Microbes and Health
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Summary/Abstract: The pathogenic role of microbes has dominated society's view of this critically important biological community that lives on us, in us, on our food, and throughout our houses. This article discusses the current state of knowledge, as well as the enormous gaps in our knowledge of the microbial world and how it affects human health. The microbial communities in our foods, our digestive systems, on our skin, and associated with other parts of our lives are discussed, and how these microbes affect our immune system and even our mental health. The beneficial role of pathogen challenge in human health is discussed, and why eradication of all pathogens from food is a mistaken objective. The need for a shift in science policy toward a focus on non-proprietary, public domain-oriented research is suggested as being critical to the next generation of research on microbes.

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When I was a teenager in the 1960s I read all of the Carlos Castaneda books, tales about the shaman's apprenticeship in Mexico, fascinated by the possible existence of parallel worlds of beings alongside our physical existence. Like the shaman leading the apprentice through doors of perception to *see* the formerly unseen, science can lead us to perceive the formerly unseen, albeit via mundane and laboriously collected data. It is only after years of data creation, analysis, and interpretation that science allows patterns of the unseen to be perceived by society. Microbes are one such unseen part of the natural world that can now be understood better.

Unfortunately for microbes, it has been a tiny minority of their number, pathogens, that has, somewhat justifiably, dominated human perception of these giants, thinking in terms of the sheer volume of their biomass. It was only when humans were able to understand the microbial basis of infectious disease a little over 100 years ago that the means for control of the most serious diseases was brought about. The twin pillars of public health protocols and antibiotics have been enormously successful in reducing mortality from infectious disease. However, the pathogenic view of microbes still dominates today, and despite advances in our knowledge of the microbial world, this "war on microbes" view has been over-extended beyond its useful domain. The overarching approach to microbes is still the sterilization of the human environment.

The tide may be turning however. We are now learning that good microbes can protect us from many things, and additionally, that by allowing relatively small numbers of certain pathogens - yes, the bad microbes - to be part of our microbial environment we actually are strengthened to fight against disease and ill-health.

The benefits of the microbial community. Fear of germs and the desire for a quasi-sterile living environment has been one of the hallmarks of modern society. Foods that throughout human evolution have been eaten raw, replete with hundreds of species of microbes living on and in them, are now being pasteurized and sterilized. The three-ring circus of TV commercials that the soap products industry has made of sterilizing our homes, bodies, and clothes has made them billions of dollars.

Yet the new antibacterial products that are part of this campaign have been shown to be no more effective than regular soap at protecting us from harmful bacteria.[1] The sterile household lifestyle ignores the fact that the vast bulk of microbes in the home and on our bodies are either harmless or beneficial. Additionally, the antibacterial compounds used in these household products, triclosan and triclocarban, are now being shown to be endocrine disruptors,[2] compounds that mimic hormones in the body. Children, pregnant women, and fetuses are especially vulnerable to endocrine disruption.

The total number of bacteria on our body surface is said to exceed the total number of cells in our body by ten times.[3] These are made up of hundreds, probably thousands, of species. Some 182 species of bacteria specialize in living on the human forearm alone. Yet little is known about skin microbes - fewer than ten research labs in the US are doing work on the microbial ecology of human skin.[4]

Our intestines hold 10 to 100 trillion bacteria of some 7,000 strains from 500 to 1000 species. Bacteria have co-evolved so closely in association with us that, according to microbiologist Jeffrey Gordon, humans have utilized the evolutionary power of these symbionts to develop physiological mechanisms, such as the production of disease-

fighting compounds, so that we humans don't have to develop them in our own cells. Thus, outsourcing for the manufacture of goods is apparently not something pioneered by corporations – we've been outsourcing the production of chemicals and many of the body's processes to microbes for millions of years.

Humans, says Gordon, should be seen as a composite of human and microbial cells and that we should view "our genetic landscape as a summation of the genes embedded in our own human genome and the genes embedded in the genomes ('microbiome') of our microbial partners, and our metabolic features as an amalgamation of human and microbial attributes."[5] Perhaps this may be a stage of endosymbiosis, in which microbes evolved into cellular organelles.

The microbial ecologies of our food and that of our own bodies are related, although very little is known about this relationship. One square centimeter of the average leaf has anywhere from a million to 100 million bacteria and fungi from hundreds of species.[6] Raw root foods like carrots have even higher microbial density and diversity because they retain soil microbes, and the soil ecosystem is probably the most diverse and complex on earth. Our highly acid stomach kills most of these microbes, however, many of them get through to the intestine, probably at such times when stomach acids decline.

While almost nothing is known about the relationship between our intestinal microbe community and these plant and soil microbes that enter us with our raw foods, one thing we do know is that this relationship is deeply embedded in our evolution Throughout all of evolution we have eaten raw foods, some of them roots and tubers covered with soil microbes. It is very likely that the body and its microbe community are genetically adapted to be regularly inoculated with these food-borne microbes. When something like this is deeply embedded in our evolution, it is probably a good idea to respect it – in other words, integrate it into your diet.

The microbially rich mucous layer of the human intestinal wall is said to account for 80% of the body's immune system activity. Allergies are a reaction of the immune system to proteins that it "perceives" to be hostile. A healthy immune system needs to be able to react to hostile organisms like viruses and bacteria and at the same time to distinguish these from non-hostile proteins and molecules. It is the intestinal microflora that modulate this distinction between the hostile and the non-hostile entities.

It has been shown in numerous studies that exposure to a diverse microbial environment, such as exists on livestock farms or in developing countries, improves the body's ability to deal with potential allergens.[7] This is known as the "hygiene hypothesis". The microbially rich environments of farms and tropical countries (commonly known as "germ-ridden" or "septic" environments) challenge the immune system and enhance its ability to distinguish between hostile (pathogens) and non-hostile entities coming into contact with the body.

This microbial challenge from the environment is especially important for infants. Watch any toddler. Wherever they are, whatever they touch, if a toddler can pick it up they'll put the object in their mouth. They are inoculating themselves with the microbes in their environment during a time when it is critical to build the immune system and when their mother's milk contains immune-boosting compounds. If this wasn't the case, the toddler hand-to-mouth behavior would have been eliminated from our genes long ago via natural selection.

Recent experiments have shown that when bacteria from healthy intestinal systems are allowed to colonize the guts of young mice, the mice were later protected from Type 1 Diabetes, an autoimmune disease in which the body attacks the cells in the pancreas that produce insulin.[8] The researchers state that this is further evidence that people in developed countries whose living environments lack the microbial challenges that exist in developing countries are at risk of higher rates of allergies and other autoimmune diseases.

Dairy farmers and workers in Italy who regularly breathe air laden with the dust from the manure of cows have up to five times lower rates of lung cancer than colleagues who don't work with manure.[9]

In the US we have lost to the "tyranny of sterility" many of our own traditions that promote regular immune boosting inoculations with benign microbes, such as raw milk consumption,. While sterility is important for many things, such as surgical procedures and food canning, our regulatory and food industries have gone extreme with it.

It is well known that people who grew up drinking raw milk tend to have excellent health and are protected from allergies and other autoimmune diseases.[10] The generally better health of these people is a result of been exposed low levels of potentially pathogenic bacteria occasionally in milk The body's immune system had to learn to deal with it. Yet mandatory pasteurization of milk has become the norm, even though the pathogens that 100 years ago gave rise to the need for pasteurization, like bovine tuberculosis and brucellosis, have virtually been eliminated from livestock in the US.

According to the Centers for Disease Control, from 1998 to 2005 approximately 1000 people were sickened by raw milk or its products, with two deaths. This is a tiny number in a country of over 300 million people, when one considers the potential benefits to most of those people of drinking carefully produced and distributed raw milk. Yet because of state and federal statutes against the sale of raw milk, most of the dairies that specialized in raw milk have been driven out of business, even though our food monitoring and refrigerated distribution and storage systems have been nearly perfected.

Instead of doing a risk/benefit analysis on microbes, as is done with many other aspects of society, such as automobile and highway safety, the policy is simply to sterilize – in other words to treat microbes as all risk and no benefit. Stepping back and looking at the big picture shows this to be something like forcing all traffic to go 35 miles per hour on freeways and requiring all passengers to wear helmets and large armored body suits to reduce mortality from highway accidents. Such laws would save tens of thousands of lives every year, yet the speed limits are still 65-75 mph because the benefits of transport speed are taken into consideration.

A good part of the fact that microbes are not assessed for their benefits and are generally targeted for eradication may be driven by the fact that this sterilization regime is profitable for the pharmaceutical and chemical industries that sell anti-microbial products, and that sterilized and pasteurized foods have the long shelf-life needed for shipping to and from large, centralized food retailers and distributors.

It is more than a bit ironic that the common practice of using bovine growth hormone (BGH, also known as bovine somatotropin, or BST[11]) injections to artificially stimulate higher milk production in cows also causes higher incidence of bacterial infections because of the stress to the cows being forced to produce 10-25% more milk than is normal. Federal regulatory bodies approved the use of BGH despite evidence of higher levels of hormones such as the "insulin-like growth factor" (IGF-1), which has been associated with higher rates of cancer in the drinkers of milk from BGH-treated cows.

It was the promoters of the science and practice of "probiotics" who put the issue of beneficial food-borne microbes on the map. On the forefront of probiotics education is the Weston A. Price Foundation, which is leading the fight against the prohibition of raw milk as well as the campaign to promote fermented and cultured foods. Probiotic bacteria are beneficial bacteria, such as the kind that make yogurt and fermented foods. It has been found that probiotic bacteria enhance the immune system via the microbially rich mucosal layer in the gut,[12] one result being a reduction of the incidence of colon cancer.[13] The term "prebiotic" has come into the lexicon, meaning foods that, when they reach the intestine, promote the health of the probiotic microbe community.

The human appendix, until recently believed to be some kind of useless vestige of our evolutionary past ("phylogenetic baggage" in the words of late author Stephen Jay Gould), is now being postulated by medical researchers to be a repository for important intestinal bacteria.[14] These bacteria are believed to repopulate the gut after intestinal disruptions such as antibiotic use or the ingestion of a natural antibiotic or poison, something that was apparently common enough in our evolution to have had a defense against it selected-for and genetically conserved.

The positive effects of microbes go beyond inoculation with harmless species, and crosses into actual infections by pathogens. The cancer-fighting effects of bacterial and viral infections have been known for over a century. Before the turn of the 20th century, physician and medical pioneer William Coley developed successful cancer therapies based on bacterial infections and on the body's immune response to perceived infection by killed bacteria. With the development of radiation therapy, Coley's techniques were abandoned by Western medicine and only recently have been regenerated.

It was shown by researchers that the bacteria that cause acne are associated with reduced rates of skin cancer, lymphoma, and leukemia, and that when these bacteria are injected into tumor-ridden animals, the tumors shrink and the immune system is stimulated.

In 2000 a cancer-killing virus common in tropical countries was discovered. The virus, known as vesicular stomatitis, causes mild flu-like symptoms and was shown to selectively kill melanoma cells. Perhaps those mild sick days that I always experience in the tropics perhaps are even more important than I thought. I have been convinced that those sick days are keeping my immune system tuned by adding new antibody templates and by keeping the T-cell machinery well oiled, but I didn't know that it might be killing cancer cells.

The benefits of pathogenic organisms that challenge the body go beyond bacteria and viruses. It has been found in medical research that people who are infected with sub-pathogenic populations of hookworm are cured of allergies. Hookworm is a common tropical nematode (a type of worm) parasite of the intestine, which causes anemia and debility if one is infected with a large population. Apparently the hookworm has developed the capacity to turn off the part of the host body's immune system that is the culprit in allergies. A British doctor has actually infected himself with a small number of hookworms, which do not multiply in the intestine if certain easy sanitary measures are taken. The small hookworm population doesn't cause the anemia and ill health typical of a pathogenic infection, yet it "tunes" the immune system enough to eliminate allergies. The doctor has been deluged with requests for the hookworm treatment and hookworm treatment clinics have been set up in Mexico.

The evolution of the sneeze. In this context of pathogen challenge I would like to talk about the common cold. I believe that the common cold virus is not a uniformly harmful pathogen, and that this organism is with us in a beneficial mutualistic relationship with humans. We derive some benefit from the common cold virus as well as it from us. The common cold tunes and strengthens the immune system – it forces us to become stronger so that we can resist the more deadly viruses like influenza, which has a similar but more severe pathogenesis. The cycle of the annual cold was evolutionarily conserved (maintained instead of eliminated). But how?

Let's talk about the sneeze - yes, the sneeze that is associated with the common cold, in the context of the importance to the body of immune system challenge by microorganisms. The sneeze is ostensibly a mechanism for discharging foreign objects from the nose and sinuses. But what is it really? The sneeze may be a way of aerosolizing and spreading mucous at a time when it is full of highly infectious but usually not deadly viruses like the rhinovirus, the most common of the common cold viruses. This is a highly efficient way of spreading the virus – people simply breathe the sneeze-discharged, aerosolized, contagious mucous particles into their noses and sinuses where it can best infect.

Now why wasn't this trait, the infection-generated sneeze, selected out of humans during evolution if it is detrimental to us? One would think that if aerosolization of virus-infected mucous (the sneeze) was detrimental to our fitness, then traits for expelling mucous and foreign objects without aerosolizing them would have been favored in evolution.

The evolutionary conservation of the sneeze likely occurred because the common cold is beneficial to us. It enables us to resist deadly influenza viruses. By spreading the cold virus to our associates we make sure that everyone has processed it through their immune system and can better take on the really serious viruses which cause influenza. This is perhaps similar to babies putting every object they can pick up into their mouths – it's inoculating and tuning their immune system.

Microbes and mental health. The benefits of exposure to the natural environment's microbes goes beyond fighting disease and, surprisingly, may impact mental health. A group of cancer patients was given a harmless soil microbe *Mycobacterium vaccae*, which is related to the bacterium that causes tuberculosis, to determine if it could help to fight cancer. While there was no reduction in cancer, the group that was given the bacteria reported that they were happier and their quality of life improved. The researchers then designed an experiment with *Mycobacterium* and depressed rats (yes, they can measure rat depression). It was found that the depressed and stressed rats that were exposed to the *Mycobacterium* showed a significant reduction in those symptoms, a similar reduction as the treatment group that was given anti-depressant medication. The British research group explained that the microbe causes the body to release cytokines, which in turn increases the serotonin levels.

These Mycobacteria are found in soils with healthy levels of organic matter. We can hypothesize on the evolutionary significance of this relationship. Obviously, if rats possess the response then it occurred early in mammalian evolution. Sites with healthy levels of organic soil matter would have boded well for survival, this being an indication of soil fertility. The gene for a happy response to Mycobacteria may have facilitated socialization – animals living in areas with these soils had to live at higher densities, promoting the development of cooperative behavior and happier animals. In this hypothesis, those that lacked the Mycobacteria response gene migrated away in order to free themselves of population constraints and inhabited less fertile areas that lacked Mycobacteria, and did not survive as well. More research on Mycobacteria could elucidate more precisely the kinds of soils it survives in.

One news source printed the headline "Why Gardening Can Help with Depression and Allergies". If you want to feel happier, go out and pull some weeds, get the soil on your hands, and don't wash them. I recently went for a hike in the hills and "washed" my hands in the moist forest soil. I know that I always feel better after gardening and hiking in the forest (which always includes a bit of groveling in the forest floor in the form of rest stops and naps).

More recent research has shown that psychological depression is associated with certain problems in the intestinal flora (microbial community). (citation)

The War on Microbes Goes On. In September of 2006 over 200 people were sickened and three people died from bagged salad spinach from California that was contaminated with *Escherichia coli* (*E. coli*) bacteria of the type known as O157:H7 (pronounced E coleye, the letter "O" one-five-seven-H-seven), a highly virulent diarrhea-causing strain of this bacteria that normally lives in the lower intestine of warm-blooded animals, including humans. Subsequent investigations determined that the cause of the contamination was most likely feral (wild) pigs that had walked through fresh manure of a neighboring cattle operation and then entered the crop farm and trampled on the spinach. Contrary to initial reports in the press, the spinach was not from an organic farm.

This kind of incident, like tragic accidents on highways, is part of a larger system that is critical to society - the growing of food in an environment surrounded by nature and benign microbes. With nature, "stuff happens." However, the response of the California agriculture industry has been to clamp down on the leafy green-producing farm operations with regulations, many of them reversing and eliminating environmentally friendly farm practices. The Leafy Greens Marketing Agreement (LGMA), the industry response to the spinach incident, is forcing farmers to adopt some draconian practices, many of them favoring large capital-rich corporate farms, in order to attempt to maintain a sterile environment.

Farmers who take pride in their farms being wildlife friendly and who have designed water filtering systems like grassed waterways to filter the nutrients out of irrigation tailwater before it goes into creeks, or who have trees that line the edges their crop fields over which birds can sit, are being forced to eliminate many of these features.

According to Judith Redmond, organic farmer and a leader in the small family farm community in California:

> "the [mainstream agricultural] industry has used the LGMA rules as a precedent to strike against the heart of biological agriculture, calling for sterile zones on farms, fences to keep wildlife out, cancellation of conservation projects and removal of grassed waterways. There is no scientific basis behind the demands made by the handlers and buyers, and the effect on conservation practices and the environment has been devastating."[15]

Studies have shown that wildlife do not pose a significant threat to food in most agricultural situations, yet in a recent survey, 90% of California leafy greens farmers of said that as a result of the new rules they have acted to discourage wildlife near their farms. One grower is quoted as saying that he feels "many new food safety ideas are being driven by fear and uncertainty than sound science."[16]

Enteric bacteria like E. coli do not last long outside of their anaerobic intestinal environment. Thousands of species of microbes and microfauna in the aquatic and terrestrial environment love feeding on bacteria like E.coli (again, the benefits of the larger microbial community), so it only survives for a short time outside of its intestinal home.

The misguided idea that raw foods are a source of bacteria that cause food poisoning was used in an anti-organic foods campaign in the 1990s, led by a guy named Dennis Avery who worked for the Hudson Institute. The Hudson

Institute derived its funding from a number of agrichemical companies that apparently saw organics as a threat to their business. The campaign was based on the fallacy that fresh manure is applied to organic salad and fruit crops when they are close to harvest.

In 1997 unpasteurized apple juice contaminated with E. coli O157:H7, believed to have come from fresh manure that was used as fertilizer, was implicated in a food poisoning incident that resulted in the death of an infant and the hospitalization of several others. Despite the fact that the juice was neither labeled nor implied as organically grown, a press release by Dennis Avery shortly after the widely reported incident stated: "According to recent data compiled by the U.S. Centers for Disease Control (CDC), people who eat organic and 'natural' foods are eight times as likely as the rest of the population to be attacked by a deadly new strain of E. coli bacteria.." This theme, plus what later proved to be false statements about pesticide residues on organic foods, was featured in a prime-time television news magazine story that negatively portrayed organic foods and farming. The story was rebutted after researchers from the CDC, whose E. coli data were used for the report, stated that there was no basis for Avery's statements. However, the disinformation persisted: years later the U.S. representative to the U.N. Food and Agriculture Organization, George McGovern, was quoted as saying, referring to food poisoning, that "in some of these organic foods ... fertilizer residue makes them unsafe to eat."[17]

The most common source of E. coli food poisoning in the US is the consumption of contaminated beef, yet beef industry practices that are known to promote the kind of E. coli that can poison consumers, such as the use of high grain diets, are perpetuated.

Furthermore, antibiotics are used in the meat industry as a feed supplement to get an increase in growth rates. Seventy percent of antibiotics used in the US are consumed in this way. This practice has promoted the development of antibiotic resistant bacteria, a seriously complicating factor in the E.coli contamination scenario.

The mandatory sterilization and pasteurization of salad, fruit, and nut foods is becoming more common. The California almond board in 2007 mandated that all almonds must be pasteurized because there were a couple of incidents of Salmonella poisoning from raw almonds. The tainted almonds were a tiny fraction of the total almonds. Such measures as the pasteurization of foods normally sold raw, or washing with dilute bleach solutions in order to eliminate any chance of pathogen contamination, completely ignores the importance of the greater microbial community and their benefits to consumer health. Society has always balanced risks and benefits. By attempting to eliminate microbes from foods, all we are doing is weakening our immune systems, which needs regular doses of microbes in order to stay tuned up.

Mainstream science shapes society's view of the microbial world. There has existed a certain allegorical joke about science and scientists that has circulated in academic circles for some 50 years and that still very much applies to science today. It goes something like this: It's night-time in a city and a pedestrian encounters a man under a street light, down on his knees intensely studying the pavement within the small circle of light surrounded by a vast area of urban semi-darkness. The pedestrian asks the man what he is doing. "I lost my keys." "Where do you think you lost them?" The scientist replies "I don't know, but this is the only place I can see."

The microbial world that we literally swim in, and yet know almost nothing about, is a case of the scientific community being completely engrossed in its mapping of small circles of light under the street lamp, many of them financially lucrative, while ignoring the vast reaches of darkness beyond. This is because it's difficult to get funding for such exploration, or because the necessary analytical tools aren't well developed, or, perhaps most importantly, especially in recent years, there isn't potential for profit in ecological studies. Up until now scientists' work on the larger microbial community has been heavily skewed toward screening them and their genes for possible use in medicine or industry. This largely ignores the ecology of microbes unless the microbe is a pathogen, which make up a tiny percentage of microbe species.

Mainstream[a] science's focus on the small isolated circles of light, instead of towards a less concrete, less patentable, but perhaps world-shifting perception of the whole microbe community, comes at great cost to society. The larger

[a] I say mainstream because there are significant numbers of scientists out there who are trying to explore, with what funds they can come up with, the vast realms of nature that are not conducive to proprietary "ownership" or to neat funding-garnering publications. Very often these scientists' work remain out of the spotlight.

microbial community, represented in our metaphor by the large areas of darkness, appears to play a vastly greater role in human health and well-being than previously thought.

Funding is needed for research into these dark areas in our metaphor that represents that unknown microbial world, which can also be imagined as the submerged 90% of the iceberg. As it is now, most funding goes to endeavors that can emerge with or support patentable outcomes, like identifying strains of microbes and the products of microbes. Yet we know that there are many non-patentable aspects of microbes that are beneficial to society, ways that the microbial community can be managed to benefit us. However, research funding to generate this type of knowledge has steadily shrunk to a small fraction of the total.

Symptomatic of medical science's ignorance of human microbial ecology is the entry in the Merck Manual for Irritable Bowel Syndrome – "cause is unknown" and "treatment is symptomatic." My mother suffered from IBS and gave up on the medical establishment's ability to deal with it (antibiotics!) and has had success with an alternative practitioner who is working to repopulate her intestine with the body's natural flora. Medical research on this would involve – god forbid! – ecology! – a word that appears to strike fear into the hearts of reductionist scientists and profit-minded medical researchers. However, I know for a fact that a healthy percentage of scientists who, with adequate long-term funding, would love to research these things.

If we do the benefit/cost analysis of publicly funded research on non-proprietary solutions to society's problems, I am convinced that we would see a ratio as good or better than the proprietary-focused science. It just doesn't make sense to fund this area so dismally, and I implore readers to become aware of how profit-oriented science has taken over. We need our taxes to go toward building a strong scientific community that explores non-proprietary aspects of the natural world.

The current short-sighted approach to science has kept US science increasingly like the guy under the street light at night – focused on mapping his small circle of light, while there is increasing evidence that the dark areas out there are important and paradigm-shifting aspects of nature waiting to be discovered.

Thoughts on our shifting view of microbes. When I was young, my parents took me and my three brothers to Africa in the first years of the Peace Corps (read about it in my Mom's book *To Africa With Spatula*[18]). We were challenged by numerous pathogenic and non-pathogenic microbes and had many of the common tropical ailments, including malaria, dysentery, traveler's diarrhea, and numerous viruses and undiagnosed tropical bugs. Since then none of us has ever had any problems with allergies.

I have done a lot of traveling and sojourning in tropical countries since then (currently I live in Africa) and have had to substantially modify the germ theory of ill-health that I had learned growing up. Make no mistake though - a large dose of an infectious pathogen is usually going to make you sick, such as drinking Nile River water (which is what an acquaintance of mine did during his travels – he got very sick). However, eating from street vendors in different parts of the world has been fine for me most of the time and doesn't seem to be any more risky than eating in tourist and business hotels and restaurants if you stick to some basic rules, like not using the sauces and toppings that come straight from the cutting board. My own strategy is to carry a light bowl and spoon, as most risk comes from faulty washing of utensils.

Travel in the tropics is rigorous, and the traveler's immune system is continuously assaulted by new microbes and depends on staying well hydrated and nourished. As a traveler in non-touristed areas of the tropics, if you don't abandon the strict germ theory you'll be stuck in a conundrum: If you don't eat and drink adequately, you'll get sick from dehydration and malnourishment, yet if you *do* eat and drink from local vendors you expose yourself to germs on the food and dishware. In my travel philosophy, I go with eating a full meal whenever I'm hungry and wherever locals are eating. I often end up eating food made by street vendors or accepting generous offers of meals at people's houses, often poor people who don't have Western standards for sanitation. When I get sick it is almost always when I allow myself to become dehydrated or fatigued.

Minor sick days are common in the tropical sojourner's life, but usually it's just for a day or so, with mild fever or a single attack of diarrhea. Keeping the body hydrated is a real key. I carry a small water boiler for making tea, and can drink quite astonishingly large amounts of the stuff - liter after liter - during these occasions (hibiscus-fresh

ginger-green-tea-honey[19] blends are my favorite). Along with the teas I eat large amounts of the fruits that can be found locally – my favorites for the down days being papaya-banana-lime juice.

It has been shown in research that stomach acids kill the bacteria that can infect the intestine,[20] so when you are hungry, the stomach, with its extremely acid environment, will do a pretty good job of keeping bad microbes from getting to your intestines. When you are fatigued and dehydrated, or when you overeat or have an unbalanced diet, those stomach acids can't do that job and can allow the pathogens to pass through to the intestine alive. I have never bought the myth that drinking alcoholic beverages keeps bad microbes away – alcohol dehydrates you and therefore can make you more susceptible to infection.

Many societies have traditional ways of keeping the digestive system healthy, and if these traditions don't have any big risk factors, I usually utilize them. Concoctions with local herbs and fruits are common. Yet I would never abandon Western medicine, because in many of these same societies, people live with parasites that Westerners aren't adapted to and that can badly debilitate us, like hookworm, schistisomiasis, or amoebas. If you have persistent poor health or see any blood in your stools you need to get your stools tested at a lab, preferably at a good one in the tropical region itself. The local laboratories know what to look for under the microscope, and the cost is often $20 or less for both testing and treatment with an anti-helminthic or antibiotic.

I see vibrant health in expatriates who live in these "septic" countries, as long as they follow the rules for preventing the major illnesses and getting medical checkups and lab tests, and I have experienced this vibrancy myself. Do our bodies/minds respond to the immune system challenges in these "septic" environments by taking us to a higher energy level? Are the feelings of well-being associated with exposure to certain soil-borne tuberculosis-related bacteria, as I related earlier, also at play with exposure to tropical microbes?

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This article is not a call to regress back to unhygienic times. Ending the "war on microbes" does not mean relaxing the basic rules of hygiene and public health such as isolation of sewage; control of flies, vermin, and rodents; use of window screens; and hand washing etc., although it may mean modifying some of these practices in light of risk-benefit analyses. Nor do I reject the use of antibiotics in critical infectious situations. In a nutshell what I advocate is an ongoing and comprehensive risk-benefit assessment of the microbes in our environment (and in and on us) and to go from there. However, we need more science on these issues that takes into account the benefits of the larger microbial community, and we need to make sure our medical and public health professionals are up to speed on these things, and that the non-proprietary solutions that work are discussed in medical journals and taught in medical schools.

Scores of questions present themselves in this arena. In which situations does hygiene, the killing of microbes, outweigh the benefits of exposure to microbes and the challenge our immune systems need? If kids growing up touching farm animals and their manure end with better health than kids who don't have that exposure, where do we draw the line on hygiene? A first approximation tells us that hygiene is most important when there are lots of humans and their "germs" around, and that healthy, well cared for animals and "dirt" from healthy, natural soils don't pose a risk, and in fact boost our health. Distinguishing between these two situations is what science is for.

What roles do skin microbes play in our health? How do we affect those populations with our lotions and potions? How does sun affect skin microbes? Does body hair provide cover for these guys? Do depilatory practices do harm to them? When I swim in the chlorinated pool, what happens to my skin microbes? How about the effect of different soaps, from my favorite, Dr. Bronner's peppermint, to the popular deodorant bar soaps? Is there any connection between skin cancer and skin microbes? And digestive system microbes: What is the effect of the different common food preservatives on this important microbial community inside us? If preservatives, by definition, inhibit microbial growth, does it not follow that these compounds will have an effect on our intestinal flora? How does one's diet and things like herb teas affect these microbes?

Like the shaman's apprentice learning to negotiate the nether world of allies and demons, we need to learn to negotiate the unseen world of microbes around us – to learn which ones are bad and need to be avoided or eliminated, and which ones to make friends with.

Author bio: Don Lotter received his Ph.D. in agroecology in 2000 from the University of California Davis. His research showed that organically managed northern California vineyards resist damaged from the grape phylloxera significantly better than paired conventionally managed vineyards. The systemic resistance of plants and production of defense compounds that are beneficial to human health is a topic that came from this research.

He did his postdoctoral work at the Rodale Institute in Kutztown, PA, and published two papers on the 21-year Rodale Farming Systems Trial, which compared organic and conventional crop systems.

Following the post-doctoral year, Lotter wrote for Rodale's New Farm magazine, publishing feature articles on organic and traditional farming and food, traveling from Guatemala and the Caribbean through Canada. (See articles and papers at www.donlotter.net) According to New Farm senior editors Greg Bowman and Dan Sullivan, Lotter's articles were consistently the most viewed and commented-on on the magazine web site.

In addition to his Ph.D. Lotter also has a Master's degree in International Agricultural Development from Cornell University and a B.S. degree from UC Davis in agronomy and range science.

He is currently on the faculty at the Institute of Development Studies at St. John's University in Dodoma Tanzania.

A fully linked resume is viewable at www.donlotter.net .

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