life forms that have resided within them long after their human inhabitants left. Cappitelli is often asked to identify whether or not microorganisms are at the root of cultural heritage's deterioration and helps conservators to decide whether or not to apply biocides. In this case, however, the hope that the scientists' bacteria would work in Solunto because they *already* work in Solunto—and better yet, because they work without damaging Solunto—assumes a logic of belonging that brings together Italian scientists, Italian cultural heritage, and Italian bacteria in both material and symbolic production.

PATINA AS MULTISPECIES WORK

Microbes can work not only on ancient architecture but also on more recent, even modern, art. (Fig. 4) A few years ago, Cappitelli's laboratory and Micro4yoU collaborated to restore a marble statue in the Monumental Cemetery of Milan. Set against the skyscrapers of the city's business district, this cemetery, which

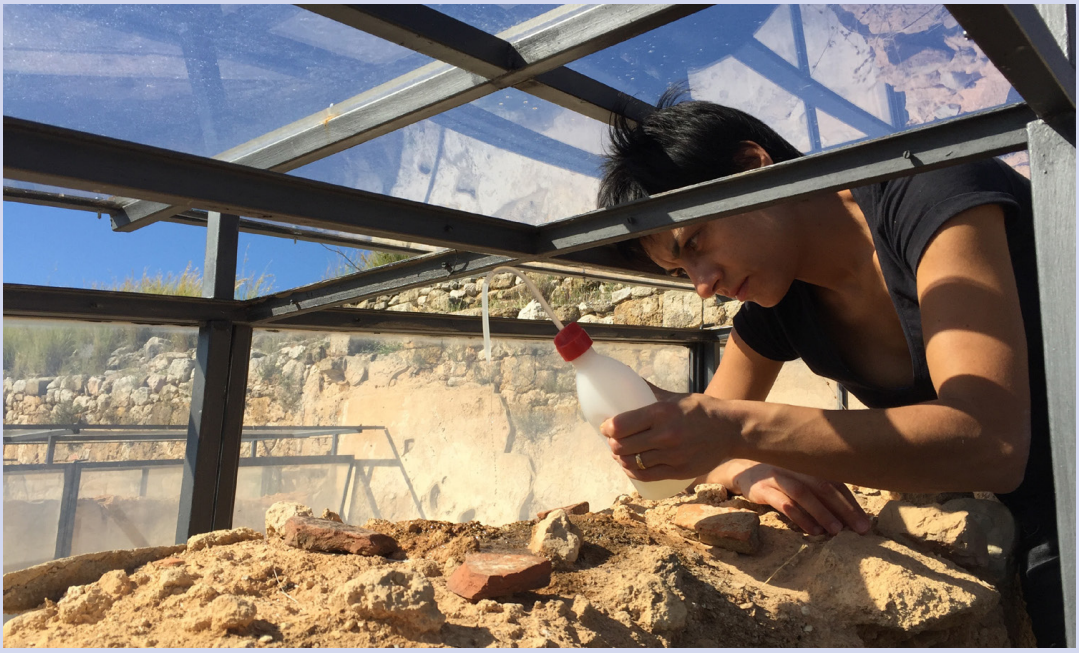

Fig. 3: Balloi applying microbes to *terra cruda* in Solunto. Photograph by author.

is also called an "open air museum," has amassed a diverse collection of tombs and monuments since its opening in 1866. It represents an overwhelming mix of movements and styles, including structures based on the designs of Egyptian pyramids, Greek temples, and Trajan's Column as well as endless variations of Christian iconography. Among works made to honor national figures, such as entrepreneur Antonio Bernocchi, novelist Alessandro Manzoni, poet Filippo Tommaso Marinetti, and conductor Arturo Toscanini, sits sculptor Lina Arpesani's 1921 funerary monument *Neera*. Named after the pseudonym of Milanese writer Anna Zuccari, this statue towers just over seven feet and features a nude female figure balancing a large, open book above her head. Unlike Solunto's remains, this sculpture did not present any "structural damage" but instead had acquired grey and black layers on its surface. In response, the microbiologists used bacteria to remove—rather than produce—substances and reveal the "original sound marble" underneath.[5]

The discoloration, the scientists found, was largely due to the inorganic and organic compounds in Milan's polluted, urban air. These compounds had been deposited onto the statue's surface to create a comprehensive grey film. On some areas of *Neera*, however, smog particles were further trapped in a matrix of gypsum that had been formed when the marble reacted with sulfur dioxide in the atmosphere. This sulphate-based "black crust" is thick, dense, and difficult to clean. Moreover, it can be seen not only on the stone monuments throughout the Monumental Cemetery but also on the various stone surfaces that make up the city beyond it. Since WWII, Milan has become one of Europe's leading industrial and economic centers as well as one of its most polluted cities. The European Environment Agency recently reported that Italy had the highest number of premature deaths attributable

5 Federica Troiano, Davide Gulotta, Annalisa Balloi, Andrea Polo, Lucia Toniolo, and Emanuela Lombardi, "Successful combination of chemical and biological treatments for the cleaning of stone artworks," *International Biodeterioration & Biodegradation* 85 (2013): 294-304.

to air pollution in 2012.[6] To combat the high levels of smog, Milan's officials have most recently responded, for instance, by issuing a three-day ban on driving cars, motorcycles, and scooters in the daytime.[7] Alongside growing concerns for the health

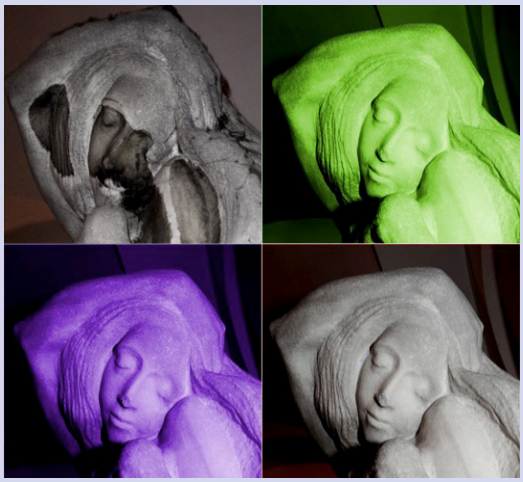

Fig. 4: Rendering of Neera pre-treatment (upper left) and post-treatment (lower right) in the style of Andy Warhol. Permission obtained from Annalisa Balloi and Emanuela Lombardi.

of Milan's residents, however, scientists have also rallied around a fight against the effects of poor air quality on the health of the city's cultural heritage.

According to microbiologists such as Cappitelli and Balloi, conservators conventionally employ harsh mechanical and chemical methods to eliminate black crust from stone monuments. Alternatively, they argue, a microbiological approach offers a more precise way of cleaning. *Desulfovibrio*, the bacterium that Cappitelli and her team applied to *Neera*, uses sulphate as a source of energy. According to the scientists, this bacterium can therefore eat away the sulphate-based black crust "without affecting the stone surface."[8] In this view, the bacterium removes unattractive residue while preserving the marble that forms the artwork. This "selectivity," the scientists claim, makes biotechnology the superior alternative to existing restoration techniques because it relies on the microbe's natural ability to discriminate between materials—namely, between the materials that constitute art and those that devalue it.

Remarkably, however, the final steps of the protocol ensure that the bacteria themselves are removed from the marble. After each treatment, the scientists carefully wash away *Desulfovibrio* from *Neera's* surface with distilled water. Despite the bacterium's apparent selectivity for sulphate compounds, living cells must not be left behind. So, though they cleaned *Neera*, from the microbiologists' point of view, the bacteria remain foreign to the artwork and do not belong there. Unlike the microbes used to restore Solunto, these microbes needed to be shed from the ecological system to which they were introduced.

In light of these biotechnologies, architectural and artistic surfaces are becoming workspaces for microbes—workspaces that are at the same time painstakingly crafted by their science-minded counterparts. If physical and cultural constructions of patina—for instance, as a sign of an artwork's authenticity or of the social status of its owner—have long been conceptualized as exclusive to the domain of human activity, then microbiologists such as Cappitelli and Balloi are ushering in a new view on the production of patina that includes nonhuman lives.[9] These

6 European Environmental Agency, "Air Quality in Europe – 2015 Report," No 5 (Luxembourg: Publications Office of the European Union, 2015): 44.

7 "Pisapia: 'Misure maggiormente efficaci se condivise su area vasta,'" last updated December 24, 2015, accessed January 3, 2016. https://www.comune.milano.it/wps/portal/ist/it/news/primopiano/Tutte_notizie/sindaco/smog_misure_condivise_area_vasta.

8 Troiano et al., 295.

9 Grant McCracken, "'Ever Dearer in Our Thoughts': Patina and the Representation of Status before and after the Eighteenth Century," in *Culture and Consumption: New Approaches to the Symbolic Character*

efforts coincide with a line of thinking in contemporary anthropology that attends to a multispecies world—a world no longer focused solely on the political and social lives of people but also on the ways that they collide and blend with the likes of dogs, mushrooms, and even microbes.[10] Anthropologists who practice "multispecies ethnography" thus attempt to give voice to those species that have not yet had a chance to "speak."

In parallel, scientists today are revising the question of who matters in the maintenance of material culture as they enroll microbes in restoration practices. In remaking patina as a spring of microbial vitality, these scientists are transforming microbes into a source of both fear and hope for the future of cultural heritage. In one instant, microbes may appear as heritage's villains, and in the next, helpful—even patriotic—biotechnologies. The lens of microbiology also transforms objects of cultural heritage and the places within which they reside as particular kinds of workspaces. Although the geological substance of Solunto emerges as the generator of the microbe that can consolidate it, the atmospheric substance of Milan reformulates microbial consumption as a coordinated process of cleaning. As long as these facets are bound together by scientific theory and practice, interventions from microbiology render the restoration of architecture and art as multispecies work and the surfaces of architecture and art as multispecies workspaces.

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of Consumer Goods and Activities (Bloomington: Indiana University Press, 1988), 31-43; Randolph Starn, "Three Ages of 'Patina' in Painting," *Representations* 78 (2002): 86-115.

10 See Eben Kirksey, ed., *The Multispecies Salon* (Durham: Duke University Press, 2014).