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The Immeasurable Benefits of Plastics to Humanity

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It is popular these days for people to proclaim that they are giving up plastics. Just browse the Web and you will find all sorts of advice on how to live “plastics free,” including blogs,¹ books,² and online shops for alternative products.³ Legislation on Capitol Hill has even taken the name “The Break Free from Plastics Act,” as if consumers are imprisoned by a plastics-laden lifestyle and only heavy-handed government regulation can break us free from it.

While there may be good intentions behind these efforts—such as the desire to stop ocean pollution and adverse impacts on wildlife—they are unlikely to solve real problems. Moreover, two bills currently in Congress—the Break Free from Plastics Act (H.R. 2238, S. 984), sponsored by Rep. Alan Lowenthal (D-CA) and Sen. Jeff Merkley (D-OR),⁴ and the Climate Leadership and Environmental Action for our Nation’s Future (CLEAN) Act (H.R. 1512), sponsored by Rep. Frank Pallone (D-NJ)—go to such extremes that they could destroy the U.S. plastics industry.⁵ Individuals, of course, should be free to reduce their personal plastics use, but lawmakers need to take inventory of what is at stake before they pass legislation that will undermine—and potentially destroy—the entire U.S. plastics industry and all the jobs it supports.

This paper is the second in a series of four papers related to plastics. The first demonstrated that anti-plastic policies could jeopardize many environmental benefits associated with the use of plastics.⁶ This paper details the impact of plastics on human well-being and how proposals to curb their use could produce devastating results. The third paper will address real challenges to managing plastics waste—such as litter on land and in the ocean—and how we can resolve those problems without draconian government bans or regulations that would harm both humanity and nature. The final paper will directly address the provisions of the Break Free from Plastics Act and similar proposals, detailing why the legislation will do more harm than good.

What Is at Stake in a “Plastics-Free” World. Miranda Marcus, a plastics welding engineer with a company known as EWI, explains on Quora just a few of the many challenges and sacrifices people would have to make if we phased out all plastics. Automobiles would become much heavier, slower moving, and less fuel efficient and run on wooden or metal tires that would wear down roads and highways. Without silicon, gone would be compact computers and handheld devices, at least until perhaps “in a few decades” engineers could “figure out a work around.” In addition, we would see more deaths because medical procedures would become more expensive and diseases would

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spread more readily. Internet connections would become highly unreliable and basic infrastructure that keeps our utilities on would be more expensive, lower quality, and would eventually fail.⁷

Her examples highlight many benefits of plastics that people take for granted. In fact, the invention of plastics opened the door to once-unimaginable improvements to human well-being, making possible a vast array of life-saving, life-extending, and life-enhancing technologies, such as cell phones, pacemakers, sanitary food packaging, and much more.

Even the most basic plastic products can yield profound benefits. In Africa, for example, the introduction of a simple plastic bucket relieves substantial hardships for some of the world's poorest people. Stephen Fenichell in *Plastic: The Making of a Synthetic Century*, explains:

You cannot survive in the tropics without water; the shortages are always acute. And so water has to be carried long distances, frequently dozens of kilometers. Before the invention of the plastic bucket, water was carried in heavy vats made of clay or stone. The wheel—and vehicles that use it—was not a familiar aspect of African culture; everything was carried on the head including the heavy vats of water. In the division of household labor it was the woman's task to fetch water. A child would have been unable to lift a vat. Acute poverty meant that few households could afford more than one vat.

The appearance of plastic buckets was a miracle. To start with, it is relatively cheap (although in some households it is the only possession of value), costing around two dollars. And it is light. And it comes in different sizes: Even a small child can carry a few liters. Now it's the child's job to fetch water. Flocks of children playing and bantering on the way to a distant well are common. What a relief for the overworked African woman!⁸

Plastics Are Essential to Modern Medicine. The number of plastic products on which medical professionals rely is vast. Without them, medicine would be less advanced, more expensive, and less accessible to many people. Other materials, including various metals, also play a role, but plastics have become indispensable to medicine. Plastics' light weight and durable attributes make them particularly valuable for home health applications that rely on portable equipment.⁹

Specifically, plastics compose, or are part of, many vital medical products, including:

- Machinery such as magnetic resonance imaging scanners, mammography machines, and X-ray equipment;
- Devices used inside or connected to the human body such as pacemakers, stents, and prosthetic limbs; and
- Basic yet essential items like tubing, IVs, blood bags, gloves, masks, hospital gowns, catheters, and much more.

Plastics are also critical to many medical breakthroughs, such as 3-D printers that now make it possible for medical institutions to meet essential needs on demand, including the manufacture of custom prosthetics. In his book, *Plastics*, Norman Finkelstein highlights many other such inventions. He notes, for example, how blood-clotting plastic bandages quickly halt bleeding in an emergency. These are particularly valuable for soldiers because, in the past, “about 50 percent of those who died on the battlefield” would bleed to death in a matter of minutes. “Today, new blood-clotting plastic bandages save battlefield lives,” he notes.¹⁰ Finkelstein also highlights a product known as the Plasti-Bone that can replace and help regenerate bones lost to injury. It is a porous material through which the attached bone will grow and eat through, until a new natural bone takes the Plasti-Bone’s place.¹¹

Plastics also help make medicine more affordable and accessible to a larger share of the population by allowing for considerable cost savings. And plastics, thanks to their flexible nature, allow for innovation in product design and manufacturing. They can be easily and affordably molded into many complex instruments, devices, and components of medical equipment. As Bayer Materials Engineering Manager Mark Yeager explains in *Design News*:

Injection molding can economically produce millions of identical parts with complex geometries. For this reason, plastics have already displaced metal in a wide array of applications in which the high cost of metal fabrication is prohibitive.¹²

Yet, environmental activists continue to push for regulations and advocate the elimination of many medical-related plastic products. Worse, they routinely second-guess the expertise of medical professionals regarding the value of such products, claiming that plastics use is excessive, and they target single-use plastics in particular.

For example, just a few months before the world learned about COVID-19, activist Gary Cohen downplayed the value of sanitary single-use medical supplies. Cohen, the president of Green Practice Health, a left-of-center group designed to pressure medical facilities to reduce the use of plastics, once called the trend toward single-use devices an “overreaction” to the AIDS crisis.¹³

Patients whose lives are at risk from hospital-acquired infections might not consider it excessive to rely on some single-use sanitary products as part of their treatment. Hospitals are chock full of infectious agents because, after all, they are places where sick people congregate. “If you’re sick, then the hospital is often the last place you want to be,” notes reporter Jon Evans in *Plastics Engineering*. Disposable products are a critically important tool in reducing the spread of such infections.¹⁴

According to the U.S. Centers for Disease Control and Prevention (CDC): “On any given day, about one in 31 hospital patients has at least one healthcare-associated infection.”¹⁵ Similarly, the European Center for Disease Prevention and Control estimates that 25,000 people die annually in Europe as a result of hospital acquired infections, while 100,000 Americans die from such infections in the United States.¹⁶

The risks of hospital-acquired infections may also substantially contribute to deaths during pandemics because of higher admissions, overworked staff, and supply shortages. One research report published in April 2021 found a high number of intensive care unit-acquired infections among a large sample of critically ill COVID-19 patients in Italy. The authors noted:

The incidence of infectious complications was very high, with almost half of the patients experiencing at least one infectious episode during the ICU stay. Specifically, 14 days after ICU admission, the probability of having an infection was more than 40%.¹⁷

In addition, COVID itself became a hospital-acquired infection for patients admitted with other ailments. The scope of the problem in the United States is not clear because the CDC has not released data related to hospital-acquired COVID infections, and U.S. nursing facilities are not required to report such data.¹⁸ However, there are indicators that the problem is substantial. Medical researchers estimated in January 2021 that reports from several different hospitals, around the world and in the United States, indicated that “the hospital-acquired SARS-CoV-2 infection rate is 12–15%.”¹⁹ According to data from Britain’s National Health Service, as reported in *The Guardian*, 40,000 people contracted COVID in British hospitals during just the months between August 1, 2020 and February 21, 2021.²⁰

To make matters worse, several infectious agents transmitted in medical facilities and hospitals have grown resistant to antibiotics. For example, *Staphylococcus aureus* (MRSA), which is resistant to the antibiotic Meticillin, accounts for a significant share of hospital-acquired infections. The CDC reported in 2019 that there were 119,000 cases and nearly 20,000 MRSA-related deaths in 2017. The agency also reported that while infection rates had dropped between 2005 and 2017, the rate of decline has slowed, and hospital-acquired MRSA continues to be a problem in the United States.²¹

There are also growing problems with the fungus *Candida auris* spreading in hospitals around the country. Its death rate is one in three infected patients, but some outbreaks have produced mortality rates as high as 72 percent.²² The rise of *Candida auris* infections in hospitals presents a “catastrophic threat,” according to Anne Schuchat, a former deputy director of the CDC. And it is one of many germs spreading in hospitals that are not responding to drugs. This is a serious problem. *Candia auris*, as journalist Betsy McCaughey reports, “clings to privacy curtains, blood pressure cuffs, thermometers and even walls and ceilings.” From there it can attach “to patients’ skin before invading their bloodstream and organs.”²³

Unfortunately, *Candida auris* has been a persistent problem in long-term care facilities since it was discovered in 2017, and it is appearing more often in hospitals as well. As the CDC’s Dr. Meghan Marie Lyman explains: “During the COVID-19 pandemic, there has been an increase in *C. auris* cases, particularly in some areas of the United States that had not previously had many cases.”²⁴ According to *Medical News Today*:

Dr. Lyman said outbreaks may be related to changes in infection control practices during the pandemic, including limited availability of gloves and gowns, or reuse of these items, and changes in cleaning and disinfection practices.²⁵

Similarly, “conservation strategies”—such as reuse of personal protective equipment because of supply shortages during the COVID-19 outbreak—may have contributed to the doubling of *Candida auris* infections in Southern California hospitals during May and June of 2020.²⁶

Despite these realities, activists actually use the pandemic as an excuse to advocate elimination of single-use plastics in hospitals because of increased waste related to masks and other single-use products. They ignore the value that such single-use materials provide, and they second-guess the decisions of medical professionals who are closer to the situation and have a better understanding of the implications. The fact that shortages—and inappropriate reuse of certain supplies—contributed to COVID transmission underscores the reality that single-use products are essential to reducing the hospital-acquired infections.

For example, something as simple as a single-use syringe has proven critically important to public health, which is why the CDC says syringes should never be reused.²⁷ Cases where misguided medical professionals have reused syringes have transmitted deadly diseases like Hepatitis C²⁸ and AIDS,²⁹ as well as other illnesses. As *USA Today* reported in 2012:

Since 2001, more than 150,000 patients nationwide have been victims of unsafe injection practices, and two-thirds of those risky shots were administered in just the past four years, according to data from the U.S. Centers for Disease Control and Prevention. The errors led to at least 49 disease outbreaks, a USA TODAY examination shows, and a trail of victims suffering with potentially life-threatening bacterial infections, such as MRSA, and sometimes fatal viruses, such as hepatitis.³⁰

Those 150,000 cases could have been avoided had medical personnel used a new syringe every time. While few people might openly advocate for reusable syringes, the all-out assault on plastics could eventually undermine the availability and affordability of disposable syringes. In fact, provisions of the proposed Break Free from Plastics Act could shut down U.S. plastics facilities and produce serious medical supply shortages that would force hospitals to reuse syringes.³¹ Disposable syringes also underscore the value that disposable products play in preventing unnecessary illnesses in hospitals.

Rather than curb the use of plastics, particularly single-use ones, medical institutions should seek to expand their use. “Growing concerns about hospital-acquired infections make single-use instruments increasingly attractive,” notes a materials science expert with Bayer. “When you consider the high cost of treating infections, switching from reusable metal instruments to pre-sterilized plastic versions can actually reduce costs by eliminating one potential source of cross-infections,” he notes.³²

Something as simple as more frequent use of plastic sheeting to cover certain instruments can help make them safer. For example, in 2015 a metal endoscope exposed 200 patients to

an antibiotic-resistant bug, leaving two people dead, yet a simple disposable plastic sheath could have been used to prevent those infections.³³

Similarly, infection risks can be reduced by increased reliance on single-use tourniquets—the plastic bands that wrap around a patient’s arm to make veins more visible for taking blood or administering intravenous medicines. A 2012 study sampled reusable hospital tourniquets and found that 36 percent were contaminated with *Staphylococcus aureus* and 12 percent contained MRSA. They concluded: “The introduction of disposable tourniquets to clinical practice should be an adjunct to current measures for MRSA prevention.”³⁴

Even component parts of reusable equipment can be outfitted with disposable elements to help reduce disease transmission. One study points out that the lead wires that are attached to patients during electrocardiograms cannot be sufficiently sterilized. The authors recommend disposable wires to “eliminate risk of infection through these pathways” and “decrease infection rates in acute health care facilities.”³⁵

Blue wrap—another product activists advocate replacing with reusables—offers another example of single-use plastics’ valuable role in medicine.³⁶ Blue wrap is a plastic wrap that keeps medical tools and equipment sterile during transportation and storage that has proven to be highly effective at preventing dangerous contamination. One study comparing rigid, reusable containers and blue wrap found that blue wrap performs substantially better at controlling pathogenic contamination. It notes:

Of 111 rigid containers tested, 97 (87%) demonstrated bacterial ingress into the container. Of 161 wrapped trays, 0 (0%) demonstrated bacterial ingress into the tray. Contamination rates of rigid containers increased significantly with increasing duration of use. ... In this study using a dynamic bacterial aerosol challenge, sterilized wrapped trays demonstrated significantly greater protection than sterilized rigid containers against the ingress of airborne bacteria.³⁷

Phillip Van Gorp, a sterile processing manager for the Clinics and Surgery Center at the University of Minnesota Medical Center, explained additional difficulties associated with the reusable equipment storage containers. They take up much more space and they create a “decontamination backlog” because medical staff must disassemble and sterilize them between uses. Then staff must reassemble and inspect the containers before they can store instruments. After all that effort, “the better part of an hour has gone by,” while the wrap takes three or so minutes to wrap instruments. But in the final analysis, he notes, “the real argument is one of safety.”³⁸

In addition, some single-use and reusable plastics are now being made with antimicrobial attributes that resist the spread of diseases.³⁹ For example, one company has developed a plastic coating for medical instruments that eliminates microorganisms that come into contact with the instrument before they can infect a patient.⁴⁰

Clearly, plastics are essential to modern medicine. Environmental activists’ attempts to ban or limit their use present a serious threat to public health. Pandemic-related shortages were

bad enough; the reckless elimination of such single-use and other plastic products for political reasons would actively facilitate the spread of deadly hospital-acquired infections.

Packaging and Public Health. Decades ago, the chemical company DuPont published an ad that touted: “Cellophane protects you from dirt’s danger. It is on the job, protecting your health and your pocketbook.”⁴¹ Today, the fact that plastics protect our food supply seems obvious, yet such realities are overlooked as people campaign to rid the world of plastics without regard to the impacts.

Plastics are essential part to protecting our food supply—and our health—from dangerous pathogens. And by extending shelf life, plastic food packaging also makes it more affordable to feed the world’s growing population, while leaving excess land for wildlife.⁴²

In fact, it is hard to overestimate the contribution of plastic packaging toward preserving and maintaining the safety of the world’s food supply. Food packaging:

- Enables us to safely transport food long distances;
- Allows many different individuals to handle the food during shipping and in supermarkets without adding dangerous pathogens;
- Provides protection from UV light, oxygen, and chemicals that reduce shelf life; and
- Limits physical damage that would ruin or shorten product life.

Reducing food waste with plastic packaging means we can farm less land, leaving more for wildlife. That also means less energy and water for farming and reduced use of pesticides. As the American Chemistry Council’s Steve Russell points out, growing and distributing food requires 10 times more resources than are used for making the packaging we use to protect it. “So when we waste a food item, we’re wasting 10 times the resources that were used to make its protective packaging,” he explains.⁴³

Plastic packaging in particular allows food to reach markets in better condition and allows for longer shelf life at home. For example, studies show that plastic packaging extended the life of bananas from 15 days to 36, beef from four days to 30, bell peppers from four days to 20, and cucumbers from three days to 14.⁴⁴ Other studies found that switching from paper bags to plastic reduced bread waste from 11 percent to 0.8 percent and cheese spoilage waste from 5 percent to 0.14 percent, and that bagging grapes in plastic rather than selling them loose reduced in-store waste by 20 percent.⁴⁵

Plastics Europe points out that Europe loses only 3 percent of all its produce to waste, while less developed nations, where more food is sold unpackaged, lose 40 percent. Much of that food waste, the trade group points out, results from “the lack of appropriate packaging and transportation solutions to maintain its quality and freshness on the journey from farm to fork.”⁴⁶

Back in 1985, researcher William Rathje and his colleagues made similar observations in a comparison of food waste in cities in the United States and Mexico City. In Mexico City, where a large portion of food was sold unpackaged, food waste was one third higher than in

comparable U.S. cities where food was commonly sold packaged. They also reported that only 2.5 percent of processed and packaged food ended up as waste, while 50 percent of fresh produce was wasted. That is because when manufacturers package food, they find ways to use nearly all parts of the food—including fruit and vegetable skins that consumers often discard. Meanwhile, consumers will remove and throw away a large portion of their produce either because they have no use for it or because it spoils quickly.⁴⁷

And while many people think that replacing plastic grocery bags, straws, utensils, and other single-use plastic products with paper or other alternatives would be beneficial, there could be public health consequences associated with such changes. Research demonstrates that reusable grocery bags often harbor bacteria that could pose a health risk for consumers.

A 2011 study conducted by the University of Arizona and Loma Linda University examined a sample of reusable bags from shoppers and found “large numbers of bacteria,” including dangerous fecal bacteria such as coliform, *E. coli*, and salmonella. Bacteria were found in 99 percent of the tested reusable bags, while no bacteria or viruses were found in a sample of disposable plastic bags and new reusable bags. Bacteria can easily be transferred from leaking meat packages and from fruits and vegetables, and the study found it grows in bags that are stored in car trunks.⁴⁸

A 2018 study by researchers from Loma Linda University assessed the probability of norovirus transmission from reusable grocery bags carried around in supermarkets using a similar, but not infectious, virus as a proxy. It found that the virus easily moved from the bag all around the store, with a high concentration found on the hands of both consumers and store checkout clerks.⁴⁹

The impact of such pathogens is not merely theoretical. In 2012, nine members of a soccer team in Oregon contracted the norovirus, a leading cause of food poisoning, either from touching a reusable bag or eating food contained inside it. The bag had been stored in a bathroom. That might seem like an outlier, but people cart such bags all over the place, touching surfaces on public transportation, taking them into public restrooms, and other places—thus creating plenty of opportunities for the bags to pick up bacteria and viruses.⁵⁰

Single-use plastic bags are not the only reusable products that can transmit pathogens. Studies dating back to the 1970s have shown that reusable utensils often contained dangerous levels of bacteria even after being washed, particularly in fast-paced restaurants where a high volume of people circulate in and out quickly.⁵¹ Of course, not all food service outlets need to use single-use utensils, but all should have the option. In fact, fast food eateries, school cafeterias, hospitals, nursing homes, and other medical facilities have long relied on single-use plastic products to help reduce risks of disease transmission. Banning such uses is dangerous.

Plastics in our Homes. Plastics make homes more affordable and bring many benefits to construction, but somehow those simple facts are left out of any discussion about plastics and the environment. Plastics can be used for vinyl siding, vinyl flooring, pipes, wire coating, insulation, window frames, decking, fencing, components of lighting and

appliances, tools, and more. They are pervasive because they are affordable and useful in many applications. One plastics company lists some of those uses on its website. Here is a quick summary of the key points:

- Plastics require less energy and other resources to make than many alternative products, so they make both new home construction and upgrades to existing homes more affordable.⁵²
- Because they do not corrode and are waterproof, plastics make long-lasting, rust-free pipes and other plumbing components and are suitable for any infrastructure that might be exposed to moisture.
- Plastics reduce transportation cost and injury risks to workers who otherwise would be forced to move much heavier materials.
- Plastics can be colored easily to meet a wide range of needs and they can be easily molded into many different objects like zip ties, cable clip holders, and more.⁵³

Imagine if every plastic product in our homes were replaced with a “natural” one. We would need to use more materials like wood, metal, and stone, which would substantially increase the price of homes and any upgrades. Homes are expensive enough already, so adding to their cost could completely price many people out of the market for a home. In addition, without plastics, using other materials would require environmental tradeoffs associated with logging more forests and increased mining for metals and stone. While these alternative products are fine and many people prefer them, forcing the elimination of plastics would raise homeownership costs for everyone.

Other Benefits of Plastics. Manufacturers use plastics in many consumer products, providing benefits that most people rarely think about when discussing plastic bags or regulation of plastics in general. Yet, legislation advanced by anti-plastics campaigns, if passed, would place all these applications at risk. Consider just a few.

Manufacturers use plastics to make many affordable, lightweight safety devices, from hardhats to goggles to sporting equipment. And the benefits are far more substantial than many might think. For example, during World War II, the U.S. military started using plastics to line metal military helmets, which helped reduce fatal injuries from impacts. Norman Finkelstein notes: “According to U.S. Army estimates, the newly designed helmet liner was credited with reducing battlefield casualties by 8 percent, saving an estimated 76,000 soldiers from death or serious injury.”⁵⁴

Plastics have replaced glass in many applications because they are safer and less prone to break. Importantly, plastics greatly relieve risk of injury to babies and children from the potential of broken glass cups and bottles. Farmers use plastic alternatives for greenhouses, because they can be made 250 times stronger than glass, reducing potential breakage from bad weather among other things.⁵⁵

The Plastics Industry Association, in an August 2021 report, points out that plastics have greatly reduced automobile weight—which has helped improve fuel efficiency—and are key components of many auto safety devices. The report notes:

Seatbelts, made from polyester fiber, save nearly 15,000 lives a year and reduce the risk of death in frontal car crashes by 30 percent, according to the National Highway Traffic Safety Administration. Airbags, which are made from high-strength nylon fabric, reduce driver fatalities by nearly 30 percent a year. Side airbags can reduce death rates in accidents by over 50 percent. An added small layer of plastic on windshields, windows, and sunroofs protect passengers by preventing splintering glass that prevent over 300 fatalities a year. Fiber-reinforced polymers used to create better crumple zones, or the area that absorbs impact in a crash, absorb four times the crush energy as steel, reducing impact and passenger injury.⁵⁶

Plastics are also used to make affordable, lightweight high-tech devices, including ones that help us connect to the Internet. Plastics insulate wires that connect computers to the Internet, make laptop computers light and portable, provide insulation and heat resistance in television sets and cell phones, and much more. For example, according to the website Techwalla, the average cell phone is about 30 percent plastic, which helps make it less breakable when dropped and more resistant to scratches. And plastics are particularly valuable because they “stand up to all but the most extreme temperature fluctuations. The material is very flexible, and it does not cause reception problems when you’re trying to find a cell signal.”⁵⁷

Conclusion. Certainly, real problems associated with plastics litter warrant efforts to resolve them and reduce the impact on nature. Fortunately, there are workable solutions, which the next paper in this series will outline. Yet, thus far, such reasonable and workable approaches have fallen to the wayside as extreme anti-plastics campaigns have emerged. While many people might think that some of the proposed legislation would involve modest efforts, the final paper in this series will demonstrate how anti-plastics campaigns have produced extreme legislation that, if passed, would not only be unworkable, it could destroy most if not all of the U.S. plastics industry. Undermining the U.S. plastics industry would likely force the United States to depend on foreign sources for plastic products to meet our most basic needs.

As outlined in this paper and in the first one in this series, plastics are everywhere in our lives because they provide substantial benefits for both wildlife and people that could be lost if Congress or state legislatures were to pass anti-plastics legislation. Such misguided anti-plastic policies will jeopardize the level of care that people receive in hospitals and medical facilities, undermine measures to control hospital-acquired infections, and will likely make pandemics and other medical emergency events far worse. The world food supply could suffer as anti-plastics policies undermine sanitary food packaging that helps keep food safe, extend its shelf life, and reduce the amount of farmland needed to feed the world’s population. Even single-use plastics are not as replaceable as people think, and replacements could undermine public health. Plastic bag bans and the like already are creating new risks associated with alternative products for which the alleged benefits are not being realized.

Notes

¹ For example, see MyPlasticsFreeLife.com.

² For example, see Sandra Ann Harris and Dianna Cohen, *Say Goodbye to Plastic: A Survival Guide for Plastic-Free Living* (Hobart, NY: Hatherleigh Press, 2020); and Rodale Sustainability, *F**k Plastic: 101 Ways to Free Yourself from Plastic and Save the World* (New York: Rodale Books, 2019).

³ For example, see <https://LifeWithoutPlastic.com>.

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<https://www.congress.gov/bill/117th-congress/senate-bill/984/all-info>.

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¹¹ Finkelstein, p. 98.

¹² Ann Thryft, “Plastics Grow as Materials of Choice for Medical Devices,” *Design News*, May 12, 2015, <https://www.designnews.com/plastics-grow-materials-choice-medical-devices>.

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¹⁴ Jon Evans, “Warding Off Infection,” *Plastics Engineering*, October 2013, <http://read.nxtbook.com/wiley/plasticsengineering/prototype/coverstory.html>.

¹⁵ Centers for Disease Control and Prevention, HAI Data, website accessed July 14, 2021, <https://www.cdc.gov/hai/data/index.html>.

¹⁶ Evans.

¹⁷ Giacomo Grasselli, et al., “Hospital-Acquired Infections in Critically Ill Patients With COVID-19,” *CHEST Journal*, April 12, 2021, published online, [https://journal.chestnet.org/article/S0012-3692\(21\)00679-6/fulltext](https://journal.chestnet.org/article/S0012-3692(21)00679-6/fulltext).

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¹⁹ Rosario Barranco, Luca Vallega Bernucci Du Tremoul, and Francesco Ventur, “Hospital-Acquired SARS-Cov-2 Infections in Patients: Inevitable Conditions or Medical Malpractice?” *International Journal of Environmental Research and Public Health*, Vol. 18, No. 2 (January 2021), p. 489, <https://www.mdpi.com/1660-4601/18/2/489/htm>.

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²⁶ Jan Dyer, "COVID Unleashes the 'Lurking Scourge' Candida Auris," *Infection Control Today*, Vol. 24 No. 10 (December 2020),

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