Danny Lennon:

So maybe let's get straight into things today. We're going to be talking about GMOs genetically engineered, food and topics surrounding this. Of course, this is a topic that is often high on emotion and maybe activism, but maybe quite a bit lower in terms of good faith scientific discourse. So hopefully we're going to try and walk through some of the issues that we see and what we actually can glean from some of the evidence here. Maybe as a way of giving an example of this disconnect there's a couple of surveys. I came across from the pew research center. One was a 2015 one that surveyed both citizens and a representative. So ample of scientists. So these were people that are connected to the American association for the advancement of science. And within that particular survey, they found 88% of those scientist surveys reported.

They felt GMOs were safe to consume, whereas 37% of the general population did. So this represents a 51 point gap in opinion, showing this disconnect, that's maybe there between what we can generally call the scientific community and the, the general population in a similar fashion a survey from pew the following year found the same type of result. So again, a nationally representative survey about 1500 adults found that 39% percent thought GM foods were worse than health than non GM foods. So maybe a bit lower than we might actually suspect, but that's still a sizeable proportion of the population of that opinion. And within Europe, we see a similar situation. There's a European commission report. I think this was an older one, 2010, that showed that 60% of those surveyed in the EU disagreed with the statement that GM food is safe.

So something where we have quite a lot of people making or ha being of a certain opinion when it comes to the safety or health effects of this food. Beyond that there's of course, other considerations that we might touch on in relation to the environment and other ethical concerns, but from a health perspective, we see this I suppose, difference in extreme positions. And I think there's probably more nuance to this than this sometimes convey right on one end, it's like GMOs or these kind of Franken foods that are going to wreck your health. And you're introducing all these things that are going to mess up your DNA. More of the obviously outlandish claims that I don't think any of our audience would be particularly bought in why, but then on the other hand, we could fall into the trap of thinking, well, they're just 100% safe. There's nothing, nothing to look at at all. And there's probably some investigation we can do in the middle to see which one of those or along that spectrum, which one are we closer to? Is there anything that you would want to frame this conversation with before we start talking about exactly what these are?

Alan Flanagan:

Yeah. I think that some of the themes that we've touched on in some of the quack asylum episodes, or, or just generally kind of how people might think their way through various questions as it relates to diet and health is, you know, various types of, of, of fallacies in thinking and, and blind spots that, that we tend to have. And we do see pretty consistent themes that come up, you know in these conversations you know, the kind of the nature fallacy, you know, something is if natural is good, if on natural is bad, even if we're talking about the, the, the same kind of conceptual thing, and that, I think that really needs to be born in mind with the discussion around genetically modified foods. And then inconsistencies often in, in the kind of application of that thinking, therefore, well, this, you know, the genetic modification is quote unquote bad because it's unnatural or it's artificially achieved extends then to, you know, examples where we see genetic modification all, all the time.

We, we are ourselves products of genetic modification. You know, I have my mum's eyes. <Laugh> like these simple things that people often don't, and we see this a lot with wider nutrition conversations or, or scientific conversations. It's like when people don't see how the thing that they're critiquing actually occurs in everyday life as a matter of course. And really the distinction that we're making here is that the genetic modification that created me or you or anybody else, and that happens all the time in nature is completely random. Whereas with the artificial and scientific biotechnology, engineered genetic modification, it's much more precise. It's very precise. And you know, we can talk about that precision, you know, as, as, as we go through. But I, I think for, as you said, at the outset, there is a hysteria in this conversation that needs to be tempered.

And that hysteria is not without consequences. There's an example of golden rice, which was a type of rice that was genetically modified, so that it, the steps that create carotenoids such beta carotene. So these are a family of compounds that are the reason that sweet potatoes or, or carrots or orange, or that to tomato are red. There are incredibly important compounds in the body, particularly for sight and

vitamin a, which is what carotenoids ultimately become a deficiency of vitamin a is the leading nutrient deficiency in the developed world. It's the leading cause of comorbidity in the developed world, particularly infant blindness and this perfectly safe based on all of the data that the human trials showing that it effectively at a, a dose of only about 40 I grams of rice a day, which would easily in countries that rely on rice as a dietary staple, be obtainable and consumable to the four to eight year old age group.

Would've eradicated the burden of it, of vitamin A deficiency, and yet because of really misplaced unsound and onsite scientific, hysterical activism it's been blocked and organizations like green peace, for example, have been a huge part of the obstructionism that has prevented this being rolled out on mass. And as a result you know, ironically, because act this often portray themselves as acting purely for the benevolent interests of humanity and, and the planet. This has led to the ongoing suffering of, of millions of people in the developed world. So, you know, there, there is a real importance to just nipping that nonsense in the bud and having an objective conversation about these types of foods, genetic modification, as a, as a part of the food industry and, and how it could be beneficial for planetary health and human health.

Danny Lennon:

Hmm. Yeah. And I'm sure people listening may have seen this, if you've ever seen a small TV segment or an interview on like morning TV, where they bring people in and you have someone arguing against it with typically a lot of hyperbole, a lot of emotional rhetoric, and then certain claims about what is being done and the effects that are maybe not actually grounded in, in nuclear evidence. And I think one of the interesting things to consider is a as is the case with any of this where, where evidence is trumped by activism is mm-hmm, <affirmative> what is actually at play here. And, and one of the things that came out of that pew 2016 survey that I had mentioned is they actually tried to see what other things they could tie it to. And one of the strongest connections was in relation to the philosophy that people had about food and wellbeing.

And this is obviously a huge thing. When we look at the wellness space, generally wellness is full of gurus that say crazy stuff all the time on the basis of purity and being natural. And, and these other aspects that you've mentioned. And the survey, when you look at it showed that of those people surveyed, who had determined that they cared deeply about the issue of GM foods. They were much more likely to see it as problematic for health. So most of those people did. Whereas even though that was only a minority of the overall population, and then people who didn't care as deeply about GM food specifically tended not to think of it as a problem which is probably not very surprising, but basically the connection then was that people who had a deeper concern about those foods tended to be more skeptical of any information from the food industry from any leaders that had any connections to the food industry. And then anything that they were more of the opinion that the food industry has an overwhelming influence on any scientific research findings or at least more so than the other people in the survey. And so whilst there's not we can't say

there's no basis to that. Of course, that occurs, but when there's a skepticism that goes too far in the other direction yeah. You end up with this type of maybe yeah. Activism, trumping evidence,

Alan Flanagan:

Trumping evidence. Yes. And, and a point, you know, that, that we've raised before is that there's often a kernel of truth in, in some of this and, and that warrants being addressed. And we can address that, but that kernel of truth is often taken and the baby is thrown out with the bath water. An example of that is the concept of industry funding. <Affirmative> so critics and, and this applies, you know, equally to kind of some of the loud voices within the plant based community about dairy, for example, like as a food group or other kind of animal sourced foods will bang on a drum about industry funding. Well, look, industry funding is a reality of any field of scientific research be because they're often the people that have obviously the capability financially to be able to fund research. The question is, does that funding have an influence on the outcome?

And we can actually, you know, we can look at that. You can compare industry funded versus not industry funded studies and look at the outcomes or the effects side and this kind of thing. So there are ways of getting to the bottom of the influence of industry funding, or if it's a single standalone study, you can look to the methodological quality of the study. Does it appear from any of the methodology that, you know, oh, well this looks a bit Dodge or, or not. So it's not, it's a consideration that is always important, but it's not like a hand wave that the entire field is automatically corrupt or otherwise it requires it's a call to further scrutiny and it requires further scrutiny. But if on further scrutiny, there's, doesn't appear to be anything particularly untoward. Then, then, then we leave it at that. Mm-Hmm <affirmative>. And, and often, you know, those criticisms are kind of taken and magnified into something that could only be, you know, a net negative or to infer some degree of kind of corrupt influence and otherwise,

Danny Lennon:

Yeah, there's a, I suppose, a lack of being charitable in what someone says. So if someone says something that might show, well, look, we might not need to be as concerned for human health, with consuming GM crops as your position dictates that is not someone saying there are no potential issues whatsoever could be discussed, right. That, or it doesn't mean that person is a shell for Monsanto or Bayer or whoever, right? Yes. They're just making a, a claim that then we can talk about. And I think the same will go on the other end. So maybe to, to get into this, we should probably start with, again, some definitions. So we've talked about GMOs genetic modification, genetic engineering. And in, in general, when we're talking about GMOs or genetically modified organisms or GMO crops, most commonly, this is people referring to crops developed through genetic engineering.

And that's more of the precise term than genetic modification, which is more of an umbrella term for are many different ways that we can just modify genes. And this is genetic modification of crops has been around basically since the advent of

agriculture, because there's many different ways to do that. But our focus with GMO crops is specifically in, on genetic engineering where we have typically gene transfer in the most simplest term over taking some sort of genetic code from one organism and then putting that into a plant in order to get a specific trait from that those traits could be for, to be more resistant to insects or to the herbicides to be tolerant, to, to drought better to be more resistant to certain diseases like light for, for example or as you noted with golden rice maybe to enhance the nutritional content other, so there's a number of different ways or different traits that we could be looking at.

And through genetic engineering, we have this precise method of taking a certain set of genes from one organism and putting it into this plant with the idea of getting that beneficial trait. And of, of course it's probably worth noting that there are other forms of plant breeding or genetic modification as it just outlined that are separate from genetic engineering, but we can also discuss those as well. I mean, one simple example is your traditional cross breeding, right? We, we take yeah, two different types of apples and we're going to cross breed them to try and get a sweeter variety of apple and so on. But there's that as an overview is just to clarify that difference between genetic modification and then genetic engineering specifically, which is a more precise term that we'll discuss. And the role then of GMO crops are those crops that are used or are created via genetic engineering. Is there anything you add to those definitions or that is worth touching on?

Alan Flanagan:

Yeah, no. I think just to enhance the point that this is a very targeted process. So as you like noted, and this is really important for people to grasp genetic modification occurs all the time in nature, you know, take an Alsatian and a cockatoo <laugh> and breed them, an Alsatian doesn't come out the back end, you know, like, so the examples you used as far as kind of food stuffs, yeah. This goes back to a Memorial you know, plants of the capability to hybridize in nature. We can breed different kind of strains of the, of the same type of food. But what comes out is random because it's, it's, mainly genetics at play, you know, it's, it's completely random. What traits the, shall we say, offspring or byproduct of that hybridization or crosspollination would, would be, this is a very targeted process.

So you're isolating the specific genetic trait that you are interested in inserting to a plant, and you are doing that in a very targeted, engineered way. Nothing else is changing. So with the golden rice example, just to kind of, to give this example, some kind of context, the rice, as we know is white. The reason that doesn't produce any pigment is because of its base genetic makeup. But with the engineering of golden rice, what you were taking with any grain, you have the brand, the endo sperm and the germ, and this was taking a, that would allow beta carotene, this what gives sweet potatoes and carrots, their orange pigment and it was inserting it into the rice. It was basically switching on and inserting this particular gene that would into the endo spur of the rice, which would allow the rice to then produce beta Carine, but no other characteristic of the rice has changed.

So it's a very, very targeted scalpel like precision approach, the engineering process. And that's an important, because one of the arguments you'll often hear is, well, if you're modifying it, there's all these other changes that will happen. And of course, then there's potentially changes in, in our bodies. And, you know, and we've seen some of the similar kind of fallacy arguments with vaccines with COVID, you know, this idea that because it was an mRNA vaccine, you were, you were putting RNA into yourself and changing your DNA. That exact same argument before the COVID vaccines came out, has been long argued in relation to genetically modified or engineered foods. And there's really categorically, no evidence that that's the case. So it's, it's changing a very, very specific trait and engineering that trait, that desirable trait in a plant without altering anything else about that particular plant or its characteristics say for the fact that in this case, the rice went. Yeah. So I think that's an important take consideration.

Danny Lennon:

Yeah. And, and especially when we compare it to more traditional forms of genetic modification, you are actually, like you said, less likely to change other things that you don't mean to change. Mm-Hmm <affirmative> because you're getting a very precise change in this particular gene that is being transferred. One other maybe point distinction, because people may see similar terms is when we're talking here about this genetic engineering and this gene transfer from one organism in, into the, the crop, there's also now gene editing, which is a very precise in the same way, but using like CRISPR technology where you can go in and silence one specific gene. So you're not doing a transfer from one to the other, but you can go and silence a gene that's in a particular food mm-hmm <affirmative>. So I think there's development right now of looking at low gluten wheat, for example, where can use CRISPR CAS nine to go and, and silence some gene.

We've seen this in things like apples and potatoes where you take certain varieties and you can go and silence the gene that is responsible for that Browning, that oxidative Browning process. Yes. So that they're not going to spoil. So that is just that distinction between gene editing, where we're going and, and silencing say a particular gene versus an actual gene transfer from one organism to another, just in case people see those different kind of terms <affirmative> with that, then probably we can start talking, but well, well, where does it actually show up in the food supply? Because I think if you talk about some of the, or if you hear some of this rhetoric online, you'd be led to believe that basically every food you encounter or every crop that you come in contact with is, is genetically modified and you need to go and purposely seek out the opposite.

Whereas in reality, there are probably not many individual foods, at least let's say that are, are GMOs, but probably more so that many GMOs end up in commercially prepared foods. Right. So mm-hmm, <affirmative> and there's going to be distinctions here that we're going to mention throughout this conversation between let's say the us and, and here in the EU because there are some drastic differences

there, and we'll maybe try and highlight those as we go along. But if we talk about where it's maybe more prevalent in the us, there are, I think, as of my understanding, there are 10 GMO crops commercially available right now. Yes. So corn soybean cotton canola, alfalfa, sugar beets, papaya squash, apple and potato. Yeah. And GMOs may be ingredients in many other foods. So if you have like corn starch or corn syrup or canola oil in a certain product, of course that part, or that ingredient may be from one of these GMO crops, but it's still down to those 10 crops specifically we do see differences then of course within the EU.

And then I suppose one aspect we should probably discuss when we talk about some of this regulation is the particularly in the EU where there's a difference between what GMO crops are allowed to be cultivated versus which ones are allowed to appear in the food system. Yeah. And then also, which ones are allowed to appear as animal feed. So I don't know if you think there's a particular good point to start here in terms of where we find these and maybe some of those initial differences between let's say different jurisdictions like the EU or, or the us.

Alan Flanagan:

Yeah. Well, so I think one immediate difference is just the number of, of foods that are currently used as far as genetic engineering crops go. So you listed the 10 that are permitted in the EU. I think there's five or six more permitted in the us. So things like flax plum like antelope, there are other fruits and crops that are allowed by the FDA as far as like current genetic modifications go. So the, but as far as what are ultimately in the food supply and how they get to the food supply, that that's really where the big jurisdictional differences between the us and the EU is for people that have listened to our episode on artificial sweeteners. We discussed quite at length, the regulatory processes by which the EU evaluates the safety and technical data for any addition to the food supply whether that's a non-nutritive sweetener or indeed in this case, a genetically modified food.

Alan Flanagan:

And that process is, is analogous to what we're, we're kind of talking about today, as far as the EU regulatory process goes. So it's regulated by the European food standards, food safety agency EFSA, and it involves the submission of safety data technical data and the evaluation of the thresholds of, of exposure that the population might have to that particular food should it be in the food supply and how that might influence human health. So this is a process of pre-market approval, similar to the way that non-nutritive sweeteners are used. So we, we won't go massively too in depth into the kind of detail that we did on the artificial sweeteners episode. So re listen to that, if you want really more geeky detail on the regulatory process, but this is a pre-market approval process.

All of the safety and technical information is evaluated by SA it's, then approved. And the law in the EU is that if a food contains over 0.9%, so essentially 1% of the food product, if over 0.9% is of the ingredients are comprised of genetically engineered or

genetically modified ingredients, then it must be stated on the label that, that, that is the case. And so there's a very kind of clear commitment to not only the process of regulation, but also to the consumer as far as informed decision making goes. And that, that was really the primary distinction between the EU and the us as, as, as anyone could probably imagine the us as less hot on regulation as a result their, their regulatory framework for genetic modified foods and org, you know, kind of food ingredients is a little bit looser, a lot looser.

It's slightly messier structure, whereas you have the EFSA in Europe kind of as essential regulatory body or there's individual member states have a degree of leeway in the US. You've got a mix of the FDA, the USDA and the EPA, and they all regulate slightly different aspects of the use of genetically modified crops in farming or the production in the food supply. There's historically been no labeling requirements, and there are multiple avenues through which companies can secure an exemption from having to go through any sort of pre-market regulatory process. So the US takes the approach that no pre-market safety and otherwise evaluation is required, and that there's, post-market evaluation that i.e. it's retrospective. If you can prove something, shouldn't be in the food supply, then they'll take it out, but it's not going to stop it going into the food supply in the first place.

So that's a, a very American approach to health and safety in the population. So that slightly changed. There was a bill passed in 2016 or 17, a slightly watered down version of an initial bill proposed that would really strengthen the kind of labeling and, and regulatory framework for consumer information. So now there is some degree of legislation that supports labeling a, a food product, if a there has been ingredients that are derived from genetically engineered crops or otherwise but it's still way less of a stringent regulatory framework and, and much less compliance because there's no real enforcement mechanisms compared to the European union.

Danny Lennon:

Yeah. And, and so that's a good way for people to, to think of that is, as you've just outlined in the EU, it's very much built on this kind of precautionary principle, right. That there's going to be tightly regulated until we have at a good of evidence that we're have a real degree of confidence that there's no risk of being harmful. Whereas in the us, it's almost literally the opposite way around where yeah. Innovations in this area are permitted until harm is shown. And so they are quite significant departures. One of the other things that I bring if we touched on that just to kind of clarify for people, is that at least in the EU here, there's a difference between what is permitted for being say, commercially cultivated? I think there's only one right now in the EU.

I think that's a GM corn, maybe. And then there are like maybe 60 of them that are authorized for use in foods and feed stuff. So it's just difference between what is being cultivated versus what is allowed in these food stuffs. And then maybe as a kind of side note, just generally, regardless of the jurisdiction, most of this kind of

crop growth is going towards animal feed which we should probably maybe then discuss of concerns that then get brought up in this area, right? The, the common thing you may see is, yeah, maybe most of it is used in, in animal feed, but that's going to cause problems for these particular animals. It's going to end up in their tissues. It's going to do X, Y, and Z, and therefore it's going to impact human health in, in that manner. But I, as, as of far as I can tell, there's no real evidence that is the case, or there's any issue to the DNA or tissue of, of animals from consuming these

Alan Flanagan:

Exactly. So, so that the principle at play here is a concept of like genetic transfer. And that, you know, if there is a modification in, let's just say for a example, a crop that crop is used to feed an animal, that there is this kind of ongoing process then of, of modification. So the, the animals either response or something like that is, or the, the DNA of the animal itself is influenced because they've consumed a genetically modified crop feed, or a feed inclusive of genetically modified crops, probably a better way of putting it. And that, that then if we're consuming, it has this kind of like knock on effect. And there, there, there is, there is little to no evidence for that. If we were talking purely about crops, like for example, there, there was a case in America in the late nineties, early two thousands of cross contamination between a genetically modified crop and a non-genetically modified crop, and they were both corn.

So it was genetically modified, [and] corn non-genetically modified corn. And the genetically modified corn was, it was a specific kind of protein that, that had been modified. And there was evidence of an allergic reaction in a number of individuals that when they do into, it seems to be, to do with the expression of this particular protein. And, and that was to do with, with this kind of like mixing between those two, but that's, that's a really rare example. And, you know, ultimately that's the kind of thing that once recognized was, was easy to deal with far as you know, like planting and proximity of, of different things go or different crops go. The, the main issue here is whether certainly within animals, there can be this kind of genetic modification of the organism as a result of consuming a food or feed containing a genetically modified ingredient.

And there's, there's, there's literally, you know, at this point, no evidence that that occurs yes, similar to other toxicology kind of studies and, and areas. We do rely on animal models where they look at intergenerational effects or other effects. And you know, there there's really no evidence from any of models that there is a negative impact on you know, on, on, on this kind of on, on, on the genetic makeup of the animal itself. And this is often feeding 7,000 times greater what the average human daily assumption of a genetically modified food ingredient or product may be, again, a similar principle to what we talked about in the artificial sweeteners episodes is these studies are designed to give enormous amounts of these compounds that would not be replicated in the human diet to try and enforce an effect essentially.

Alan Flanagan:

And there's, there's really, yeah, there's really no evidence that there is any sort of DNA alteration or effect on reproductive function or, or anything like that. Or even in relation to individual organs that have been analyzed comparing animals that have been fed enormous amounts of a GMO specific and only diet versus a non GMO diet where they're feeding them the same foods, right. So genetically modified, you know, apple versus non GMO apple, and they feed them enormous amounts of the compound and see no difference in terms of any Geno toxicity or, or, or reproductive, or, or generational kind of transition of any sort of changes. There's, there's none of that evidence in any of the research.

Danny Lennon:

Yeah, because that topic of the allergenicity of GM foods is one that's commonly perpetuated. And again, yes, you can make a plausible argument as to hypothesize how that may occur if there's going to be gene transfer from one to the other. But it's something that is well known or that, that is a risk that as being known as examined for, right. And there are strict standards to make sure that is not the case. And I think there's a couple of reviews that we can link to in the show notes here. And there there's one particular systematic review that, that looked at this. And as you just said, it kind of summarizes with the idea that if one has an allergy to a particular food, whether that's GM or non GM, it's going to be a problem. But something being a genetically engineered crop doesn't increase its allergenicity and, and at least we have no real evidence that, that tends to be the case.

Danny Lennon:

Yes, by a few kind of specific case studies. So with that, maybe we can start again, maybe addressing more of the, the common claims that come up and, and let's start with the, kind of, some of the aspects of, of human health, particularly maybe the easiest one that should hopefully be the, the least controversial is this proposed nutritional difference between mean a GMO or an a non GMO food. And here, there's probably very little to say unless that if there, if the goal is to have, if, to be nutritionally equivalent, it tend to be, that is the case that they are, there's no worsening in effect of nutritional composition. And in an example that you gave of the biofortification of vitamin A in fact, you can have an improved nutrition profile if that is indeed the goal. And so there's other examples like hi, oleic soybeans, for example, and then the golden rice. So here you can, you can change the nutritional composition yes. The GMO food, but that, and is the specific goal of doing that in those cases? Yes. Yes. Otherwise there's no detrimental impact. And there's a number of studies that seem to show that nutrient composition when that isn't, the goal is basically the same. I don’t know if there's much more, we need to add there, do you think?

Alan Flanagan:

No, I don't think so. So, so there's, there's, there's, we can broadly, I think, think of this into perhaps different ways. One is, is the aim to enhance or alter the nutritional composition of a given food for a specific reason. And then the second is, is the aim to influence certain properties of the food that are not necessarily new nutrition

related, but may relate to, for example, shelf life or perishability and these kind of factors. So in relation to the former, if we're talking about enhanced nutritional composition, this tends to be a deliberate focus as was the example with rice or in the case of wheat, it's looking to you know, switch off the, the, the gluten content of that food for, for people who are celiac or, or wheat sensitive. So in, in either K you're doing a deliberate nutritional modification, that's very specific, and it's doing that without altering any of the other nutrition, characteristics of the food.

So with the golden rice example, the other elements of the nutrition of rice were still present. It was now with the addition of beta carotene with the gluten example, if you're, you know, coming and, and making wheat bread, you know, the other nutritional components remain minus the expression of, of, of gluten and, and the, the, the, the, the presence of gluten protein then in that product. So the nutritional modification tends to be, to enhance whether that's adding or, or kind of removing a characteristic of a given food for the benefit of people in the, in, in, in the population. And then the second one is, you know, influencing things like perishability and otherwise, or some property of the food that enhances is it's you know a kind of some of the qualities of it from a growth or, or from a sales perspective even is done, but that does not affect the nutritional composition of the food.

And I think that it's that latter one that tends to in, in certainly in my experience of this conversation, be where people really get hung up on, because most of the stories you hear about you know, a genetically modified food is, oh, look at this, you know, the tomatoes are bigger, the blueberry taste different, this kind of thing, is it? So what most people are objecting to usually is actually the, the, the altering of some of the characteristics of it for a specific kind of purpose rather than the nutritional content. And they're then assuming that, because that modification has been made, the food itself is now different either in terms of nutritional content or indeed safety and health effects. And, and there again, there's no evidence that, that is the case. There is the enhancement potentially of some quality, like it's not going to spoil, like you said, that's not going to oxidize and brown as fast, or it may actually, yes, it may be, you know, it may have a longer shelf life or some characteristics of it that are enhanced, but that does not alter the nutritional composition of the food. And it doesn't mean that the nutrients provided at that food are treated any differently by the human body.

Danny Lennon:

Yeah. And it's similar to the, the type of thinking that you outlined at the start of the discussion of, if this thing is so different to what I'm used to, then surely it can't be okay, right. This, how, how can it possible for us to go and play God to some degree and make these kind of bigger fruits or things that look different or a different color, or, or take something from a certain organism and put it in this plant and it to be okay. And again, that is a start point to question, but it's not a basis of any degree of argument, right. It's similar to those, those types of arguments where oh, well, you might say, they look safe now, but how do we know it's not going to cause problems

in 50 years time or a hundred years time, et cetera. Yes. Which has the same parallels to much of the kind of vaccine debate, which was the other kind of analogy that you talked about earlier and you see them kind of crop up yes, no pun intended.

Alan Flanagan:

We'll that this is it. And what's, it seems to be very difficult to get people to grasp the concept of like, we, again, we've seen this with the vaccine trials where people say, you know, oh, we don't the, the idea of, you know, statistical power, the, the, the, the ability to detect effects. I mean, the vaccine interventions, as an example, had hundreds of thousands of participants, and it's now been administered to millions of people worldwide with genetically modified foods and crops. What people tend not to realize is there, there is a degree of UBI equity in the food supply already. It's not enormous. And again, certainly if people are listening from, you know, within the EU there's a lot more comfort. They could probably take in the rigor of DE's regulatory framework. The fact that it's a very low threshold for a manufacturer to have to label a product is containing genetic modified ingredients.

0.9% of any given single of, of, of the total ingredients of the foods product would have to be labeled. So you know, these, and, and there's already widespread use in certainly animal feed, which as you outlined in the EU is certainly the primer. The primary use of the kind of 60 odd genetically modified crops that are used as primarily for feed. And really you've got one, which is like a maze corn who's maze, corn maze and the, the, the, the, the idea that there isn't already some degree of exposure to this across whole populations. So when people are saying, oh, we don't have that long term data. It's like we have been using these products for quite some time. These are not necessarily recent additions to the food supply, and they have been in the whole population in countries like the us and the EU.

So, you know, with, as a post kind of market monitoring you would certainly expect to detect adverse effects in the population. And indeed where kind of isolated examples of adverse effects have occurred. They have been detected as in the case of the CRY protein kind of allergy. And that was intact go bell, corn shells, I think. And, and there's a number of other isolated examples. So I, I think people kind of almost assume that there isn't this level of scope and exposure that we might actually detect effects when we would expect to, and in certain instances already have. So yeah, I just think it's a disconnect between people's perception of risk, which humans are really bad at generally versus the, the reality of the presence of these compounds in our food supply.

Danny Lennon:

Yeah. And, and speaking of looking at some of the health impacts from an epidemiological perspective, that there is a expert rep war 2016 report from the national academy of sciences. And based on that findings, you can see that their group, and again, independent experts from different labs from around the world found that the epidemiological data, at least on incidents of things like cancer or

other chronic disease in, in humans, mm-hmm <affirmative> was no different between exposure to genetically engineered crops versus non genetically engineered crops. So at least that would be again supportive of, of the idea that for human health directly there seems to be no major concerns as it's current seen, or at least what's currently available and consumed in, in the amounts that currently are right now. We, we just don't have evidence for that. I'm not sure if there's any other claims or questions that you commonly see brought up in relation to effects on human health, from consuming GMO foods that we should touch on before we move on to maybe more of the environmental concerns.

Alan Flanagan:

I can't really think of, of, of any I, I think save to make the point that actually, when you do start to dig into the literature on this, it's the opposite of the hyperbole a as is often the case with some of these kind of arguments. But if the idea is that there is this there's evidence of some sort of profound, detrimental effect on to human health of genetic, of the presence of genetically modified crops in our food supply, or indeed in, in food products that people consume. Then it's not on impossible to really find any, any good evidence to support that claim. But then when you do start looking at it, you actually see benefits in terms of improvements in, in the food supply, you see, you know an enormous reduction in the presence of mycotoxins in various grain products.

You see you know, enhancement of nutritional content of certain foods you can see, although there's obviously been issues with getting them rolled out to, to the level that they would have the benefit, particularly in the developing world. And, and as far as human health and economics go it's, it's UN like ambiguous in the research unambiguous in the research that there is a significant economic benefit, particularly in the developing world to farmers and growers, because of their capacity to create a significant increase in the yield of crop, they get for a given unit of land and as a result the, the kind of net profits that they, that they derive from that. And so they're, they're really important considerations. I think if we're talking about human health, it's, it's impossible to kind of separate out that, that economic benefit as well. But, but certainly as it relates to the health effects of foods themselves, most of it has been used for the benefit of enhancing the food supply.

Danny Lennon:

Yeah. It there's, there's some degree of irony in, in some of the arguments where you see people that will be worried, worried about genetically engineered crops at the same time as being worried about, for example, pesticides that show up in our food supply. Yes. And not knowing that the use of one would reduce the other <laugh>. Yes. So but so I, I think some of the interesting debate and, and you see kind of arguments made on both sides of this and some of them, I, I think, do have more validity that we can maybe explore is there related to certain environmental issues. One is on the potential impact on biodiversity, which is a big question for a lot of people. And that will include both for diversity of different crops that are available.

But then this also extends out to other environmental issue, like impact on B populations, for example, mm-hmm <affirmative>.

So if, if we look at this and, and maybe I'll start with putting forward some of the arguments, at least I've heard that maybe there's a suggestion of potential harm. It might go something along the lines of that. The problem with GMOs may not actually GMOs themselves, but it's the idea that their use can bolster an already problematic industrial system of farming that's present in many places. Let's particularly take the example of in, in the us where you look at the industrial agricultural system there that people say is a very unsustainable one, or that maybe they point to certain issues with it. And then they may point to, well, the use of GMO crops is just further perpetuating that. Now of course, that argument in itself is highlighting that maybe GMOs are not the problem necessarily, right. That they could be used elsewhere, but that is one argument that, that we can maybe touch on. And then the other is a more direct one that looks at GMOs of the, this is actually causing a loss of diversity. But before we get to, I don't know if, if there's any others you would add to that of arguments you put forward suggesting harm in terms of biodiversity and the environment that we should maybe then work through.

Alan Flanagan:

Yeah, I think there's, there's, there's one other argument which is the idea that if you're kind of genetically modifying certain traits to be advantageous in, say, for example, a crop or more particularly in kind of like animal sourced foods themselves, that, you know, that if there's kind of escape into the natural environment, or if there's, you know, if there's kind of cross breeding, then that occurs, then you're kind of creating this almost like mutated you know, cross breed of whatever that particular species is. So I think that that kind of fits in with the argument in relation to, to, to, to biodiversity. And I think we can probably just kind of maybe take them as well kind of under the one under the one heading.

Danny Lennon:

Sure. So I, I mean, I I've seen arguments for on both sides of the biodiversity, right? And there's, there's certain maybe places that you see discussed there's one particular paper. I think Johnson was the lead author where they say, look, there is some, it's plausible to think that there may be an impact on biodiversity because of, let's say if you're using a genetically engineered crop that has some degree of herbicide resistance, mm-hmm <affirmative>, then you may get an elimination of certain plants that are on field borders or irrigation dishes, and so on, because now you can have a lot of use of certain herbicides of Roundup or, or others let's say, because these crop ups have herbicide resistance, but then it's going to cause problems for these the diversity of the plants in the surrounding area. But the problem is then quantifying that, that impact and quantifying how much of it is down to genetic engineer crops seems to be difficult to, to do based on at least that analysis mm-hmm <affirmative>.

And then in other place, you see the claim that it's actually not only not a problem, but that it could potentially improve or protect biodiversity, because how it might change practices in agriculture of if it's less intensively cultivated, then you may get an improvement in biodiversity over time. So again, there's the, these differencing differential arguments put forward. And I don't know where we should start on those or what you think so far is the most compelling and seems to be where most of the consensus of the evidence suggests in relation to this biodiversity question.

Alan Flanagan:

Yeah. So, so there is, there is evidence of the, you know, capacity for cross pollination that has, that has, that has occurred. So you take genetically modified crop or plant. And if they are cultivated in close proximity with wild type plants, there can be a cross pollination and the concern with, and again, it's important to really stress that this would ordinarily be a perfectly normal course in, in nature natural hybridization, and that's considered a positive because of the genetic lottery, that results. So it's contributing to genetic diversity in a given population. The, the idea with genetically modified crops or species is that if you're enhancing them through genetic engineering, then if random kind of cross pollination or, or interspecies breeding occurs, then you end up conferring this enhancement of the evolutionary fitness of the, of the modified organism or crop.

And that, that then over time would lead to it just dominating its particular species or ecological niche, therefore reducing biodiversity. And there are like isolated examples, like you said, kind of earlier, we alluded to one of the allergen examples, which is, which is where a genetically modified corn kind of accidentally mixed with, with a, with a wild type corn. And there's been some other examples in relation to grass types, but again, the, these, these aren't issues that necessarily reflect GMOs themselves, like you said, this is actually more of a, kind of a regulatory thing, because this is addressed through the actual practices involved in the cultivation of the crop itself. So ensuring that they're not in close proximity with wild tide crops, ensuring a buffer zone, if, if is any sort of proximity and all of these kind of steps that can be taken from a regulatory standpoint to ensure that that kind of random process doesn't happen.

Alan Flanagan:

So those, those kind of steps can actually be taken from a regulatory standpoint. It's not necessarily a reflection of some kind of deterministic outcome for the use of, or, or even wider use of genetically modified crops. And you know, another example that I saw was in relation to the genetic modification of salmon to allow it to kind of grow its silence, the gene that basically allows it to kind of grow faster and not just in warm weather. So these are obviously farmed salmon. And so the argument is, well, if they escape in into the wild and they mate with other salmon they're breeding mutant salmon and again, like that's not necessarily a reflection, that's, that's a that's a regulatory issue in order to address as far as like food safety and, and the kind of the, the, the, the production and manufacturing process goes. Although obviously there are concerns, but there doesn't seem to be any evidence that this is

something that is, that I've seen that is, is of occurring at such a sufficient you know, rate or threshold that, that there would be concern warranted.

Danny Lennon:

Yeah. That the, the salmon one is an interesting example where you've seen that approved the, the application by the FDA for these particular Aqua advantage salmon or, or it's called that seems to be just as, as safe and nutrition as the non GMO Atlantic salmon. And I think this has already been sold in certain places. At least there was in Canada there's been some sort of salmon like that sold. So, yes. Interesting to see, but a, a again with relation to some of these issues around, around environmental reasons, one of the, I suppose, positive or the pro arguments put forward is, well, if we can use some of these genetically engineered crops to lead to more efficient biofuel production then we can therefore mean that the environmental impact is reduced by moving more in this direction, right.

We, we would need less water to be used less electricity or gas produce the biofuel. And so these potentially could be beneficial in terms of their environmental impact. The other, then the suppose, the only other aspect on this that we need to address is things that we've already mentioned of what we'll, we'll really, I think it comes down to, as you said of, can we imagine changes in, in regulation or practices in farming that mm-hmm <affirmative> are more environmentally sustaining that include genetically engineered crops? And is that any different to, if there was no genetically engineered crops, because if that's the case, then as you say, the problem is the regulation and current practices that are common, that are unsustainable, not necessarily anything to do with GMOs or genetic engineering as a technology. So it's just how we apply it and what we use it for. And tho those are different arguments then instead of blaming GMOs or genetic engineering as, as the problem. And I think that's kind of the, the crux of the issue, at least that, that, that seems to be emerging from the environmental discussions.

Alan Flanagan:

Yeah, I think that's absolutely the crux of it. And, and one of the, in relation to some of the biodiversity points that we were, we were just discussing one of the key kind of points in that that I I've seen raise is that these concerns are not restricted to genetically modified crops or organisms at all. These concerns would've, you know, predated there was, you know, concern over the fact that even before the use of genetically modified crops, we were kind of relying on increasingly narrow number of, of staple crops globally and that diversity of, of crop use growth and, and kind of production into the food supply was increasingly narrow. So it, again, the, these are issues that are not necessarily exclusive to GMOs they're issues that pertain to the food supply in general they're issues that arise in relation to our systems of production and, and manufacture and their issues that do obviously need, if there is an issue that arises regulatory consideration and, and potentially intervention in order to either address some of these issues or reduce some of the unwanted or intended or unintended consequences that may have negative impact on the wider environment.

And I, and I think that's, you know, that's an important aspect of the discussion is much of what we could end up talking about here from an environmental standpoint is really not unique to the presence of GMOs in the food supply or the growth of GMO foods. Nor is it some thing that has only arisen as a consideration, as a result of the use of GMO foods. These are issues to do with our whole food supply that preceded the use of GMOs and are certainly then now that GMOs are part of our food supply landscape, they're part of the conversation of this wider kind of food systems issue that we have as far as you know, the relationship between our systems of production and the environment.

Danny Lennon:

Yeah. They are not necessarily the cause or even one of the primary factors. They are just something that is part of this larger system, which actually has some parallels to the issue that people raise around. Well, what is the impact on things like B populations or butterfly populations? And again, you kind of see this association where you see these declining populations and problems in terms of yeah, B populations and butterflies is also get mentioned, and there is a plausibility to it that you have the potential to harm certain insects like that. When you get a degree of a, a stress to them, or some degree of low grade poisoning from what, whatever that may case to be. So there is a plausible basis to that. It kind of lines up in terms of the increased prevalence of these losses of, of insect populations along with use GMO crops.

Mm-Hmm but again, in much a similar way, it doesn't seem to be the primary driver causing it. And at least of, of some of the data that I come across, you, you see an example of this in relation to the, the Monarch butterfly, where you have one group putting out a report saying that there's a line in these populations that has been driven probably by the planting of genetically engineered crops, but that's pointing to some degree association, but in one of the analyses of that it's thousand 19 by boil and colleagues, they showed that this decline had started before GM crops were even a thing, right. And while the heard that it's down to the occurrence of milkweed, and this was something that is that GM crops could play a role in, but there are many other factors that are probably having a much bigger impact that are probably more likely to, to be the cause of this.

And then you see a similar situation with bees where most of those analyses that you see whether meta analyses or otherwise tend to see that there's no real evidence that GM crops have injured B colonies mm-hmm <affirmative>, and potentially if there is an impact, it may be a benefit to them because there's a reduced frequency of pesticide application, for example, on crops, which could again, cause harm or, or the oh, great poisoning. So this is another issue where there's a real thing with declining insect populations. Yes. And of course GM crops are being grown in, in places where these problems are occurring, but it may be other factors that are part of the larger system that are more of a driver than, oh, it's, it's a hundred percent genetic, the engineered crops that are causing these problems.

Alan Flanagan:

Mm. Yeah, exactly. And, and, and that's where that's that that's where bringing some kind of rigor to the questions or the, the hyperbole that, that, that comes up in relation to these issues is really important. And that's obviously not something that is done in the wider kind of populous space, but again, it's one of those things where we hear a given claim that there's these negative effects and you go actually looking at it and you, you either see the opposite, or certainly you don't see the, the, the claim as stated supported by, by existing evidence. And you know, when you do look at a lot of the, the, a application of it, or some of the evidence synthesis in relation to, you know, like the, the factors that would relate to the, the wider environment, I mean, you know, one of the major things that we have as an issue that's discussed is just the sheer scale of land use you know, and deforestation, particularly with the Amazon, which is a major concern that is ongoing as a result of, you know, like renewing and it's, it's often that kind of deforestation is often blamed on you.

Oh, it's they want space for, you know, cows to roam because everyone's eating meat. And it's like, that's again, there's a kernel of truth in that, but it's not the whole story because a lot of the space is being cleared for the growth of crops. And one of the major advantages of the use of, you know, crops that have been genetically modified to be higher yield or resistant to different pathogenic kind of insects or not require pesticide use is that you're getting greater yield you know, without necessarily having to have an expansion of the land mass that's assigned to crop growth. So, you know, there, there, there are some other kind of nuanced considerations like that, that really stack up in favor of, of the use of and the continued development of, and refinement of the characteristic sticks of crops that are genetically modified so that we can actually allow the increase in yield and productivity of food systems to feed a growing global population without necessarily having to cut down every tree in order to achieve that.

Danny Lennon:

So maybe as, as we start rounding up before we get to some conclusions, maybe one thing that we haven't touched on that maybe could have been included within some of the health claims is again, along the lines of what we just discussed, maybe not a direct impact of consuming GM crops, but because of the use of GM crops, the potential impact of consuming other things that are problematic. And one of the most common ones you hear in the, the kind of wellness space is around glyphosphate or people talking about the use of, of Roundup as a herbicide, for example, and the kind of line of thinking as well, because we have these genetically engineered crops that are more herbicide resistant, then you get this increased use of glyphosphate, and glyphosphate is really bad ad for humans and it's going to cause all sorts of things.

And you can basically go and find people on the internet talking about anything from autism to coeliac disease to cancer, et cetera, and everything in between. Yes. And I think as, as you've noted earlier where some of the other analogies it's, it's striking to see this in relation other kind of conspiratorial thinking around health that is

sometime prevalent in the, in the wellness space and much of it, from what I can tell circles back to a paper that is commonly circulated by Samsel & Seneff, who I, I believe were in like computer science is, is their background basically did a, just an analysis of associations and basically came out saying, well, look, this is we're showing that consumption of glyphosphate through consuming these crops that have them in it is leading to things like coeliac disease hypothesizing links with kidney issues.

I think there was also then another analysis where they talked about autism. Yes. And again, all of that seems to be completely divorced from any actual trials and, and interventions that we have looking at this compound. Yeah. And it just is, is again unfortunate that we tend to see rhetoric push forward because it ticks all the boxes of, oh, this is something that's unnatural because the involvement of genetically engineered crops, but also then because of the use of herbicides made by say Monsanto and, and all the things that get collected in that and these kind of ethical concerns and therefore it's kinda the perfect storm for seeing this is a, a huge issue. So we're just going to connect up to these associations and therefore say, this is one of the problems. So I think that's just one other one that, that came to mind, but it, it ticks a number of those boxes of parallels we've talked about with many other Health related issues, right?

Alan Flanagan:

Yeah, yeah, I think so. Yeah. I and even again, with the environmental kind of arguments that people have said that, you know, the addition of, you know, Roundup and, and, and the use of kind of glyphosphate is, you know, damaging to, well, there's a nuance within that, that apparently it's, it's really it's to do with wider me weed, my management techniques and where Roundup is the only technique used, then you get overall benefits, but when it's not, and there's kind of either mixed methods, techniques used, you can, you know, get a resistance buildup or you can get mutations that allow that allow kind of pathogens to survive even with Roundup spraying. So it's, again, it's, it's some of the detrimental effects may not, you know, don't appear to be related to the compound itself or the, the use of that particular you know, the use of Roundup spray, but related to kind of wider technical issues that may have arisen in the, in kind of like farm and crop management techniques that are now better. Understood.

Danny Lennon:

So I think we have nearly touched on everything that we had planned to talk about. So maybe we can start circling this into some conclusions to summarize what we've discussed. So in relation to any of the most important topics, whether that's the impact of these on human health or some of the common claims that people may hear, what are the kind of big takeaways that we should leave people coming away from this discussion with?

Alan Flanagan:

Yeah. Maybe there's kind of three branches that we could think about concluding under there's nutritional factors, there's environmental factors and there's kind of economic factors. And there's a relationship between all of, of course, but certainly the evidence that we have for the enhancement of a specific food through genetic modification, whether that's to activate and kind of enhance the presence of a specific nutrient, like in the golden rice vitamin a example, or to, or to kind of eradicate or switch off a specific kind of protein like gluten, you know, these are beneficial adaptations to that food that can be of benefit to human health. And overall there's really little to no evidence that we can find of any sort of detriment to the nutritional composition of a food product. If other aspects of its characteristics, such as perishability have been influenced by genetic modification, it doesn't make it quote unquote Franken food.

And the nutritional content is equivalent to the nutritional content of a natural version of that food. And there's no evidence to suggest that the body treats those nutrients as distinct and recognizes, Hey, this is from a GMO and this is not, I think from the environmental standpoint, it appears to be a, a, a kind of an overall, although there are some concerns in relation to diversity, biodiversity, some concerns in relation to potential selective kind of enhancement and evolutionary fitness and advantage. That could be a problem where there just to be wider kind of breeding and cross pollination, they appear to be a valid concerns that are important to keep live, but B primarily addressed through regulatory frameworks and is rather than dismissing, you know, the use of kind of genetic modification as a strategy in and of itself. And certainly in relation to the use of pesticides, specifically, the evidence appears to be fairly overwhelming that there is a dramatic reduction in the use of pesticides, the cost of pesticides without any concomitant increase in the actual cost of production itself.

So, and, and again, we've got the biomass and, and land mass use element and the potential for greater yield without necessarily having to expand biomass use for food production. And from the economic standpoint, again, I, I, I also kind of, you know, submit that that evidence is quite overwhelming. As far as net profits goes, particularly in the developing world, there was a 2014 meta analysis that I think it was nearly a 70% increase in profits. And, and that was higher in the develop. That was the average, and that was higher in the developing world than the developed world. So the, and, and insofar as economics and food security ties to human health particularly at a time like this, where we see big kind of global south versus developed world divides. I think these are conversations that are we really inseparable from when we discuss human health overall, it goes beyond just the nutrition composition of these compounds and extends to people's food security and, and economic stability and security.

Danny Lennon:

Yeah. And, and with those conclusions to echo what we said at the start of just approaching them in a, an object non-emotional manner should mean that when we hear such conclusions of, well, we don't necessarily need to be worried about

consuming such foods that is not the same as saying, there is no ever risk of harm ever. And we should stop looking into this in any scientific analysis mm-hmm <affirmative>, or it's not to say that yeah, the food industry is always an ethical, honest player, and we should never try and hold them to account or look at what they're doing. Exactly. And it's not to say that the food system doesn't need reform in, in some pretty significant ways, particularly on an environmental. And so they are all things that are, are still very much the case. But hopefully this discussion and these conclude are helpful for people of bringing some clarity related to maybe much of the hyperbolic claims that they may see online.