Key:

I = Interviewer
R = Respondent
Unclear: [unclear + timestamp]
Talking over each other: [over talking]

Welcome to IFL Science, the Big Questions. A series where we ask the experts some of the most pressing mysteries of science technology and humanity. I'm your host, Rachael Funnell, Social Editor and Science Writer for IFL Science. Today I'm going to be speaking with Luca Gamberini or Nemo's Garden, which is an organisation who have achieved the first ever under water cultivation of terrestrial plants. Gamberini has been working on a new way of growing food using biospheres which, kept in underwater environments like the ocean, are capable of producing their own condensation to water growing plants. Being inaccessible to insects the biospheres also remove the need for pesticides, which can be harmful to pollinators as well as the environment.

Here, the mission of Nemo's Garden ties in with Our Green Planet, which is an impact initiation from BBC Earth that we at IFL Science are proud to be a part of. The goal: to raise awareness for the beauty and fragility of our planet's green ecosystems and forward a deeper understanding of the important role that plants and green spaces play in biodiversity, as well as being inspired by the extraordinary stories of people from around the globe who are dedicating their lives to enacting positive change. Gamberini and his team at Nemo's Garden certainly sit within this category as they've been working hard on perfecting underwater biosphere cultivation processes which could reduce some of the negative impacts agriculture currently has on Earth's green spaces.

So, let's find out what it's all about.

[Music]

Hi, Luca, thank you so much for joining us for the Big Questions podcast today.

Hi Rachael, it's great to be here.

I guess the first question I want to touch on is what was it that first inspired you to think about growing produce underwater?

Well actually, the story is kind of funny, it started as a garage experiment for my father. He's the founder of the company. I am the third generation, so it all started with my grandfather and my father is an engineer, he's a chemical engineer. He does spend a lot of time in Noli, where we ended up to have this project installed. During one summer he was having dinner with a friend who is a traditional farmer, working on land. They have always had a great relationship and they were trying to find a point of contact in both their worlds professionally. In their downtime, one of my father's hobbies is actually gardening and growing plants and produce in our countryside house. Just as a bet, as a fun bet, in discussion his friend said why wouldn't you try to grow something underwater? My father is

that kind of guy. The kind of guy that just goes, you know, what, I'll try that. It was a bet, it was something stupid during dinner, and quite honestly I was the guy that most opposed the thing. It started as a garage experiment then it took a little bit more time. It went from vacation into work, into working vacation and blended, and we're doing a lot of stuff. We're really all over the place. In the beginning to me it just seemed like a loss of time, but I think the first time that I actually saw a seed sprout under water, I was hooked. I was convinced. Sometimes it happens with an idea, you can engineer the thing. We went from a bet, so something very childish, very stupid, very fun, to "wait a minute…" It does solve some issues and that's what took us to the next steps.

Fantastic, that's a brilliant origin story. I guess it's crucial to ask how actually does it work?

Yes, that's the retro-engineering that we did. The principles are incredibly simple. The fact that we're underwater, the biosphere behind me is a real live model. This is a real life biosphere model, this was underwater for a while, a working unit. We have one of those with an air environment trapped inside, but under water. The air stays trapped because the biosphere, this cupula is anchored to the sea floor. It is just like when you flip over with the canoe, there's air inside, you can breathe. It's the same thing. Water will not go in and the air will stay there. You do have a volume of air trapped underwater. You do have transparency, so you get sunlight through the water and into the biosphere and it's enough for the plants to grow. It actually cuts harmful frequencies of the light, which is great. Also, warmth, there's a lot of energy in the water. When you think about cities that are built close to the oceans and sea, it's usually because in the time when they were founded, it was a very comfortable temperature. That's because the huge basin of the oceans and the water just holds warmth so much longer. Vice versa, during the very warm summers, such as the Mediterranean one, even though we're in the North, at least by Italian standards, it does become really, really warm outside.

The ocean, in this case the sea, chips in with the cooling effect. What it does is regulates temperature. It does the same thing in the biosphere. We always have a very comfortable temperature around the biosphere, and some degrees more inside the biosphere, given by the fact that it is air volume. That volume will shift quickly in temperature. Outside it will stay warm. What happens is that during the summer it's going to be warm but not too warm, and during the winter inside it's going to be much warmer than the air outside and a little bit warmer than the water outside, which is very much warmer than the air. That's for free. One of the most other important and basic concepts of this project is that you get evaporation. It's kind of the reason why we called it a biosphere. The biosphere is a term usually connected to a small scale of what the planet is. Our planet is a sphere, it's a biological sphere, and this is a biosphere as well. It works in the same way. Because of physics that water will slowly evaporate. It's just what happens in the oceans, right? When it evaporates inside the biosphere it loses its content of salt. It's not salty anymore and it becomes fresh water. That fresh water can then be harnessed to hydrate the plants through humidity or condensed, thanks to the difference in temperature, outside and inside and actually used to irrigate the plants.

That's another factor that is completely free, that you get completely for free underwater. Then you have protection of course. There is nothing that is a common threat to the growth of plants that would reach them underwater. We don't need any pesticides, we don't need anything of that sort to protect the plants. All in all I would say that in how it works and why it would work well is the fact that it's using an unutilised space, better volume and as long as we do it consciously then bingo.

Amazing, I've got to ask, does it feel weird when you're inside the biosphere?

It's incredibly weird: you are in an inverted aquarium. For once it's the fish looking at you, like "what the hell are you doing there". It's very strange. It happened in the first years of experimentation when we knew nothing. Again, we come from manufacturing scuba diving and protection equipment, so definitely not agriculture agronomists at all. We started with soil. We still hadn't explored the idea of hydroponics, aquaponics, and not taking soil around the world. It's a concept that we transcended, that we passed. At the time we did bring some soil and the soil carries a lot of issues. One of them is being contaminated, meaning normal stuff, as larvae. We've had small flies hatch in the biosphere and all of a sudden you would be in scuba diving equipment, breathing air underwater with fish outside and a fly in the air, maybe five, six, eight meters under water and that was really weird, really weird.

So why is it that we need to be looking for alternative solutions for agricultural practices like this?

Yes, let's take the serious turn. I would say I think there are multiple reasons. It's now years that we're talking about issues with bioenvironments. It can be global warming, it can be the depletion of our resources, the rise of sea levels, pollution, CO_2, plastic. There's a number of things that us human beings are doing to our planet that is not okay. We are leaving a huge footprint to the point where scientists are telling us that this footprint might not be erasable at all and we might be close, if not surpassing, the turning point of not being able to go back. Agriculture is a huge part of this footprint. It is one of the culprits, the major culprit, of global warming. We know that for various reasons. One might be the growing of crops for animal growth, so the big industries, the meat industry. Of course in general agriculture does not only deplete resources in that way, there is pollution of the water ways, there is the reduction or arable land space, there is the deforestation that is that we're trying to increase that space to grow more. We have incredibly resource-consuming cycles in agriculture, so we're trying to increase the yields way more than we actually can and so on and so on.

Everyone in this industry is trying to find a solution. There's experiments in the UK with growing in the subways I believe, or anyway definitely underground. There are incredible companies huge companies developing hydroponics to the max, we are evaluating aquaponics, we're evaluating other food sources. If we are creatures of intellect we understand when certain signals are all going in one direction. That direction is that we are a lot of people in this world and there's not enough to sustain us all, and definitely not enough to sustain us all in a way that can be valuable for the Earth, the cycle is too quick. And hey, if you just look at the news, today, we're talking about the fact that we are possibly looking at hunger possibility coming up because of the war in Ukraine and the fact that we are losing at least 15 percent of the global production of grain. That's happening because we are so sensitive to these changes and aspects because we are pushing it too hard. I think it's inevitable, to try to cut my talk short, I think it's inevitable we need to explore every possibility and we need to do that in the most responsible way. It means we can not only answer the question of let's make it cheap, let's make it a lot.

We need to find a way that is sustainable for the future and it has to be a multi-dimensional answer to this question. It cannot be anything different. I think that this solution is ticking a lot of boxes, maybe not all of them, maybe we can do better. Actually we can, for sure do better, we can develop more. But we can use a lot of that space that is free to use, at least in our experience, it's not damaging the

environment, the underwater environment at all. It's creating new job opportunities, there's not a lot of underwater gardeners out there. It's something that can be used in a lot of places in the world. I would say the whole middle belt of the world where there are incredible differences in temperature, lack of soil, arable land, resources, definitely water and there's a lot of actual sea and ocean available. Accessing even small fragments, a small percentage of that space is already a huge gain, I believe.

Those environmental issues are really important, and on that vein, how does this method of growing food using the biosphere compare in terms of sustainability to terrestrial produce growing practices?

Well I think that the fact that we can extract a lot of components that are needed for the plants in a sustainable way, and in some ways for free. I want to say for free but let's give you an example: If we need heating for greenhouse, let's compare it to a greenhouse. If we install a greenhouse we need cooling and we need warming. That's the point of a greenhouse. Now we have the ocean doing that for us, at least to some extent, and that is the selection of the location where you go in and install it, right. So, it's kind of deciding "where am I going to place my land to grow produce?" "Am I going to do it on top of a mountain?" Well no, it doesn't really work that well. You are adapting anyway, to find the correct place. I'm just saying let's find that correct place, in a place that wasn't used before. In this case, the ocean. Let's decide a depth that is convenient for all the factors, that can maintain a certain level of temperature that it is reasonable for the crops that you want to grow, and that you will have for free. You will never need to consume resources and thus pollute, money and resources in terms of environment resources to heat and cool the greenhouse, the underwater greenhouse.

Then you need water. The depletion of our waterways, because of the diversion for the use of agriculture, is known, it's very known, and we don't need to do that. We are utilising the ocean in the ocean, so it's very quick and doesn't create bad consequences in the use of this water. You're not using pesticides, of course there's nothing that can reach our plants. You don't need pesticides and you're not polluting the water ways in that way either or any of the soil or anything else. I think you are combining the pros of greenhouses and I want to say some aspects of hydroponics and aquaponics, and putting it in an environment that benefits the plants through natural aspects. Another one is light, again there is no need of protection for the plants that is involving anything complex. The ocean does that already pretty pretty well.

Then we can go more in detail on what are the actually pros of the changes that occur in the growth of plants on the water. This is all a new thing I think for us and for everyone. It has to be still explored better, but our plans grow faster. Especially in the first phase of the life of the plant, there's a sprouting which I want to say is at least 50 percent faster in our plants. It's certainly due to various reasons. Light, as we said the environment, the stability, everything like that can be replicated in a greenhouse or in a lab.

But the aspect that is not commonly replicated, and thus that we think is really applying to our plants in order to give them a faster growth and in a concentrated essential oils, let's take the basal plants that are our control plant is possibly the added pressure. Right now we are just ambient pressure, but when you're underwater we have an increased pressure. That increased pressure possibly is contributing to both the growth factor and the heightened concentration of certain contents of the plant which can benefit who consumes the plant, of course. Or, it can benefit the pharmaceutical

industry whenever you are planting or growing things like superfoods or plants that have a content that is interesting for pharmaceutical companies.

Wow, that's really interesting how the pressure can change the growth rate like that. I was wondering if you can tell me some examples of things that you've already grown, what you hope to grow, and if there are limitations on what these biospheres can create?

We tested a number of plants, I would say at least from 50 to 100 different plants, from aromatic herbs to salads and strawberries and beans, anything with higher content energy wise. Melissa is a plant used as a sugar derivatives and we've had success with most. We have had flowers underwater which is incredible. We've had fruits such as strawberries growing underwater and I think they've all been very, very successful. Of course you need to select a plant that makes sense for the conditions you're in, otherwise you're doing exactly what we as human beings are doing wrong everywhere in the world, just expecting that a mango can grow in Helsinki, which is ridiculous I think and it's not the way we should go. The same thing applies to Nemo's Garden, you cannot grow grain, the plant is too big and this is too small. That's not going to be an alley that we're interested as of now, with this shape even though we are developing different shapes and different kinds of systems to maximise growth of bigger plants.

This is the selection we are doing. We would select a plant that is compatible with the environment we're going to install the biosphere in. I want to say in that temperature, so it's something that makes sense there with that degree of humidity without having to alter it too much. With size that makes sense to maximise the use of these biospheres.

Amazing. And with those limitations in mind, but considering all of the environmental benefits, do you think that the future of farming could be underwater?

I honestly think so, I honestly think that there is a part of demand that can be solved and can be answered with this technology. I find it very logical. In our experiences, all these biospheres have become an artificial reef where we decided to install these biospheres that was on gravel, nothing. Of course there's always life in the ocean luckily, mostly, and it's of course a place where it's not polluted, I want to say that. But it had been destroyed by dumping of an amount of quartz and sand due to what happens in Italy, which is often trying to rebuild the sand and beach for the tourists during the summer. They just dump a lot of dirt, and that suffocates everything. It goes on top of the algae and the ecosystem and just suffocates it. The result is what we are experiencing, which is a desert, apparently a desertic flat land of gravel stone and mud and sand. So we installed the biospheres there and all of a sudden what happens is it becomes a shelter for smaller organisms, they all crowd there, they all grow on the things that we've made, which attracts bigger animals and the normal food chain. Now it's an aquarium.

We've had students there studying the biodiversity around the biospheres with actual scientific papers demonstrating that we have a unique environment which is not replicated around it, which means that's a magnet for sea life. If we can do that and at the same grow produce, I think we're doing something good. If we also accept the fact that these technologies can be installed where it's going to be most needed. Let's take the Maldives as an example. The nation imports everything, or mostly I think almost everything. They cannot grow anything in their country. Everything comes through ship and that's a toll on the environment, on resources. They also need to keep the costs down because

then it otherwise becomes inaccessible. How is that reasonable? It is not. It is not something that can be in the long run sustainable at all. I think if you start installing biospheres and things like this in places such as the Maldives, that have these constraints and resources, you are, for sure at least partially, answering the demand and the needs for these places. Imagine all the new jobs that you can create also. It's a whole new technology that blends competencies that people there might not have. Also, it could create some more. It can create incredible tourist attraction as well. It's just beautiful and looks incredible from the surface and from underwater. I truly believe that it's a futuristic answer to our issues.

Amazing, I'd love to see it. What do you hope to achieve next with Nemo's Garden?

We need to maximise the yield for sure. It kinda sounds like it's a counter-argument to what I said before, where we're always trying to achieve that, but I do understand and agree that there is a price point that you need to reach, which is definitely not what you will find, for 50 grams or 10 grams of basil in the supermarket. That's not possible, I think as of now, with our technology. We need to try to get as close as possible, I don't expect it to be the same price at all. I truly believe that the prices that we are accustomed to, the costs that we're used to paying for these products in supermarkets, it's artificial. It's given from the fact that we are not included the damages in our environment, that we are bringing into our environments to have these costs so low. I truly believe that that is true and we will see that in the future. If we aggregate all the damages that we've caused and the billions of dollars that we need to, we will need to and we have already invested in damages due to global warming and climate change, I think that prices rises up easily and then the gap is reduced.

Definitely. For my final question and speaking a bit more generally now, how do you think we could make better use of our seas?

That's a great question. We need to regulate it for sure. At least in my experience, we've been working with the ocean and the sea and waterways for quite some time now, and definitely all my life has been in the ocean, and what I see is there is no regulation. There is really no regulation. Just the fact that there are international waters that are non-regulated as the national waters and you see fishing with absolutely no rules and I just think it's a no-one's land and we don't care as much. We're starting to care now thanks to documentaries, and sensational documentaries of course that try to sway public opinion to not accept that this should be okay. I think we need to do much, much, much more. Much more. We should try to regulate also a little bit more in a rational way. There are incredibly strict regulations that block research due to environmental reasons which I understand completely, and then there are black holes of deregulation everywhere else. I think we need to come together as a global community. There's no other possibility.

As long as we are following different rules, a different set of rules or certain parts of the world follow incredibly strict rules and other parts of the world are completely deregulated, and that is then mixing up into the international community of the free exchange and catalytic market which is normal. That's not going to work, it's simply not going to work. We need to understand that I think, and regulating whatever happens in the ocean on a global scale is of paramount importance.

I think you raised some really interesting points there. Thank you so much for your time today Luca, I'm really looking forward to see where you go next with Nemo's Garden and I hope we get to catch up again soon.

Thank you very much, it's been a pleasure.

Thanks for listening to IFL Science, the Big Questions, head over to IFLScience.com and don't forget to sign up to our newsletter so you don't miss out on the biggest stories each week, until next time.

[END OF TRANSCRIPT]