**The Taproot Podcast**

Season 6, episode 2

Guest: Olivier Hamant

Hosted by Liz Haswell and Ivan Baxter

Transcribed by Jo Stormer

Liz Hello everyone and welcome to the Taproot Podcast. I'm Liz Haswell.

Ivan And I'm Ivan Baxter. We hope you are ready for some navel-gazing, because today's episode gets pretty deep pretty fast. Our discussion centers on the concepts of efficiency and robustness, and the ways in which they are often in conflict. This framing has wide-ranging application, from plant biology (of course!), to lab organization, to the global economy.

Liz And, in keeping with this season's theme (finding a new normal), we discuss these ideas in the context of the pandemic, and how we might keep applying them even now.

Ivan One programming note: we are taking a break over the holidays but will be back in January with three more episodes. So without any further delay, let's get started.

00:13 Liz So our guest today is Olivier Hamant. He is a PI at INRA in the Plant Reproduction and Development laboratory located in Lyon, France. Olivier did his PhD on knox homeobox genes and that was in 2003, and then did two back-to-back postdocs: one in Berkeley with Zac Cande and one in Lyon with Jan Traas. He took his current position there in 2012, where he works on the mechanobiology of development. Olivier has received a huge number of awards in recent years. I wanted to mention his recent award called The prix Foulon from the French Science Academy, which he received in 2020. Welcome to the Taproot, Olivier.

01:04 Olivier Thank you for having me.

01:06 Ivan Thank you for joining us. Today's paper is a comment entitled, "Plants show us the light", published in *Transplant Science* in 2020. Olivier, can you give us a short summary of this paper?

01:18 Olivier Sure. So the idea is when you look at photosynthesis the yield is very low; it's less than one percent. You have to wonder why photosynthesis is so inefficient. It's been this paper actually two years ago now, that showed that the reason why photosynthesis is so inefficient is because photosynthesis has

been selected to match a fluctuating environment - fluctuating light, fluctuation inside the cell. For this, there's only one solution, basically to absorb light in the red and in the blue, and to reflect the rest. So there's a lot of waste, a lot of wasted energy. I guess the take home message at the end of this is that during evolution, living systems like plants build their capacities based on fluctuation and not on performance or efficiency.

02:17 Liz This is such an interesting article that you were discussing. I loved it because I've actually taught this question in my class, asking them why are plants green and why don't they absorb in the green? And the answer that I've always used in the past, red light has very long wavelengths, and blue light has really high energy, those are two good things. So you either capture lots of high energy photons or you capture long wavelengths, but the green light doesn't have either of those benefits. But it sounds like this is a completely different explanation.

02:57 Olivier I guess it's not mutually exclusive. I mean, what they show in that article is quantum physics so that's beyond my pay grade [laugh]. What they show is that if you wanted photosynthesis to be at the maximum of efficiency, the photon capture would have to be stable; I mean the photon flux would have to be stable, whereas it's never the case, right? Light is fluctuating and also the cells are fluctuating. So there's only one solution, at least based on that paper: to absorb in the red, absorb in the blue. That way you allow all these fluctuations.

03:35 Ivan Do you think that means that we can't engineer photosynthesis to be better?

03:42 Olivier There are projects about improving photosynthesis, but I indeed agree that that's probably a bad idea to try [laughing] to make it more efficient. They will be negative externalities for sure. We know already that plants are doing everything they can not to burn their leaves. There's already some pigments that dissipate the excess of energy. Even if you look at photosynthesis, the light capture is only one element of it. There's also downstream; rubisco is the typical incoherent enzyme, but still it's the best we have. It's so inefficient, but it allows the fixation of nitrogen. It's all a multi-component system, like everything in biology, so, if you make something more efficient in one corner, you're going to have some problems in other parts of your system.

04:36 Ivan Why you would want to engineer photosynthesis and make it more efficient is that in our crops it's already a very artificial system, as opposed to the natural systems where the bulk of evolution happened. If we are sort of agreed that we're going to put these very carefully (carefully controlled as a strong word) fields or things then you're already doing enough artificial stuff. If you can make it more efficient, it may work as well.

05:09 Olivier My take on this is that right now, these agro systems, they work but it won't sustain for too long. That's why I focus so much on fluctuation. When you, when you look at the environmental reports either IPCC or anything else, basically the main takeaway message is that the world is going to become turbulent; fluctuations are going to increase. So what we should build is agro systems that are able to sustain themselves in a fluctuating world. For this, the more you have a system that is dependent on control, the more fragile it becomes.

05:56 Liz As I was reading your article, I was thinking about this word *efficiency* - which has a very specific use when we're talking about photosynthetic efficiency. But I couldn't help thinking about a conflict between robust human behavior and productive human behavior. Do you know what I mean? Human systems can be very productive, they can make a lot of stuff, but they're often not very efficient. Actually, a great example of that is the whole supply chain fiasco that the world just went through, where I guess in a way you could think that those systems are super-efficient, because they were making sure that there was never any supplies stacking up anywhere. Everything was always being shipped at a moment's notice to where it was needed. But then as soon as there's some disturbance in the force [laugh], then the supply chain just completely fell apart. Does that make sense to you?

06:58 Olivier Absolutely, absolutely. Exactly. Actually, the idea is that when you optimize something, you weaken it. The more you optimize the system, the more the system becomes weak. You talk about supply chain, that's a typical example. The Suez channel was a typical example where you have these big boats that are super efficient, right? And the minute they go oblique in the channel, then that's it. That's another case where you optimize transport in the Suez channel. You transport a lot of goods through the shortest path, but the minute you have these big boats in the wrong orientation, then that's it. You're done [laugh]. And it's true for pretty much everything. As a human society, we've put a lot of weight on performance, which I define as the sum of efficacy and efficiency; efficacy (reaching your objective) and efficiency (with the least amount of means, it's really like to be straight to the goal). And so if you look at everything around ([unclear], supply chains, even the way we sometimes do science education), everything is optimized. Engineering is becoming really like the job for everything, right? From electronics to didactics. They are generating in every single system. We always want to increase performance everywhere, but we don't always ask the question of robustness. There are a few places where we ask the question of robustness; for instance, it's in robotics or sometimes in the digital world where the question of robustness is prevalent. But overall, we tend to believe that performance increments are always positive, and we are actually at the stage where we can see that performance increments start to be negative.

08:57 Liz Interesting. I have to say, I find this ironic coming from you since you were such a productive and efficient scientist [laughter]. I wonder,do you feel like you're balanced on the edge of something, you're so productive that you're losing robustness? [laugh]

09:15 Olivier Everyone here, we are all driven, right by passion and something? But I guess one trick to not fall into the performance increments all the way to the burnout is to diversify. If you do several things that are quite different, then you know you're never going to be at the top of your game in every single field. It sort of balances things out a little bit. This is true as well for biological systems, actually. Biological systems, when they are challenged with resource scarcity, when they're really challenged, they usually diversify. So it's also a way to counteract rebound effects or like the negative effects of high performance - always to diversify.

10:03 Liz Give us an example of that.

10:06 Olivier For this, I can take the example of soil, for instance, the little animals like the decomposers and everything. The soil is a rich environment, right? And because the soil is rich, usually these small animals are reproducing asexually; in terms of genetic diversity, not so much. But when the soil becomes poor, when the resources are becoming scarce, those animals switch to sexual reproduction; then you mix the genes and you increase the diversity. This is true for most, but of course you'll find exceptions. Usually when there's a challenge, you diversify. We humans, we do exactly the opposite, right? We are facing resource scarcity (energy, materials, metals) and what we do is to try to make energy production more efficient.

This is exactly the wrong way to go, because when we do this, actually, what happens is that in the short term, we gain some performance - those technology become more attractive. We buy more, we consume more; at the end, the global consumption of resources is increasing. So we should learn from the living systems and diversify instead of becoming more efficient.

11:23 Liz What is your diversifying activity? I think it might be music.

11:30 Olivier It goes always to music, even in my team. I say “our team”, because now it's a multi PI team, as are often in France. We have different subjects. I mean, part of it is the role of mechanical signals in development; that's the core aspect of the team. But Charlotte Kirchhelle has joined the team so now is the idea of the cell edges linked with mechanical signal, which I think is super exciting. That's also taking the team to a slightly different direction, and there are also people in the team working on more science and society questions. It's one project on spelt with local farmers. I can tell you that this is taking a

very, very different direction compared to the rest of the team, of course, a very exciting project as well.

There's another student working on Pollard trees - trees that you cut midway, and then they make these big heads because of extra proliferation. There are some mechanical aspects to it, but there's also some citizen science associated with that cuz people use this to have biomass in winter, for instance. It can be these kind of things.

There's a third project, just to tell you the extent; it's very eclectic. There's a third project on bio-sourced meta materials. Basically, so without physics, where actually we found that if you take an onion and some peels - an onion peel, basically - these peels have phononic properties. So it means that they let many acoustic waves go through, but they can filter some specific acoustic waves. These is what some rare materials are doing in your smartphone, for instance. So the idea would be that you change this with bio sourced material. This is for the team and then of course, you have this music.

13:20 Liz So we're gonna have onion cell walls in our cell phones? That what you just said?

13:25 Olivier Yeah, that's the idea. [laugh].

13:27 Liz That's pretty cool.

13:29 Olivier Of course that's very upstream research, right?

13:32 Liz Very cool.

13:33 Ivan I think this is a really interesting topic, cuz we do talk about labs. Well, that lab is so efficient. They just put out the papers, they get the grants, and we talk about it. I feel like that's often used as a compliment by people who wanna ignore all the terrible toxic culture stuff that happens in labs that are super efficient. But I do think it's really interesting to me that you say you have this very diverse team that's all working. I guess when I think about robustness, one of the things I think about is what happens especially in a science lab, is what happens when you lose someone who is like the one person who can do something. So as you were talking about all these people and this diverse team, part of me said, “Well, what if somebody decides to become a full-time musician and leaves?" Do you just drop that project and it's gone? But you've got this diverse stuff, so that's okay? How do you decide what's an essential project to keep going when you've got all these different approaches?

14:57 Olivier True, that's a good question. Usually the project we have are highly collaborative. That means that one person in the team is collaborating with many people outside of the team. I guess the robustness is a bit external, as

well; it's a network of collaborators. But I agree that if someone was leaving the team and with very specific project, probably that project will leave the team and maybe something else would go. I guess it's diversity in time as well, right? We are open to changing subjects in the team. I mean, there's a core on mechanical signals where there are several people who can do similar type of things. There's sort of a core, let's say, know-how in the team, but the more peripheral projects are a bit more open to change.

15:51 Ivan Some of this is sort of built into the French system - this idea that there's gonna be multiple PIs with small labs. My external view of how the French system works is that you end up with these research institutes that have lots of small groups and there is core funding so you always can keep that going, but also it's very hard to get really large grants and really scale up so I don't think you get many large labs in the French system.

You did your postdoc in the U.S., so you were sort of exposed to our system. Can you sort of contrast for us? In thinking about this efficiency versus robustness contrast, where do you see the two systems - the benefits, and the drawbacks of those two systems?

16:42 Olivier It's an interesting comparison. When I went to the US the first word that I thought about was *trust*. There's a lot of trust in the US, I mean of course in the scientific teams. When you do research, I felt completely free to do what I want. I could pursue some ideas. No one would say, “Well, that's crazy, stop it." Just the opposite. “Go for it. Go crazy. Try it. Go for it." I think in France we have less of that culture. It's more a culture of constraint, I would say. That’s to say, “It's good if you do this, but have you thought about that? There's also that person who is doing this, so maybe you should do it a little bit differently." There's that general philosophy, which is actually also beyond science. Trust is a problem in France, I would say it's more constrained, less trust.

17:40 Liz That is so interesting.

17:42 Olivier Yeah, actually in French it's a *confiance* for trust and *contrainte* for constraint. They almost look the same in French (*confiance*, *contrainte)*, but it's two different things.That's the general philosophy but then on the positive side what I like about the French system is, well, the fact that we have permanent positions, which means that you can do risky projects and no one is going to judge you for it. [Laughing] No one is going to value you for it as well, but at least you can you can try it.

The flip side of this is usually because you have permanent position, we work a lot as a multi PI team. Indeed one PI as a small team, but PI usually are grouped into larger team, which is interesting as well because then you can

share expertise within the team with several PI, and also the people behind the PI can collaborate and everything. Everything is more mutual, I would say, shared. Equipments, everything is very horizontal, I would say, for sure. But that goes with the permanent position.

18:51 Liz I can think of so many ways in which shared laboratories (like co-PI-ships) would be so beneficial here. Think about the robustness of being able to take a maternity leave (for real), and then have your trainees have somebody else that already knows them that's already part of their leadership team just to take over. It seems to me that the US should be thinking about the shared PI-ship more, sort of along those same lines.

19:26 Olivier I agree. I think it makes sense for certain situations like maternity leave, but also if you want to have a more interdisciplinary team. For instance, that's what we did with Arezki Boudaoud. He's a physicist, I'm a biologist. Then you can have a team with the two expertise, and then suddenly you can welcome students in math doing molecular learning, right? This is possible because in the team, everything is there and it's a bit - again - eclectic, but it's a fertile environment.

19:58 Ivan I totally agree that this is something that people should be thinking about and I absolutely see how it makes you more robust. I also guess when I hear “permanent positions" and then these tightly integrated teams, I really want to know what happens when you have a complete asshole on your team? I mean, there's so many lovely people in France. There are, I think, a couple assholes around.

Liz [Laughs]

Ivan Going back to this idea, if you have a toxic person in this tightly integrated team, it can be disastrous, it seems to me. Maybe I'm missing something that allows you to work around it.

20:46 Olivier It can be destructive or disruptive. This happens sometimes. The main thing is that if you are in an institute that is working already with a very horizontal way (where you have a lot of sharing), then everyone that enters the lab will follow that rule, basically. It's already a filter. The people who are problematic, usually they enter labs where the system is already problematic [unclear] where there's a lot of competition between teams that's going to attract people who are super competitive towards dominating and everything. This you don't have if you have policy or general philosophy of making it horizontal. If someone has no funding, we share the funding, we share the equipment, we even share the personnel. So in this environment, you sort of filter this kind of people.

But I shouldn't be too, you know . . . [laugh] It's not always so rosy; you can have toxic people. In the French system, those people, they would be offered to move somewhere else. It's not like it's a permanent position, but it's not . . . you can also be fired. If you do sexual harassment, or if you do, I dunno, like just harassment, you

22:04 Liz Image manipulation?

22:04 Olivier This kind of thing, right? [Laughing] There was some cases, so this can happen. But it's usually for less dramatic situations people are moved or they have to change teams. There's some psychology that are involved. It's a whole process.

22:26 Liz In some ways that's more robust, than a system set up where there's one big PI who is kind of making all the decisions, and if that person is one of these rare assholes, then like, how do you get rid of that? That is a lot more complicated, I think with our real hierarchical system.

Olivier I guess it can be also for the students and the postdocs. If you have a multi PI team or a multi PI institute, let's say, where it's more integrated if there is a problem in a team or if there's a personal problem, then you can even switch teams much more easily than if it's really secluded.

23:06 Ivan Olivier, we've talked a little bit about structuring, how you structure your groups, structuring groups in France. When you look at our science institutions, what are the other things that now that you've sort of taken this lens of robustness and celebrating inefficiency [laughs] going at it taking a different view of how things are structured, what are the things when you look around and you say, we should, we should really be doing *x* in science in our institutions to become more robust?

23:42 Olivier The first thing for me, it's a very simple one, is to drop the h-factor, drop the impact factor [laugh]. This is Goodhart's law. Goodhart's law says that when a measure becomes a target, it's not . . . how you say it -

23:59 Ivan It fails to be a measure. It's not like it when once the measurement becomes a target, it fails to be a valid measurement or something along those lines

24:07 Olivier Yeah, exactly. It fails to be a valid measurement. Exactly, exactly. So that's Goodhart's law. This is really everywhere, right? It's true in sport competition, when there's doping, there's betting, there's money laundering. So sport competition, sport is toxic not because of sport, but because of competition, and in science it's the same in the measure of the h-factor, impact factor, all this ranking, the Shanghai ranking now it's completely disappearing. All these rankings, what they produce is slow **[?]** science, because then you have to go

faster. This is really not the spirit. Robustness is to go against the Goodhart law and to not focus on the measure [laugh].

24:53 Liz What were you saying about the Shanghai ranking? I don't know what that is.

24:57 Olivier The Shanghai ranking is based on the number of Nobel Prize publication in the so-called “best" journals - *Nature, Science*, this kind of items. Of course you have a ranking of universities. Just to take an example where the Goodhart law can be really counterproductive. I can take the French example. For a long time France was not in the top universities so what our French government decided to do was to merge all the university around Paris in a new university called Paris-Saclay. They built that university on the best arable lands in the country. They've been artificializing the land to build a new university. This is the criminal act, at least in ten, twenty years, because this is the most precious thing we have - arable land. And so you build a university on arable land, that doesn't make any sense. So we indeed increased the ranking, but we lost the [laughs sardonically], precious land.

26:00 Ivan Olivier, one of the things that we wanted to do on this season was to really take a hard look at what COVID has taught us about how the way we do science should change. As we are “going back to normal" (I say on the day that my daughter's sleepaway camp has COVID exposures), how do we keep the good things that we learned - go back to the good things we had before - without going back to the bad things we had before.

26:34 Olivier That's actually almost an easy one. I think one thing we learned in COVID, this is the virtue of being slow. When there was the confinement, we had to stop, right? It was painful when you have an extra experiment to do and then you have to stop, and you're just like, “I really want to finish that thing." But we had to stop to think.

When you're slow, actually you think better. You interact with more people, somehow you can bring up, you can read more papers and everything. This is already a positive. And if you push it one step further, really like taking a step back, one possible evolution in the future is to switch from science in the lab to citizen science - meaning that you involve the citizens in some of the questions you ask.

27:21 This is much slower, much more inefficient, but it's much more robust for the society because now one of the main lesson we got from the Covid is the distance between science and society. There was a lot of papers on COVID-19 that were making no sense at all, and that were accepted by the journalists, or they were discussed on the TV show that should have not been discussed at all. They were not even scientific. This distance between the science and the public, the only way we can bring it together is to actually

involve the citizens in the science making. This is much slower, this is much more inefficient. It's also more local so usually it's more difficult to you know, to value in the high-ranking journals because it's situated knowledges. But in the end, you add robustness in the world (scientific world and in the society as well) because now you can deal with science at any level. Maybe that would be my first take on this.

28:26 Liz I like that. We definitely want to think about ways to not go back to the way things were, but it seems like that's happening. What you're talking about sounds great, but do you think that's actually something that ten years from now we're gonna look back and say, “Oh, cool, we actually did start doing all this citizen science, and now we've democratized scientific research," or is it gonna be like, “Well, it was cool, but my postdocs need great papers so they can get jobs so we didn't do that." Do you know what I mean?

29:00 Olivier Yeah, I see that there's a risk, of course, but I think I would still be optimistic. I can just take one example, the example of varietal mixture in the field. So that's opposed to the super efficient monoculture where you remove the fluctuation by adding water, nutrients, and the pesticides. That's the superefficient system that is of course very negative in many ways. When you have a field and instead of growing one variety, you grow three different varieties. So this has been shown in land that this field becomes more resistant to drought and more resistant to pathogens. You reduce the yield, but you make the field more autonomous, more robust to fluctuations. This is citizen science and now between 2010 and 2020 in France, the surface of wheat as varietal mixture has really increased. In certain region it's 40% of the surface. This is both citizen science and the peasants themselves that sort of understood the system, they saw that it works. I think you can't really stop that kind of movement, and especially if the environment is becoming more and more fluctuating with drought, flooding, and everything.

30:24 Ivan Did you say peasants? Is that what you meant to say?

Olivier Yeah.

Ivan That has sort of a negative connotation in English. I don't know if you might wanna . . . it was farmers that you're really start talking about, or -

30:35 Olivier No, we can talk about this because there is the same thing in France. You can say farmers or peasants, *agriculteur* to *paysan*. The word farmer is a word that actually started to expand post World War II, but was supposed to mean that farmers are higher in the technique ranking, let's say. It's like they drive machines; they use chemical components. This was supposed to say that you're more independent. Actually, it's just the opposite that happened. They were actually slave of an industry.

*Peasants* now, at least in France, is a compliment. *Peasants* is the word we used before World War II when the farmers were technically autonomous. The peasants who are doing varietal mixture that are their own seeds, they manage their own field through agroecology, they want to be called peasants. So it's an interesting shift. [Laughs]

31:38 Ivan *Smallholder farmers* would be maybe the way we would say it in English, like you have your very small plot of land and you're gonna plant multiple crops, you may have animals, it's all one. But it's really . . . you're not really selling to large amounts.

31:54 Olivier Yes, exactly. That's it.

31:57 Liz Interesting.

31:58 Olivier Maybe I can comment on something else, because this might be a little bit far away from the lab stuff on the lessons from COVID, because there's one thing that of course we learned from COVID is teleworking, right? This is much more there. I think there's some positive side and negative side as always. The positive side is of course, if you have just an administrative meeting to do it on Zoom, I think that's perfectly fine, instead of taking your train or the flight or something. I think that makes sense. The possible negative side of course, as everyone knows, is that if you meet people in person, a lot more is happening. The richness of the interaction, let's say, is much higher when it's in person. So for the science we want to do, it has to be in person. You don't want to always fly everywhere, right? I also wrote on this, but it's a balance to find. That's gonna be a tricky one.

32:52 Ivan I do feel like what we need to somehow figure out (andI don't have a perfect answer), is that we need to do many fewer trips and make those trips so much more impactful. I feel like we've had this conversation multiple times (especially around conferences), and we seem to be going back to there's a lot of conferences. People are gonna end up going to multiple conferences a year and they're going to have talks at the conference that could be remote but there also are gonna be these key interactions. For myself, I have this desire that maybe I will go to two or three conferences a year. One of them hopefully is gonna be very local, and those are gonna be super meaningful interactions. Then I'm gonna just do the rest some way virtual. But my lab is somewhat robust - I have multiple different projects - and so each one of those different projects has sort of the meeting that I should go to.

34:07 Liz Olivier, you go to just one meeting a year, isn't that right?

34:12 Olivier So my new policy is to try to group the conferences. If I go in one place, I shouldn't say I try to do a tour, but that's pretty much it. If I go to Japan, I don't

know, for instance, that's gonna be the only big trip I'm going to do in the year. And if I go to Japan, I'm going to see many universities around. Maybe one conference and other small trips seminars.But more and more, actually, I almost now try not to fly at all. This year, for instance, I've gone to three conferences because there was some flying involved

34:51 Liz Yeah, right? Cuz you're planning a conference in Lyon, so that helps with not-

34:57 Olivier Exactly.

4:58 Liz 3 [laugh]. Yeah,

34:59 Olivier It's true

34:59 Liz So Ivan, are you thinking maybe you'll only do one conference a year? Or are you still on the fence about them?

35:06 Ivan I don't know. I mean the big answer is I don't know. So far I have driven to one conference and I've driven to another conference that was ten minutes away. Like the two conferences that I've been to in person, one was a nine hour drive and we could carpool and I felt reasonably like that's not too bad. One was in St Louis, and the other meetings that I would normally go to, I am just not going to.

Some of that is just I wasn't invited to give a talk. Maybe [sarcastically haughty tone of voice] if they had invited me to give a talk, I would totally have gone [laugh]. I didn't have a talk and I'm not super comfortable with where we're at in terms of where my COVID comfort level is respectively to, clearly, more people. So I'm just not, and that's a luxury. I'm not on the job market. I have a postdoc who went to a meeting and it was incredibly productive for his career - absolutely the right decision to go, and coming back with COvID, I guess is the price he pays.

Liz Oh my god.

36:37 Olivier [Laughing] Of course. But that's the point, actually. You can decide that junior scientists are the priority to go to conferences, right? That could be the one key.

36:47 Ivan Yeah. But junior scientists frequently say, “The reason I go to a lot of the conferences is to meet the senior scientists." I think coming out of COVID we have all these things, but the real question is: let's assume (and this is a big assumption) that COVID is going to be less of an issue a year from now. I think that's a higher possibility cuz we will all have gotten it and we'll be building up and we'll just continue to have more tools. But there's still the personal drain in terms of just what traveling takes out of you, and more

importantly the carbon. I honestly feel like we have to figure this out and I really feel like I'm in the minority, and that there is enough desire out there in the scientific community that we are kind of going back to the norm - going back to “normal”.

37:44 Olivier Yeah. But I mean the plane tickets’ price might increase. There might be some economic reason for not flying so much. I also see one possibility is the reviving the sabbatical, to do a long stay somewhere; Liz you've done that actually. [Unclear] If you take a long stay then you really meet the people, it's a novel level of interactions because you really see everyone, you work in the lab. Of course you need to have a very autonomous team because you are away [laugh] but this can develop a very different way. In a way it's closer to the old way to do science; in the antiquity where that's what they were doing, right? Traveling once, go to another country, stay there for three years and then come back. It would probably not be three years, but a few months.

38:37 Liz That works great for old people like us, but I think the big question is how as a community we can think about designing future conferences that give our young trainees the exposure and the networking opportunities without blowing our carbon emissions into the stratosphere. It's a really complicated and nuanced question, but it's interesting. I really am really interested in PIs setting their own boundaries and just being like, “This is what I feel comfortable doing," and then sort of being open about that. The mechanobiology meeting actually my postdoc will go to, and then there's this really cool cell dynamics meeting that's in Crete, and I really would love to go to those meetings and just hang out in those beautiful places and see all my friends. I do feel like sad about it, but I guess that also made me realize how much of my going to meetings was about personal and social advancement and not really about the science [laugh]. Right?

39:54 Olivier Always a mix.

39:55 Ivan Part of it is that we have built up this culture . . . those of us who have made it as PIs, you have this culture where you see your friends at meetings and you've developed friends and you have these sort of work friends. You see them at meetings and so that's your relationship, and the idea that you're not gonna go to conferences means you're not going to see your friends.

40:21 Olivier That's true.

40:22 Liz Actually, I think that's a really important point. So Olivier, I think there are so many examples both in the natural world and in the world of scientific discovery where this robustness versus efficiency trade off plays out. And it sounds like this article that we're discussing here is just the start of your investigation into this topic, right? Because you have a book coming out.

40:52 Olivier That's true. Right now it's in French, it's called “La Troisième voie du vivant Broché”. I don't know, you can translate that; it's not the same title in English, but it would be “The Third Way of Life.

41:03 Liz The third way. Is that what you said?

Olivier Yes.

Liz Oh, I love that. That's actually one of my personal principles is that there's always a third way. I love that.

41:13 Olivier I truly think there is. And it's a positive one, right? So because the minute you focus on our business, then it's a very engaging world and you sort of leave the world of burnout. It's much more interesting.

41:26 Liz Well, we look forward to seeing that when it's eventually translated into English and when we can get it on Amazon.

41:33 Olivier Oh, your local library, bookstore. [laugh]

41:36 Liz Your local bookstore. That's right.

41:40 Ivan Olivier. I can't . . .this was awesome. It was a really different perspective and a lot of stuff to think about for me and hopefully for our listeners. If people wanna continue this conversation with you, how should they get in touch with you?

41:56 Olivier Thank you for having me, again. You can get in touch with me through email, I think that's probably the easiest. I don't have a Twitter account, so it's gonna be by email. Uh, and my email is olivier.hamant@ens-lyon.fr

42:17 Ivan And Liz. How can people get in touch with you?

42:20 Liz You can always find me on Twitter @EHaswell.

42:24 Ivan Would that be “at E, as well”?

42:27 Liz Yes, “at E, as well”.

42:29 Ivan If the in the French, but yes. You can reach me on Twitter @BaxterTwit, and you can reach the podcast @TaprootPodcast. So with that, Olivier, thank you again. This was fantastic.

42:44 Olivier Thank you very much.