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SARAH BECK

You're listening to Garden Futurist. I'm Sarah Beck. I'm here with Adrienne St. Clair. Hi, Adrienne.

ADRIENNE ST. CLAIR

Hi, Sarah.

SARAH BECK

I'm so excited about today's topic, because we're talking about an area of science that we know is really on the cutting edge and a few years from now, or even a decade from now, we are going to look back and think that what we knew today was just so limited. Would you agree with that?

ADRIENNE ST. CLAIR

I do. So today we were talking about the microbiome and Dr. Martin Breed is our guest. He helps us imagine the microscopic, the microbiome inhabits the soil, the air, and ultimately breaks into our personal space to connect our bodies to everything around us.

SARAH BECK

Let's listen to my conversation with Martin Breed, a lecturer in biology at Flinders University, which is in Adelaide, South Australia.

Welcome Martin Breed. I'm so glad you're here with us today.

MARTIN BREED

Hi, thanks very much for the invitation, Sarah.

SARAH BECK

I'd like to start with a quote from journalist Wilson da Silva writing in Australian Geographic in 2019, describing your and others' research:

"Every time you enter wild spaces replete with biodiversity and breathe the air, microbes wafting through the ecosystem land on your skin, enter your lungs and gut and become part of you. They joined the many billions already living in your microbiome, the community of symbiotic microorganisms inside each human being.



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"The latest surprise is the discovery by researchers in Adelaide, that the more diverse the microbes living in the soils around us and the more you're exposed to them, the healthier you become. It's a discovery that could change our cities, make us healthier on a global scale."

Wow. I was really wowed by this quote. I have to say, Martin, you've been doing fascinating research on ecology that connects humans, microbiota, and the natural world. Can you start by explaining what microbiota are? And am I supposed to say are or is?

MARTIN BREED

So to describe what microbiota are, we need to think quite imaginatively because we can't see most microbiota. And it's the collection of bacteria, fungi, viruses, protists, all sorts of things that live everywhere. And there's a famous quote and that is "everything is everywhere." And that basically describes that these microbes are on every surface in every environment that we expose ourselves to. So microbiota, that's the collection, the community of microbes in a given environment.

And it's a collective word. So it really should be is I think, but people use it interchangeably with are as well, so we can see what comes naturally to us as we go forward in our conversation.

SARAH BECK

Sounds good. I also saw the term old friends. I'm curious if you can explain how that's being used and how do humans interact with old friends?

MARTIN BREED

Yeah, so these microbial old friends are part of our, as humans, our evolutionary history. People evolved in wild, natural environments. And today we've removed ourselves from much of that wilderness, right? So I'm sitting in my office, in my house, wherever, I'm surrounded by bricks and windows and things like that. And not in a hunter-gatherer-like lifestyle.

And these microbial old friends, it's a term that was coined by an immunologist in the UK called Graham Rook. And he talks about our ancient history, our evolutionary history, where we've co-evolved with these microbes. So these are co-evolved microbiota that support us and are intimately linked with our health, wellbeing, function, development, et cetera, as individuals. And we get them from our environment.

SARAH BECK



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So maybe you could talk a little bit more about that? 'cause I know you've found that microbial diversity is in these biodiverse natural environments, yet you've found less than other places, disturbed or degraded places. Where are you most likely to find these and where are you least likely to find the old friend microbiota?

MARTIN BREED

Yeah, and so I think the most important thing off the bat is to describe the tremendous diversity of microbes. So if you get a small sample of soil, guts, anything, there will probably be thousands and thousands of different microbial taxa or species.

So where do you find these microbial old friends? Well, that's probably in areas where we evolved from, so these natural environments where we're exposed to a tremendous diversity of environments. So it's probably not going to be the very hygienic or ultra clean environments. And that can include places in my house.

SARAH BECK

And mine.

MARTIN BREED

Yeah, because it's good for us. And I'm going to introduce a little bit of balance in a tick because not all exposure to microbial diversity is good. So there are all sorts of environments where these microbial old friends probably are not.

And without giving a very prescriptive list exactly where they are because that's probably impossible, it's probably areas that have got soil. That's probably more wilderness or more natural than those vacant lots in downtown areas. And areas that is free from contamination, which might be metal contamination or high levels of pollution, because we know that's not good for us.

So there's some general rules of thumb and one of the studies that we published was based on soil that was from a nice conservation park in the Adelaide Hills. And we compared that and showed that had health benefits to mice, mental health benefits in a mouse model, compared to soil from one of these more degraded ecosystem areas.

SARAH BECK

I'd like to hear a little more about this mouse story in just a minute. But first I'm curious, because you mentioned that microbial diversity could help the immune system, and I'm wondering if you could explain in terms I might understand how might they actually do this?



MARTIN BREED

Yeah. And it's pretty complicated. Although I guess all of us have become budding immunologists now in the COVID era, we hear a lot about vaccines and how that interacts with our immune system. And I'm not an immunologist. So I'm, I guess by default, I'm not going to talk about the technical details.

But I think probably the most important thing to recognize immediately is if you count all the cells in our body, most of them are not human cells. Most of them are actually microbial cells. And what that means is we are hosting a great richness and diversity of these microbes, and they're not sitting dormant within us. They're actually functioning. So they're producing compounds. They're metabolizing, they're exchanging information, essentially, with our body.

And so how do they interact with the immune system? Well, there's probably three main pathways. So they talk directly to our protective immune system. So there are protective commensal species of bacteria that we host. They also interact with what's called immune signaling. So our immune system is essentially getting trained by these environmental microbes. And that is in the form of two different kinds of immune system, immune signaling and immune memory, and they're sort of technical terms. So the way that I like to describe it is essentially if we live in a bubble and not get exposed to these environmental microbes, our immune system gets bored, and it is not well-educated into what is friend and foe or what is self or non-self.

And so this exposure to environmental microbes helps train our immune system to be ready to know what is friend, foe, self, non-self. And so those are some of the disorders that people have linked with adequate levels of exposure to microbial diversity: those that relate to allergies or autoimmune disorders. So these are the types of disorders that people have gotten very interested in trying to help understand through the microbial old friends hypothesis or there's another term, which is the biodiversity hypothesis, which I could describe, but basically is a similar idea of getting exposed to a biodiverse suite of microorganisms. And that helps train our immune systems.

SARAH BECK

Well, we're certainly not hurting ourselves by spending time with soil and gardening. It's sounding like that's pretty much always going to be a good thing.

MARTIN BREED



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It is. And maybe just on that, if I can add a little bit there. So I'm not an avid gardener, but I garden every weekend. You're out probably pulling weeds at the moment, in Australia it's winter, but there's this interesting discussion about wearing gloves or not.

And a lot of people really like wearing gardening gloves because they believe it protects them from the bad stuff that's in soil. And obviously, you know, if you've got cuts and abrasions, maybe that's a good thing. But my understanding is it's typically quite good for us to get exposed to that soil because most of the microbes are not going to be pathogens. Most of them are going to be neutral to us. And there might actually be some good ones. And so obviously if you've got very delicate hands, wear gloves would be my recommendation, but there's nothing wrong with gardening without on. Especially when you're interacting with soils.

SARAH BECK

Oh, I love this. This is a debate that my own spouse and I have, cause I have never worn gloves for any reason, but I'm sure my hands are quite rough because of it.

MARTIN BREED

But you might be healthier as well, accordingly.

SARAH BECK

See, I'm boosting my immune system and that is really why I'm doing it. So let's go back to the mice because you're also talking about evidence of mental health benefits. And I'm really curious about these mice that you were having all blissed out and happy or maybe they weren't happy at all. I don't know.

MARTIN BREED

Sure. So as a research academic, you need to work on an evidence base of the hypothesis that you put forth. So why is it that people or animals that are exposed to biodiverse environments, or the biodiverse microbiota in those environments, healthier? So there's all sorts of correlations that have been published, the epidemiological evidence behind it.

And so we ran a controlled mouse study a couple of years ago, which is one of the high bar evidence levels that can be used in this context. And what we did was we exposed mice to this sort of wilderness soil, but also mice that were exposed to the degraded ecosystem soil, and also mice that were exposed to no soil whatsoever.



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And across about a two-month period, we had these mice enclosures in the university facilities and tracked their gut microbiota. And at the end of the trial, we assessed essentially their anxiety-like behavior and there's standardized tests for that. You then have a measure of how anxious a mouse is, and also what its gut microbiota composition is. And we associated one with the other and found overwhelmingly that the mice that were exposed to the higher-level biodiverse soil had lower rates of anxiety-like behavior.

SARAH BECK

How can you tell when the mice are not experiencing anxiety? I'm curious what those behaviors are. If they're super relaxed or if you've got a heart monitor on them?

MARTIN BREED

Wouldn't it be great to be able to ask them? And I guess that's the important piece of evidence that we couldn't gather. So we use a standardized test where we put mice basically in what's called a naive environment or in, essentially it's a square box and you video track them. How much time do the mice spend around the edges as though they were relatively scared compared to spending time in the middle of the maze?

And that's been linked with other studies to do with the things that you described. Not the interview, but things like heart rates of mice and other indicators of stress. So stress hormone levels in the mice, which allowed us to have confidence that what we were measuring was closely linked to this anxiety-like behavior in the mice.

But maybe now is a good time also to say that, this is at the forefront of this area of science and we're not the only group that's doing this work. And the group in Finland has done what we were hoping to do, and we probably still will do down the track, and that is do something with people because there's all sorts of differences between us and mice, right? Even though it's one of the most important pillars to the medical research community.

So they, in a study that was published at the end of last year, they introduced basically forest materials into daycare centers. And without going into all the details, it's an amazing study, they found essentially the same thing. So rather than anxiety of children in these daycare centers, they looked at immune system changes in the children and their gut microbiota and observed those children that were exposed to traditional daycare centers that had this, what they called a biodiversity intervention. So they brought branches and dirt and moss from the forests of Finland into the daycare centers. Those children had these similar benefits.

SARAH BECK



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So nature play and forest bathing clearly work for everyone.

MARTIN BREED

It absolutely does. And although the most, I think, one of the really important parts here is it's not just going out into these wilderness areas and forest bathing, which maybe for many of us, that's not possible, but you can bring this stuff into a daycare center, right?

So this is not a special daycare center, the way that it was described in the study, this is any old daycare center and maybe they are quite different in Finland, but still that, I think breaks down some of those social equity barriers, which.

SARAH BECK

I love that.

MARTIN BREED

We could talk about the luxury effect and you know, the size of backyards

SARAH BECK

Yes, access.

MARTIN BREED

And those sorts of things. Absolutely. So that I think was very positive with their results from their study

SARAH BECK

Aw, that makes me want to take all kinds of bundles of forest material to all the daycare centers everywhere urban. Oh my gosh.

[Break for underwriting]

SARAH BECK

Let's jump to this. You say that there's unhelpful pathogens more present in degraded environments. So we know ecosystems can be restored. I'm curious if you're finding that microbial diversity can come back to some of these places that were degraded? Like we were just talking about cities that might not have all these wonderful old friends there. Can the cities eventually, you know, be good for our health if we can figure out how to bring all of our nature objects in?



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MARTIN BREED

Yeah, that's a really important question because really, as a research academic, I guess I could, if I wanted to, stop at the end of understanding causal links and then walk away and say, oh, it's somebody else's problem to go deal with how we implement it.

But in this day and age, or at least that's, I'm not driven by that. I want to make sure that this kind of work is implementable. As a restoration ecologist, we're working on, absolutely working on ways to fast track the recovery of microbial communities in soils that then people could hopefully roll out in relatively small areas in cities, in those peri-urban areas, maybe even backyards. It's more difficult in backyards, but the kind of evidence we're building there is both correlational, but also doing intervention studies.

So understanding how we can, let's say, if you plant a biodiverse vegetation community, how long would it take before the microbial community catches up or is the microbial community even leading some of the plants to get to this latter-stage successional state?

And so the best available evidence would suggest it takes, we're aiming more than 10 years. It might be actually substantially longer than that, depending on the extent of ecosystem degradation. And we're working a lot in that space because it's difficult to directly manipulate the soil microbiota. So if we just focus on plants, we're probably looking at several years before we get a significant ecosystem shift in the soil microbiota.

So there's the second avenue, which is in areas which might be more priority areas. Let's say it is our backyards where we can invest our own money or in areas that are designated as healthy parks. And so these sorts of areas, I think, need to get probably more investment per area than the broader areas. And in those areas you can do what's called a soil inoculation, which is essentially taking soil from one place, mixing it with the place that you want to try and rehabilitate, and then sowing those seeds as microbial seeds and allowing that ecosystem to flourish.

We know that in ecosystems that are relatively degraded, they are also linked with the presence of known groups of microbes or pathogens in them. And those ecosystems that are relatively healthy or with a good ecosystem functions and a great diversity of plants and probably animals as well, they tend to have more of these microbial old friends. And so you can use ecosystem restoration to help transition an ecosystem from a degraded state to a restored state or a recovery state.





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And that does take a long time, although there should be ways and we're working on some of these and I can't go into all the details because it's not yet published and we haven't got the results yet for many of these, but there are ways that you can fast track that.

And there's a common phrase that's used in this space and that is "the soil remembers." And what that means, it's both an opportunity, but also a significant challenge. So if an area has been a carpark for 50 years and you all of a sudden want to create a functional and biodiverse environment, that's going to be quite difficult because the soil in this carpark is going to remember those 50 years that it was a carpark, but also then if you do transition the soil environment to a functional ecosystem, it also has the ability to resist change as well.

So if you can work with these plant soil systems, invest time and effort in understanding what the key biotic or abiotic barriers are to achieving that restoration, I'm probably an optimist anyway, but I am very optimistic that there will be ways to fast track that recovery of health-promoting soil microbiota in our cities.

SARAH BECK

This is very exciting. And in just a minute, I want to get to more of how being a gardener, working with soil and plants is going to possibly come into this future scenario. I also want to ask you though, because you mentioned the aerobiome, which I know during COVID we talked about aerosol science all the time. And you mentioned that these small particles might just be in the room with you.

How does this aerobiome concept work and is this having to do with this public health, urban planning conversation? You know, it's not just placing a big garden bed somewhere, right?

MARTIN BREED

Absolutely. And I think one of the most important things that did come up before in our conversation is we don't eat dirt. Most of us don't eat dirt. So if you develop a soil biological community that's full of these microbial old friends, and we're not exposed to it, or we don't interact with it, then, well, the health gain has not been realized.

So what's the pathway of getting exposed to that? And how does that relate to the green spaces that we have in our cities? So that's an area of research and we've been trying to crack that nut because that really is a very challenging space where we need to know does the soil microbial community get aerated above the soil that we might be walking through?

And we published a couple of studies in the last year or so that shows absolutely, yes it does. And so the closer you are to the soil, the more soil-like the aerobiome is.



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That's perhaps intuitive, but we also characterize what's called vertical stratification, or we call it vertical stratification in the aerobiome. So the higher off the ground, you go, the more dissimilar the microbial community is. And that's a problem because if you're an adult, I'm about six foot tall or so if I'm walking through the park.

SARAH BECK

You might be too tall to experience all these benefits

MARTIN BREED

And little Oli, when he can walk, he's probably going to be at that half meter height. And so he's going to be exposed to a very different community just because he's closer to the ground.

And the reason why I think this is really important is because it's very hard to change people's behavior. And when public health recommendations come out about that say, do not smoke or you know, do lots of exercise. There's going to be lots of people who will not do those things. And maybe eventually people will agree to it and see the behavior and see the value in the behavior change or feel the social pressure to make the change, but it's very hard to change people's behavior. And we've seen a lot of that with COVID, with all sorts of politics and social issues that are going on. We see it all the time.

So as a public health person, you can do things that people then get the benefits without having to change their behavior. And that's where this really links in. So can we develop an aerobiome in areas that people commute on a daily basis or where people work or where people live? Where they don't need to change their behavior, but we've changed their environment.

So can we transition the aerobiome by creating aerobiome supply parks, where these microbial communities in the air spill over into the commuter areas and people can walk through and hopefully get bombarded with a safe community of microbes and get the health benefits accordingly?

SARAH BECK

Let's dive into that just in terms of, you know, those of us who are garden futurists and you know, the Pacific Horticulture crowd, maybe not immediately now, but what do you see in the future as their role? What if a community garden could be one of those hubs where you



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could passively enjoy the benefits of that aerobiome. You have to bend down and smell something probably, right?

MARTIN BREED

That's right. The garden futurist. I think that is essentially what we're talking about here. These are gardens, multipurpose gardens, we need to work with people who know how to make aesthetically pleasing gardens because people then will be more attracted to go to them and spend time in them, hopefully.

We also need to make them sustainable, where in Australia, probably like some parts, you know, Western US, in California and such, there's limited amounts of water. So we need to make them fit for purpose as well. But I'd love there to be ways as a community of people that goes around and knows one of the benefits of developing these gardens that people want to go to, is to their health.

But at a level of, let's say, a city or across a region, there's a second problem. And that is areas that are relatively poor tend to have less biodiversity and are likely to benefit more from this. So this is called the luxury effect.

Calling for ambassadors I think is a very important component here and we can't just develop really what I would call a luxury commodity. We want this to be used and the benefits are real in the areas that are relatively poor or the communities that are relatively poorer off. And so I think there's a responsibility to ensure that it's not just helping improve the wealthy areas, but also works in other areas where people may not have the spare time and the ability to do this kind of work. So, yeah, that's where the ambassador role I think comes into it. Absolutely.

SARAH BECK

I love this idea of this being somewhat of a civic experience, too. I mean, thinking about city spaces, I'm curious if you think in the future, there will be some set of recommendations that could align in terms of plant species decision-making as well? And whether some of that comes into play as far as our selection of plants and that relationship to the soil?

MARTIN BREED

Absolutely. And that's one of the most common questions I would get asked around here. And that is, if we know that we can create these sort of soil environments, what do I plant? And that's a difficult question because people just haven't done enough studies in this space.



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I would think a lot about the diversity of plants because diversity of plants creates diversity of habitats for microbes. And that then, hopefully, and there is a hope, there is an association, one would hope that also creates then that health provision from the soil microbial community.

SARAH BECK

So the work that Pacific Horticulture is doing right now, trying to encourage as many people as possible to grow biodiverse and climate-appropriate and water-efficient plants. We're basically already improving the immune health of everyone around us by doing that.

We may not know exactly what the percentage mixture is, if we should, you know, have a certain number of grasses and trees and fruiting things or what that should be. But it sounds like you're saying we're not going to go wrong on that track.

MARTIN BREED

I think that is absolutely right. So it's a very low-risk recommendation. It's probably good for us, but it's definitely good for nature and it's definitely good for our local ecosystems. So we're, and not just me and my team, there's many teams really trying to work on those causal relationships and I'd say if we have a conversation in a couple of years time, we might know a lot more about that jigsaw puzzle, which is what species we're to create this certain health outcome? Because people are really running with that around the world. And two to five years I think there's going to be a lot more known about that jigsaw puzzle, because at the moment, I completely agree. It's an extremely low-risk pursuit to do this biodiverse-orientated gardening, and it's probably got immune benefits via our gut microbiota and other pathways. The microbiome is only one pathway.

SARAH BECK

Yeah, no, I'd be fascinated to understand whether some of the habitat gardening that we're working on doing with a lot of pollinator focus, thinking about those relationships between plant and animal interactions, and then the soil. There may be all kinds of special interconnectivity there. Right?

MARTIN BREED

Absolutely. So talking about pollinator gardens or habitat gardens. I've mentioned before everything is everywhere in a microbial world, but there's a second part of that sentence, which is, but the environment filters and that's an ecological term where everything could be anywhere but things get selected for and against and so we need these pollinators. We need



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these animals in an ecosystem and these, you know, we need wind and everything else because this is helping to move and distribute these microbial communities.

So we need these, to think of a better word, we need these vectors to move these microbial communities around. So if we create a really rich biodiverse soil environment in one area full of microbial old friends, and it just sits there. That's probably not very good, but we need ways to move it around. And so creating I think these habitat gardens is a very, very good way to help move that benefit into other areas.

I think it's a wonderful opportunity to really bring nature into our cities, into our backyards, into our school systems, which, you know, a lot of them are gray spaces. And so I think it's a very optimistic vision to actually introduce some biodiversity into everybody's life, not just just the garden enthusiasts, but they can lead it.

SARAH BECK

Yeah, absolutely. And we can bring human health as well as environmental health. Thank you so much for your time today. This was really fun.

MARTIN BREED

It really was. Thanks so much, Sarah.

SARAH BECK

That was a really interesting conversation. Adrienne, what do you think?

ADRIENNE ST. CLAIR

This was fascinating. It's something that I've been interested in for a really long time and I've come to embrace this idea of the microbiome being this safe and beneficial thing for us. But I have to tell you that having a kid in the pandemic has really challenged that idea for me. And so it's great to hear and be reminded of, and it really encourages me to get her outside as much as possible in the time that we have.

SARAH BECK

And that was such a, I think, fascinating part of that conversation, especially knowing that. Dr. Breed has a very small person at home right now, himself, and thinking about just some of the issues of equity and thinking about how those of us who are city dwelling, or really anywhere where there are degraded environments, we may not have access to the microbiome that it would be present in, you know, a beautifully restored or even a landscape that is fairly untouched.



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So thinking in terms of equity, it just really made me reflect on this thought that, obviously we want everyone to be able to interact with this immune-boosting and harmonious world. And to have that, obviously all wanting to have the aerobiome around us to be safe, but also beneficial.

ADRIENNE ST. CLAIR

Yeah. Yeah, the point that he made about being able to bring in parts of the forest, into daycare centers and into schools and that that could help break some of that barrier of equity and people having access to nature, I thought was very compelling. I'd like to see that grant be written.

And this tiered layers of aerobiome coming up from the soil and how him at six feet versus his child at, you know, a meter, three feet, that difference in the aerobiome was fascinating.

SARAH BECK

I thought that was incredibly interesting that there were these strata, you know, of experiences to be had out in the world, depending on how high up you are.

ADRIENNE ST. CLAIR

It gave me this visual of like, when we talk about forest bathing, we should actually be talking about being on the ground, in the duff doing dust angels.

SARAH BECK

Forest crawling.

ADRIENNE ST. CLAIR

Forest crawling.

SARAH BECK

Is really what we need to be doing. We might be too high up. We need to get down where the children are.

ADRIENNE ST. CLAIR

Yeah. More play time, grownups need more play time.

SARAH BECK



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Ah, that's fantastic. The other thing that just occurred to me is just this conversation that he sparked about the idea of designing, how to design city spaces. Not necessarily just city, but how communal, how civic space might in the future look based on our knowledge of some of these points and this idea of, just looking at where people are passing through.

Let's say people are going on their way to public transportation or through a city park, or any of these communal spaces. If we have that understanding of the microbiome and the aerobiome, how would we perhaps fill some of those corners and those spaces that are just part of our everyday civic experience so that they're benefiting us in some way?

ADRIENNE ST. CLAIR

What I think is most exciting about what he's talking about is that we all have a path to the microbiome. So we've got our backyards and we've got the plants that we're planting in our backyard and the soil that we're working with, or we've got our community gardens, or we've got the local park or the regional park, or we can drive off into wild and urban wild settings.

And so. Whatever that path is for you seems like a great option. There's always some more microbiome to be included that isn't in your own home.

SARAH BECK

Yeah. I love that. And you know, it just creates this feeling of access and the more that we can be aware of the microbiome as we think about all of these aspects of life, whether it's as large-scale as designing a civic space or spaces that humans move through in a city or a town. Or if it's just about our awareness in our own spaces and our own gardens and this opportunity to touch soil and not wear our gloves and allow ourselves to interact with ideally healthy soil, healthy plants and plants that are adapted and appropriate to that place. It's likely that those benefits will be available.