

AAAS 2017 Annual Meeting AMA Series: Hi reddit! I'm Eran Elinav and I study the diet-microbiome-metabolism axis. Ask me anything!

AAASmtg2017¹ and r/Science AMAs¹

¹Affiliation not available

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Abstract

Hi reddit! The microbes that inhabit humans – collectively called the microbiome – play a critical role in human development and physiology and can be considered an additional organ. They play major roles in food digestion, immune system development, and inflammation and directly affect the growing epidemics of obesity, diabetes, and asthma in industrialized societies over the past 50 years. I'm Eran Elinav of the Weizmann Institute of Science, and I study how the microbiome affects humans (especially in regards to their diet) as well as how it can affect entire societies-shaping them through both common diseases and pandemics. I'm looking forward to answering questions about the several major ways microbes affect humans. Microbes play a major role in early childhood development, including affecting the immune system and even brain development. Our society's obsession with cleanliness and antibiotics is thus having a major impact on childhood development, including recently identified early microbiota effects on asthma. Obesity and diabetes rates are skyrocketing worldwide, and recent data indicate that the microbiome plays a central role, including the finding that obesity can be transferred through feces. By understanding an individual's microbiome, it is now possible to design a personalized diet, resulting in weight loss. In addition, historical evidence reveals that microbes significantly affect societal development. By studying ancient microbial DNA, new insights have been shed on the plagues and pandemics that have shaped our history. I'll be back at 3 pm EST to answer your questions! Ask me anything! EDIT:Thanks so much for a stimulating conversation, had a great time. Eran

[REDDIT](#)

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AAASMTG2017 [R/SCIENCE](#)

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Do these "pro-biotic" capsules contain anything useful or are they largely a waste of time?

[nate](#)

Great question Nate, and one that the field is actually heavily debating. The true answer is that the efficacy of probiotics is still heavily debatable and despite the heavy use, it's been (maybe) proven to be of value in a surprisingly few contexts such as following antibiotics use, and long-distance travel. We and others are heavily studying this topic, in an attempt to use new bugs and technologies that may optimize probiotics efficacy.

There's a suggestion that onions, garlic, and leeks are particularly beneficial for our microbiomes. How well-founded is that belief? What other nutrition is known to be valuable for our microbiomes, and what other nutrition is legitimately suspected to be valuable but lacks experimental justification as yet?

[drsjsmith](#)

There are indeed many claims and myths that suggest that some foods may be 'good' or 'bad' for us or

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for our microbiome. Our own research and that of others actually suggests that for the vast majority of foods our microbiome responses are highly individual-specific, so the notion of 'good' and 'bad' foods for everyone's microbiome is probably inaccurate.

How do microbes impact childhood development and how does our society's "obsession with cleanliness and antibiotics" impact that?

Also, how can we change people's ideas about what is clean and unclean in order to change practices?

[firedrops](#)

Great question. We are all born sterile and acquire our microbiome from our parents, and reach our 'adult configuration' by the age of three. There is increased evidence that our microbiome during childhood may effect our risk to develop a number of conditions later on in life. Studies by Martin Blaser's group suggest that childhood microbiome alterations may predispose to adulthood obesity, and studies by Brett Finlay suggest that microbiome disturbances during early childhood may predispose to asthma later on. The concept of the 'hygiene theory' suggests that keeping an overly clean environment early in life prevents the full development of a 'healthy' microbiome thereby leading to the development of these later health risks. Of course the need to be exposed to the 'real microbial world' in early childhood needs to be balanced with the risk of acquiring infection in this early period, which until the last 50 years constituted the leading cause of death in children.

Is there any evidence that antibiotics have permanently killed some inherited gut microbes? If they have, how could we repopulate our guts or would it not be possible? Would a fecal transplant from someone in a country with less sanitation, healthy food practices and antibiotics be helpful?

[klutzikaze](#)

While antibiotic treatment has clearly become one of the most important interventions that prolonged human health and life span in a short matter of a few decades, antibiotic treatment is also considered a 'catastrophic event' to many commensal microbiome strains, resulting in non-specific killing of many commensal microbes. While there is no definite proof that antibiotic usage has resulted in the permanent eradication of microbial strains, there is quite good evidence that modern humans feature a significantly reduced diversity than featured in traditional human populations such as human tribes in South America and Africa. We speculate that this reduced diversity may be associated with the rise in prevalence of multiple metabolic disorders such as obesity, diabetes and more, but definite proof for this is still lacking. As such intervention by FMT remain unproven in this aspect. One must remember that FMT may carry risks of transmission of microbial configurations that may be harmful to certain individuals, so I suggest to utilize FMT only as part of clinical trials at this stage.

posting for a user whose comment got messed up (my fault): What is your view on probiotic supplements? Are they just a marketing ploy? One would think prebiotics would be more important for health but some probiotic supplements contain unique bacteria. Are there any species or strains you know of that you consider worth using as a supplement?

[p1percub](#)

The jury is still out in respect to probiotics. Despite their widespread use, evidence on efficacy is surprisingly sparse. More research is needed in order to determine which probiotics and under what conditions may be good for health. Prebiotics, in contrast to probiotics, are supplements that affect the

composition and function of a microbiome. Here too, evidence proving efficacy is still sparse. Interestingly, we and others have been studying a new class of microbiome-associated intervention which we term 'postbiotics' and includes administration of compounds that are normally produced or modulated by a 'healthy' microbiome. This new approach bypasses the problem of the high variability between different people's microbiome configuration.

There is some speculation on RNA transfer between microbes and their host - in contrast to, say, innate immune responses. Do you have any insight as to how these may affect metabolic signaling, and do algorithms have any chance of accounting for these responses in the near future, such as predicting the development of disease?

[jessegammons](#)

The microbiome field is a very young one (less than 10 years old). One of the most outstanding and poorly understood questions relate to bacterial-bacterial communications and how they may affect the function of the microbiome and its interactions with the host. There is very little know about these mechanisms, and we and others are heavily engaged in trying to address them.

Does your childhood microbiome effect your allergies? I've heard about how peanut exposure in early childhood can reduce your chance of being allergic to peanuts, so I'm wondering if there may be any role of your microbiome in that.

[kerovon](#)

There is growing evidence that that is indeed the case. Allergies and even asthma (see Brett Finlay's late paper on this) may be associated with an altered microbial population in early childhood. Some experiments in which these altered microbiomes have transmitted the hypersensitivity upon transplantation into sterile 'germ free' mice, even suggest that microbes may drive some of these allergic reactions. The mechanisms, and precise strains that may mediate these effects remain elusive and necessitate further research.

Does the food you eat have anything to do with the microbes you have in your stomach? In a sense, would people around the world have different microbes in their stomachs as commensal bacteria?

Seeing as how globalized the world is now, do you think there is a huge difference between people who live thousands of miles apart but travel frequently?

[Hanmin147](#)

Of the many factors that impact the composition and function of the gut microbiome, nutrition is by far the strongest modulator. Multiple studies including our own have shown that nutritional changes impact the microbiome within days to weeks. The better we get in characterizing the microbiome we come to the realization that in fact each of us has a unique microbiome that is dependent on our genetics, immune system, and environmental impacts including our nutrition. Biogeographical variation is one of the forces that shape our microbiome. As such people that live far apart from each other tend to have a different microbiome, and people that travel tend to change their microbiome upon encounter with the new geographical microbial world. Another important factor that impacts the microbiome upon travel, which we discovered in the last couple of years, is the circadian clock. In fact, we found that the gut microbiome has a very unique diurnal activity, and that disruption of the circadian clock such as in shift workers and in severe jet lag results in the development of an altered microbiome that may even contribute to a risk of developing obesity and diabetes.

Are there any initial findings about the long term effects of medications on the gut microbiome?

[DryerdeLint](#)

Yes indeed. In the last couple of years it became apparent that many medications impact the microbiome in many medically relevant ways. For example, the response of a few important anti cancer drugs has been recently suggested to be affected by the gut microbiome that seems to react to these medications. There are many other examples of medications suggested to be impacting the microbiome. I expect this important topic to gain much attention and focus in coming years.

now a comment from me: what do we know about how human genomes interact with microbial genomes, and what would it take to design a study that would be well-powered to detect these effects? How long until characterizations of the microbiome become part of personalized medicine?

[p1percub](#)

That's a great question. There is more and more studied on the effect of the human genome on the gut microbiome. For example, a fascinating study by Ruth Ley's group demonstrated that identical twins carry a more similar microbiome than di-zygotic twins or non twin siblings, suggesting that the closer the genomic content is, the more similar the microbiome is. There are other studies exploring the mechanisms of these effects. Interestingly, we and others (Gury et al, Cell 2016) have recently shown that the gut microbiome may affect the epigenetics of the host- in other words our gut microbes may impact the genes that our human cell express, so these profound communications are in fact bilateral.

How much does the microbiome vary over our lifetimes? Are we born as a microbial "tabula rasa"?

[naturenet](#)

We are all born sterile and acquire our healthy microbiome from our parents and our environment. The microbiome achieves its adult configuration by the age of 2-3, and then is believed to stay relatively stable until an old age, if a person assumes a stable life style, nutrition, health, and geographical location. However, the more we learn about the microbiome the more we find how dynamic it is. One example is the microbiome's diurnal activity- we found that the composition and function of a healthy microbiome changes during the course of a 24 hour period. Thus, we consider the microbiome as being 'unstably stable'.

Hello and welcome!

Do you see a future for therapeutic use of parasitic worms as a means of immune-modulation and control of NCDs?

[PHealthy](#)

This is the subject of an intense research. Worms may induce a particular immune response that is termed a Th2 immune response, that may be protective in some immune-mediated disorders, such as some sub-types of inflammatory bowel disease. We still don't definitely know. Equally interesting and elusive is the role of worms and other eukariotic organisms in shaping the health or disease-associated microbiome.

Is it generally more beneficial to promote more diversity within the microbiome?

Has there been much work on identifying the role of other types of microorganisms besides bacteria like fungi, protista, virus, etc. ?

[vevyvevyquiet](#)

It is believed that more diversity is better for our health, but evidence for this mainly stems from the higher diversity seen in endogenous human populations, and from the loss of diversity that is common to many human diseases such as IBD. This is not a definite proof to the importance of diversity. Research into the roles of fungi, viruses and parasites in the microbiome is at an early stage, but very interesting and of potential importance.

Can you share your opinion on the effects of gut microbiota on weight loss/gain? Obviously many factors are involved but I'd like to know just how much you believe microbes in the gut can affect a person's propensity to gain or lose weight. Thanks!

[McFlare92](#)

The gut microbiome affects weight maintenance in at least two different ways: The first (described by Jeff Gordon's group) involves a change in 'energy harvest' (our ability to extract energy from food) by obesity-prone microbiome that may contribute to obesity. The second effect, which our group has recently described (see Thaïss et al, Nature 2016) involves a persistent microbiome that is retained after a successful diet that contributes to post dieting weight regain (yo yo obesity). This later effect is mediated by the microbiome's ability to degrade certain molecules that are important in our fat tissue ability to extract energy from fat.

companies are already offering to sequence your microbiome as a commercial service, do these services have strong evidence that a personalized diet works for everyone or does it only work for some people?

[Doomhammer458](#)

I am only aware of one company, daytwo, that is offering a microbiome-based personalized nutrition to people.

Do you think that the antibiotics present in a lot of meat products are having an adverse effect on a person's microbiome?

[dbarbera](#)

Antibiotics are very important medical interventions that may save human lives when given at a need and properly indicated. However, any unneeded antibiotic intervention may be very harmful to the gut microbiome. There are growing numbers of studies suggesting that non-indicated antibiotics exposure may predispose to microbiome-related diseases.

This is fascinating, and I hope I'm not too late... 1: I've read that fecal transplants have been used to transfer gut biota to assist with such conditions as IBS. One of the interesting side effects has been that recipients whose transplant came from obese donors, then developed issues with their weight. Have you heard about this, and could you elaborate? 2 I've also heard that a specific microbe has been

identified in lean people, that is not present in obese people, and which is critical to controlling weight. Is this true? What is it, and is it readily available?

[petuniasweetpea](#)

Fecal microbiome transplantation is a very important proof of concept that demonstrates the 'power' of the microbiome. It has been proven to be very effective in hospital acquired infections such as clostridium difficile infection that is responsible for lots of hospital acquired mortality worldwide. However, it is aggressive, results in relatively short term effects, and some may say a bit disgusting.. In most conditions FMT has not been proven to be effective, and we believe that more elegant microbiome-targeted interventions should be developed, and are working very hard in doing so! Re your question on microbes causing obesity, there is not one microbe responsible for obesity, and in reality the role of the microbiome in preventing or inducing obesity is much more complex and necessitates much more research.

I have read that the types of food we eat have a big physiological impact on the cells that make up our digestive system; it makes sense that our dietary choices would have a similar influence on the composition and activity of our gut microbiota. When you imagine a personalized diet, are you thinking of one that encourages a different population of microbes, or one that works the best with the microbes one already has?

[neurobeegirl](#)

Great question. Our own studies on personalized nutrition suggest that both may be true- a properly planned personalized nutrition results in modification of the existent commensal microbial populations and the emergence of microbes that may have been suppressed. The effects of these changing microbes on our weight and glucose balances are subjects that are intensely studied at my lab.

Do you think that the increase in soaps/hand sanitizers that kill 99.9% of bacteria will direct bacterial evolution toward complete resistance to conventional drugs, leading to the outbreak of a new plague, similar to the Spanish Flu or the Bubonic Plague?

[DNAhelicase](#)

I wouldn't be as dramatic, but I do think that the trend for overly aggressive 'sanitation' is unfounded and may adversely impact our microbial populations that are an integral part of our body. There is no way to get rid of our normal bacteria, which surround us and coat us, we just need to live peacefully with them!

Has there been any work that you or others have done on the *interaction* of plant and human microbiomes?

Context: some of my doctoral research was on *plant* microbiomes, which are not surprisingly very complex and even more poorly characterized and understood than *human* microbiome. One part of my research into dung fungi revealed that some plant and animal microbiomes affect each other a great deal (i.e., fungi with different stages of their life cycles in plant and animal hosts; pathogens of animals as mutualists of plants; etc.).

[WRCousCous](#)

That's a fascinating question, that I am not aware is being pursued by anyone in the microbiome field. I would warmly recommend that you follow it.

Do you like Kombucha? Any opinion about its potential impact on the microbiome?

[Balsamicon](#)

No clue what that is.

Are there any specific tips you could give us for creating and maintaining a healthy gut microbiome or are we all too unique for there to be "general tips" that apply to everyone?

[st1y_wan_kenobi](#)

Our own research and that of others strongly points towards personalized 'forces' shaping our unique microbiome. We've recently discovered, as one example, that people react differently in terms of their blood sugar rise to identical foods, and that this unique responsiveness is highly dependent on our unique microbiome. In fact, we've developed a machine learning algorithm (see Zeevi et al, Cell 2015) that is able to accurately predict a person's sugar response to any given food based on their microbiome, clinical and nutritional characteristics. As such, there probably isn't a 'golden standard' recommendation that is good for everyone...

I've been seeing a lot of studies show up on Reddit about Candida yeast throwing off the balance of our microbiome. Pointing to a bunch of different illnesses, auto immune disorders, depression, even one article Linking Candida's effect on autism. Is the effects of excess yeast part of your research or is this just a bunch of click bait to sell more products?

[Titan-uranus](#)

The role of fungi on shaping the microbiome, communicating with the host, and impacting health and disease is only beginning to be elucidated. All the popular media publications implicating fungi in a variety of disease are greatly non science based and over-interpretive. They should be taken with a grain of salt.

As a woman on the autism spectrum and someone with a variety of chronic illnesses, I have read a lot of conflicting information about keeping up a healthy microbiome.

You mentioned designing a personalized diet to aid in weight loss. Have you or any of your colleagues had any success in, at least theoretically, designing diets to improve health by decreasing symptoms for people with chronic conditions other than diabetes and asthma? Or is that more of where the future of this line of research lies?

[WELLinTHISHouse](#)

Great question. While noone is claiming that the microbiome is causing ASD, there is growing research on possible microbiome modulation of some aspects of ASD, mostly in animal models but recently also in some humans. Much more is needed to be studied to understand whether this indeed is the case. Once we understand, one of the interventions we are actively pursuing is dietary interventions, which we can harness to change the microbiome towards a configuration of choice. This necessitates much more research (which we are aggressively conducting)

Hello and thank you so much for being here to answer our questions!

This is fascinating research on something I think most of us don't put much thought into. When you say it is possible to design a personalized diet is this something our general practitioners are aware of yet or is this still in the research phase? If so, how long do you believe until we can really start incorporating this knowledge into our everyday lives?

Thank you again for your time, it's appreciated!

[FillsYourNiche](#)

We have made a great effort in developing a personalized machine learning based method to personalize our dietary choices in a way that will be healthy and effective (see Zeevi et al, Cell 2015). We are currently testing this new paradigm in long term trials in which we focus on pre-diabetics, diabetics, and females with gestational diabetes. We hope to reach interesting conclusions soon. In addition, our technology has been recently licensed by the Weizmann institute to a spinoff company named Daytwo that is optimizing this technology for widespread use.

Shalom Eran!

First of all, thank you for taking the time to talk to us.

I'm curious about what you mentioned in the original post about the effect microbes have on early childhood development. Could you expand on that a little? My curiosity is personal in this case—as a child, I had recurring ear infections which were frequently treated with antibiotics; would this be enough to impact my development?

In a more general sense, as we (hopefully) get better at preventing and vaccinating against illnesses, do you expect the benefits to our microbiome from needing fewer antibiotics during childhood or even life as a whole will have a significant impact on human behavior in general?

[TheSuperSax](#)

I prefer not to answer question relating to specific cases, but in general several works suggest that alterations of the gut microbiome at a critical early childhood period may impact a number of diseases later on in life. The better we get in avoiding antibiotics when they are not medically indicated the lesser these adverse effects on the microbiome will affect our society.

Regarding the gut microbiome (among others), severe illness and antibiotics are known to cause havoc on the balance of microbes colonizing these areas. Currently, I am hearing of how probiotics are sometimes being recommended by doctors to be taken alongside and post antibiotic treatment, as well as post illness (such as in severe diarrhea).

How much of an impact do these supplemental probiotics have, and what other ways can we promote and preserve a healthy microbiotic balance through illness and antibiotic usage?

[jddbeyondthesky](#)

The beneficial roles of probiotics on human health are still highly debatable. One of the indications in which there is some evidence suggesting a moderate beneficial effect is after antibiotic usage. Even in this indication, I believe that we need to learn more and understand more to reach final conclusions.

Does a vegetarian, vegan, meat or fish diet influence the microbiomes?

[altenwedel](#)

All nutritional variations affect the microbiome, but our own research on personalized nutrition suggest that these effects are highly person-specific. As such, for example, if one would go through our predictive pipeline process we could devise for a person two diets that are vegan, one that is good and one that is less favorable for that person. The same is true for any diet we ever tested. Thus, personalization seems to be the rule governing our healthy response to food.

Welcome Dr. Elinav! I had a few questions for you:

1. You mentioned obesity is transferred through feces, but is there evidence it works the other way around (ie. can a particular gut microbiome reduce obesity)?
2. And do you think microbiota and/or bacterial metabolites are responsible for this?
3. Probiotics don't seem to colonize and persist for very long in the gut. Are there any strategies to combat this and create probiotic treatments that have a lasting impact on the gut microbiome?

[footiebuns](#)

In animal models, obesity is transferable through feces. Likewise, transfer of human 'obese' microbiome into sterile germ free mice transferred the obesity phenotype. However, I'm not aware (yet) of a concise evidence for human to human transfer of an obesity phenotype. In general of the several proposed mechanisms accountable for microbiome regulation of obesity, we implicated several metabolites in these processes. Re the probiotic question- great question, this is actively studied by us and by others, no answer yet unfortunately.

Do you believe that our gut microbiota is what actually causes us to crave certain foods such as sugars or fats?

[Johnadams1797](#)

That's a question I'm often being asked, and my answer is that we do not know whether such link exists. In general the links between the gut microbiome and higher brain functions such as cravings and feelings are only beginning to be studied.

The microbiome is quite a hot topic lately (with the mycobiome slowly picking up speed), but most studies focus on gross changes in diversity. My belief is that the next phase of research should begin to investigate how these bacterial communities interact with one another and how this in turn directly affects the host (basically more mechanistic questions).

What do you think is the most critical piece of this puzzle that is missing and how can we as scientists make headway in answering this question?

[womanwithbrownhair](#)

I totally agree. The two big challenges of the field (in my view) are: A. moving from descriptions of associations between the microbiome and disease to demonstration of causality B. Exploring better microbial-microbial and host microbial interactions in a molecular level. We are engaged in both of these efforts.

Now that people can get their DNA sequenced for fairly cheap and download the datasets, a number of diet sites have popped up claiming they can use this data to tell you your optimal genetic diet. Are any of these sites legit or are they making claims unsupported by the research?

[Upvotes4theAncestors](#)

The field of 'nutrigenomics' has made many such claims. A recent meta analysis has shown that many of these claims feature no statistical significance and thus carry very little if any scientific validity.

Have the possible effects of vaccinations on our micro biomes been investigated? If so, what percentage of studies show that there is no relationship? If there are any (reputable) studies that found evidence of an effect, what effect did they find? Do you have any other thoughts on this?

[youbethechange](#)

I am not aware of a single study implicating any adverse effect of vaccination on the microbiome. In my strong view as both a clinician and a researcher, vaccinations are among the most important and beneficial interventions that greatly impacted human health and dramatically reduced morbidity and mortality of a number of dangerous diseases. I see no reason to avoid vaccinations.

Would it be possible to 'teach' microorganisms in the microbiome to produce medication?

[altenwedel](#)

There are several cool and interesting studies trying to exploit commensal organisms as vehicles delivering medications to the human host. These are mainly investigational at this stage.

Hi Dr. Elinav, thanks for sharing your work and thanks for a fascinating interview on Science Friday a few months back!

Progress has been made in demonstrating an intricate relationship between the microbiome and the innate immune response. Can you shed some light into the possibility of a relationship between the microbiome and the adaptive immune response? Specifically, how can some bacteria be integral to our normal function in some instances and cause severe infection or illness in others?

[Jolllly](#)

Thanks for this question. Indeed the microbiome is increasingly shown to impact both the innate and the adaptive immune responses in a variety of manners. I refer you to a Cell paper from the last couple of weeks by Dennis Kasper's group showing a number of such new interactions. The differing roles of microbes are highly context specific and strain specific, and we are only beginning to uncover the intricate networks that dictate the net results stemming from these microbial interactions.

Thank you for your time, I've heard some suggestions that the appendix plays a role in our microbiome. There is not much in the literature, which could either mean that it is not promising OR that it is promising, but hasn't gained momentum yet. What do you know about this, and what is your opinion on the future of this research?

[MtGroovius](#)

I'm not aware of definite proofs for this. The fact of the matter is that many individuals have their

appendix removed and maintain a healthy microbiome configuration..

Thank you for doing this! Is there any connection between microbes in our intestines and mental health? I have heard in passing that probiotics are recommended for depression and anxiety for this reason (I do not have a source). If there is a connection is there anything we can do to help keep our microbes healthy and thus improve our mental health?

In the same vein I have heard theories on autism and it's relationship to gut bacteria. I do not have a source but have heard of symptoms improving after fecal transplants and even certain antibiotics. Does this possibly have anything to do with microbes?

I guess my main question is how directly are microbes related to the brain and it's development and function?

[ieatbugsandstuff](#)

Research linking the gut microbiome and central nervous system function is very new. While interesting insights and observations have been made in this regard, many have been made in animal model, so we are at an early stage of trying to understand these associations and their impact on disease. I think that implying from the current state of research to interventions and treatment is high premature and we will have to wait for more research to come out to conclude the efficacy of such interventions.