Starvation

JG: Hello, my name is Jim Graham. I'd like to tell you about an experience that I had during World War II as a Guinea pig in an experiment in semi-starvation. On February 12th, 1945, we began our 24 weeks of semi-starvation. We were expected to lose about one-fourth of our body weight during the next six months. The days began to drag out. Each day getting longer and longer, and there seemed to be no end of starvation in sight. Six months seemed like forever. I'd look in the mirror and see that my eyes looked hollow. My cheeks were only a thin covering for the bones in my face, and my hair was getting thinner. If I tried to smile, it was just a grimace. I didn't feel like smiling in the first place, and I never laughed. My muscles were almost gone. My bones protruded, and sitting on a hard chair was uncomfortable, even for a few minutes. Most of us carried around pillows to sit on. I couldn't walk up a flight of stairs without stopping to rest once or twice on the way up. I felt like an old man and probably looked like one, since I made no effort to stand up straight.

JG: I thought about food all the time. I started collecting cookbooks, you know, the kind with beautiful color pictures of delicious-looking dishes. I felt cold all the time, even though it was the middle of summer. Nothing felt better than to find a nice, warm spot in the sunshine and do nothing but lie there and soak up the heat of the sun. We became very irritable and intolerant. Little things seemed to annoy us. We were no longer polite with each other or with visitors. It seemed as if the veneer of civilization had been removed, leaving bare the animal underneath. We didn't enjoy having guests because it was an effort to entertain them, and we were not usually very diplomatic about showing our feelings about it. Food occupied our thoughts all the time. At mealtime each one had his special way of dealing with the food. A couple of the fellows would eat their food quickly and then leave the cafeteria and try to forget about it. Most of the rest of us daudled over our food. Some would mix their food all together. Others would savor each bite of each item on the plate. We'd been told before the experiment that the food might become monotonous since there were only three menus, but it was far from monotonous. It was food. And any food tasted good. To this day, I find one of the tastiest foods is a simple boiled potato. It's delicious. Any food looked good. Even the dirty crusts of bread in the street looked appetizing, and we envied the fat pigeons picking at them. Wasting food is a crime. And we felt the waste of food in restaurants was intolerable.

JG: On July 29th, 1945 was the day semi-starvation was to end, and we were to begin eating again. It was also my 23rd birthday. After the experiment was over, I was still hungry for a long time. Even when I could eat all I wanted, I would finish a meal and still feel hungry. My stomach just would not hold anymore.

For months, I carried candy bars or cookies in my pocket and munched continually. In six months, I went from a low of 122 pounds to a high of 225 pounds. It took me three years to get back to normal weight and normal eating habits. In conclusion, I would like to say that I have experienced hunger and the apathy and depression that goes with it. But we lived in sanitary quarters under the constant care of doctors. Most people in areas of famine die of other diseases because of the body's inability to resist disease. Furthermore, we knew that it would all be over on a certain date. I often think how horrible it would be to be starving and never know when it would end, if ever.

EW: Uh, it's, that is such a fascinating perspective and like the fact that that video exists is kind of incredible.

EAU: Yeah. Yeah.

EW: Yeah.

EAU: It's, yeah, it's, especially that what he says at the end, the like, knowing that it's going to end and how much that can change the way that you are experie. I don't know. It's oof.

EW: I mean, it's like, and we'll get into it more later, but yeah, this is like artificial settings important nonetheless, but like, yes, this is not the type of thing that people experience under real world conditions of starvation.

EAU: Yeah.

EW: So, um, but yeah, so again, that was Jim Graham who participated in the Minnesota semi starvation experiment, and that's from a video that was recorded in 1990 and it's part of Colorado State University's digital library collections, uh, specifically university publications. And we will post a link to the full video and the transcript as well on our website so you can watch or listen to or read the entire thing. So

EAU: Yeah.

EW: Hi, I'm Erin Welsh

EAU: And I'm Erin Allmann Updyke

EW: and this is, This Podcast Will Kill You.

EAU: So this week and next we are gonna be talking about starvation and famine.

EW: Mm-hmm.

EAU: And those words, along with hunger and malnutrition have been used a lot lately in discussions surrounding the ongoing genocide and famine happening in Gaza and the conflict raging in Sudan.

EW: All of these words, you know, starvation, famine, hunger, malnutrition, are associated with a lack of food and the subsequent effects of that lack of food. But each one of these words has a distinct meaning. And so what we wanna do with these two episodes is to provide a bit of context for understanding, you know, what it is that we're talking about when we talk about starvation and what it means to declare a famine.

EAU: Yeah. So we're starting out this week discussing starvation, the physiological and psychological impacts, and a little bit about its history, and you'll hear more about that Minnesota semi starvation experiment.

EW: Yes, you will. And then next week we will turn to famine. We'll go through the definition or definitions of famine, what causes famine, and how famines have changed throughout history before we outline some of what's happening with the famine in Gaza and other food insecurity crises in other areas of the world.

EAU: Yeah, we have a lot to cover in these two episodes, so we decided to do things a little differently and just start right into it.

EW: Yep. Yep.

EAU: we're gonna take a quick break and then get started.

EAU: My goal for this first part of today's episode is to walk us through what is happening in our bodies, what happens inside of our bodies when we are deprived of food. So I'm gonna start with what's happening on like a fairly minute scale. Like how does the inner machinery of our body keep ticking if we don't provide it with any source of energy? And that process can happen for any reason, right? It could be because you lack access to food. It could also be because of prolonged illness. It could be a restrictive food intake disorder. It could be any number of things. But I'm gonna go through the like mechanism of what's going Mm-hmm. But then we're gonna take a step back a little bit outside

of our bodies and talk about some of the bigger picture consequences of prolonged starvation, especially in the context in which we most commonly see starvation today around the globe, which is lack of access to food.

EW: Right, right, right. So like population level effects.

EAU: exactly, exactly. Yeah. Well, individual and population level, but like, right. Um, so it's, it's a lot. It's all depressing

EW: Mm-hmm.

EAU: as animals, we use the food that we eat to create energy and that is the process that we call metabolism.

EW: Mm-hmm.

EAU: And we don't have to get deep into biochemistry, don't worry, 'cause I simply cannot. Um, but there are three main macronutrients that are most important, at least for my discussion today. And that is carbohydrates or glucose, fats and protein. And these are the majority of what makes up our foods. Of course, there's a lot of micronutrients. We've covered several of them on this podcast. They are essential to keep us functioning. But the big three are what we're gonna focus on today. We have to break down and use carbohydrates, fats, and proteins in different ways via a whole bunch of complicated cycles in order to create energy and keep our cells alive,

EW: Right.

EAU: and all animals do this. And because food is almost never like constantly available, we all have, all animals have mechanisms, physiologic adaptations in order to survive in times of food scarcity or food deprivation. And the exact adaptations are gonna vary a lot by species, which is why bears can hibernate for months on end. Salmon traverse thousands of kilometers without eating. Snakes can only eat a couple of times a year. But humans, we have relatively high metabolic rates, especially relative to like our body stores of energy.

EW: Mm-hmm.

EAU: So we actually need food on a pretty regular basis in order to survive.

EW: There are also behavioral adaptations, like caching food, which I mean, of course humans, but like, like we talked about in hypothermia.

EAU: I know as I was writing this, I was like, we just went over this in hypothermia. Um, so when animals, including humans are deprived of food, we experience hunger.

EW: Mm-hmm.

EAU: And the feeling of hunger is driven by a pretty complex interplay between hormonal and neurologic signals. But hunger is also a biological drive. So in animals, including in humans, it's a driving force of behavior. And in a lot of animal studies, animals across the spectrum like mammals, birds, everything will engage in riskier and riskier behavior in an attempt to access food if they are hungry or starved.

EW: Yeah.

EAU: And in many animal models, the hunger drive actually out competes or overrides nearly all other biologic incentives.

EW: How does it compare to like thirst drive?

EAU: That's actually a good question. I didn't see any things directly comparing that, but they're also very closely related because a lot of times, you know, if you are deprived of food, you may also be deprived of water. There's also some animals who get their water primarily from their food. Um, so yeah, it's a good question, but I don't have like an exact answer to it.

EW: Yeah.

EAU: So I'm gonna go into a little bit mechanistically about what's happening during that time, during starvation. And there are a lot of hormonal drivers and things at play that are controlling our hunger cues and our satiety cues. But I think what's important to keep in mind as we go through this is that, in my opinion, maybe this is an opinion. None of this explanation is really adequate to explain what happens to people and animals, but also humans when they feel hungry. All the time for days or weeks on end. I think that our firsthand account helped to explain some of that bigger picture about how it feels to be hungry. But the biology doesn't quite, I think, do that justice,

EW: Yeah. I mean, it, it does, it, it can't,

EAU: it can't,

EW: can't. 'cause it's so clinical.

EAU: yes, exactly. Yeah. So, but metabolically absolute food deprivation proceeds in relatively predictable stages. It starts with what's often called fasting and then proceeds through starvation and without intervention, this will end in death. So the first phase of food deprivation is it's often called fasting. And there's arguments about like when do you hit the threshold between fasting and starvation and et cetera. But the point is that this is just the first few hours after you've eaten food. Once we've absorbed all that we can from our meal, the first thing that our body is going to do is start using glycogen, which is the long branchy chains of glucose that we store in our liver, and we start breaking this down in order to keep our blood sugar levels up

EW: Okay. So this is what happens after you eat a meal

EAU: after you eat and you've digested and used up all the glucose in your meal. Yep. Yeah. Uh, we'll also start to use some of like our adipose tissue storage, especially to like fuel our muscles and things like that. This phase though, the glycogen storage that we have in our liver only lasts for about a few hours, which is why we usually start to feel hungry a few hours after eating

EW: Mm-hmm.

EAU: after a few hours without food. Our liver's, glycogen stores are depleted and our brain requires glucose in order to function. The rest of the tissues in our body can use other energy sources. They can go through these biochemical pathways to like directly use proteins or fats in order to make energy, in order to make ATP. But our brain really needs glucose. That's what it is dependent on. So our liver abides and starts making glucose. And this is a process called gluconeogenesis, literally making new glucose.

EW: This is, it's like, I remember all of this in such vague terms from like Bio 1 0 1, and it's, I, I don't know if it's coming back to me, but by the end of this it, it will be

EAU: It, you've, you have certainly come across this, I'm sure in like most

EW: Like gluconeogenesis.

EAU: Yeah. Yeah. It's actually one of my favorite words,

EW: It's a good word.

EAU: it's a good word. We go through glycolysis and now we make glu New Jerseys anyways, uh, at, at first, like the, at very first our body starts to do this with some protein because protein is, is very easy for our bodies to make glucose from.

EW: Okay.

EAU: So we'll start breaking down a little bit of protein in order to feed our brain, but. Proteins in our body are not really there for energy storage. We use proteins in our body for building stuff. We use it to make our muscles, we use it as enzymes, right? So our body tries to preserve protein aside from like what we eat and then have to use, right? So pretty quickly our body switches and we start relying more on our adipose tissue, our fat, in order to fuel our body. We cannot though make glucose directly from the fatty acids part of fat,

EW: Okay.

EAU: but we store fat and, sorry, this is getting a little technical, but we store fat in the form of something called triglycerides, which is three fats and a glycerol, and that one glycerol we can make glucose from.

EW: Okay. Could we just pause and start? So now can you put me in like a timeline of what is happening and when? Like step one, you eat step two, you digest step three, you start to pull the glycogen from your liver. And then step four, where does proteins, what, what happens with the proteins and fats at that

EAU: It's not like an exact, like this day you switch 'cause it's gonna depend on your body composition and like what your last meal was and all of those sorts of things. Right? But in general, after a meal, the first few hours, you're gonna be mostly using glycogen stores. After those glycogen stores are depleted, your body is going to start breaking down your own body in order to get the glucose that you need. It might use a little bit of protein at first, but primarily it's going to rely on using your fat stores.

EW: Where are fat stores?

EAU: I mean, all over your whole body, all

EW: and there's, it's just everywhere. It's just sort of a,

EAU: Yep. Yep, exactly. Yeah. So we start seeing a lot of this process called fatty acid oxidation, and that is the majority of what we're gonna see for

potentially weeks on end, depending on how much fat storage you have. The process of fatty acid oxidation will also result in the formation of ketone bodies. People who have heard of the whole keto diet thing will have heard of this.

EW: should do an episode on the Keto Diet, though.

EAU: We probably should. Our brains can actually use ketone bodies. They can use ketones as fuel. They, our brain prefers glucose, but it will use this as it is required to.

EW: Mm-hmm.

EAU: But this whole process is basically our body adapting to this starvation We will use up all of our fat stores and how long we can survive in this particular phase is going to depend pretty much on our body composition, our age, our comorbidities, all of these things. But it's usually a period of a few weeks or so after that we enter what's kind of called phase three, and that I think of it as when our body is really not able to compensate anymore because this is the point at which we've run through these fat stores and now we have to rely on skeletal muscle and our body has to start breaking down our muscle proteins in order to use them for energy. And you can imagine that that's not good for our body. We need our muscles.

EW: Mm-hmm.

EAU: But that is what our body will do in order to keep it alive in the short term. Right?

EW: Can I ask a question about like how food consumption changes this process?

EAU: Yeah. It's a really good question. So it's not common that people are completely deprived of food and have absolutely no access to food, right? More often people are gonna get very small amounts of food a little bit at a time, or maybe erratically, and that is what is sometimes called this like semi starvation.

EW: Right.

EAU: The way to think about that is it's going to kind of fluctuate where you are in this continuum. As soon as you eat, your body is going to use up all of that food that it can. Isn't gonna be able to store any extra. It totally depends on how deprived you have been, right?

EW: Right.

EAU: But you can think of it as kind of keeping people cycling between these first few phases for a potentially more prolonged period of time.

EW: Right. But

EAU: be that you're kind of going, your body is doing all things at once, right? You've, if you've used up all of your fat stores and then you get access to food, then your body's going to use that food. But then as soon as you, you've used that up, you don't have any fat stores, so you're gonna go right back to using

EW: You're jumping straight back to protein. Okay. Okay.

EAU: Yeah. So that's, I mean, essentially what happens, this process, especially once you get to the point of breaking down your own skeletal muscle for fuel, um, can progress fairly rapidly. And if food does not become available, this will end in death kind of directly from starvation. There are, in the literature, kind of two different syndromes that we most often see in people who are affected by starvation and collectively, this is called severe acute malnutrition. This is like the end stage of this. This is like phase three, end stage of. Lack of access to food.

EW: Mm-hmm.

EAU: This used to be called, it was when I learned it actually called protein energy malnutrition. But separately within this, there's two different syndromes. One is known as kwashiorkor, and the other is marasmus.

EW: Yes.

EAU: And a lot of the literature around severe acute malnutrition, or SAM focuses on children under the age of five because they are by far the most vulnerable to severe acute malnutrition and the complications that can arise. But it's not the only, they are not the only people. It's really important to remember that other groups are very vulnerable to food deprivation, including pregnant or breastfeeding people,

EW: Mm-hmm.

EAU: including the elderly and including children and adults with certain disabilities or comorbid conditions. Things like cystic fibrosis or cerebral palsy.

I mean, there are so many conditions that might make you more susceptible to malnutrition.

EW: Yeah.

EAU: But I wanna go through these two syndromes in a little bit of detail and then we'll talk bigger picture about all of the complications that happen as your body has gone through this starvation process. So marasmus is also known as acute wasting, and this is when you lose a very substantial amount of weight and usually in a relatively brief period, although some people, if they have been experiencing prolonged semi starvation, it might be over kind of a longer time period, but it's diagnosed based on specific like body weight and height measurements, or by measuring the upper arm circumference, um, and having that be below a certain circumference. It's like a good. Indicator of how much weight someone has lost. And this is really the kind of most classic process that happens as what I described of starvation. So as you have no food, you use up all of your fat stores and then you start to eat away at your muscles and then you are experiencing marasmus. Does that make sense?

EW: Yes. Yes.

EAU: The other condition is kwashiorkor, which historically was thought of as primarily a protein malnutrition.

EW: Well, yeah. does that mean?

EAU: Yeah, it, it used to be, so it was first seen in certain populations in association with a very low protein diet, or in infants after they switched from breast milk to very low protein, like say all corn diets or something like that. And so based on those kind of like epidemiological studies, and in contrasting that to marasmus, which was thought of as purely like a calorie deficit.

EW: Uhhuh.

EAU: Without necessarily only a protein deficit. This was classified initially as like, oh, this is a protein deficit rather than like a total energy deficit. But it turns out that that's not really quite as clear cut and the exact pathophysiology is not entirely understood. We really don't understand kwashiorkor right now, but it does look different physiologically than marasmus or wasting. It's characterized by this edema, this fluid collection and swelling underneath the skin especially, and it starts in the lower legs, but can also be in the face, in the

arms. And there's also fatty liver infiltration that we see and you can get from that, like distension of the abdomen,

EW: Uhhuh.

EAU: and then we'll have like flaky skin and other changes that we don't necessarily see with marasmus or wasting. We think, from what I could tell from the literature, that kwashiorkor more specifically might be like a maladaptive response to the way that our body is processing protein

EW: Hm.

EAU: in the face of a very low protein diet, if that makes sense.

EW: Yeah. Okay. So I'm curious, like I, the food that we eat is not just food, right? Like, there are different qualities of food, different, like types of food, different energy sources, and so how does that play a role? I mean, maybe this is jumping ahead a bit and asking sort of about like refeeding, but how does that play a role in, you know, the, the development of these sort of symptoms or conditions?

EAU: Yeah. I mean, in all honesty, we don't like really fully know because we don't know, like there can be a lot of, first of all. marasmus and kwashiorkor are not necessarily mutually exclusive. They happen simultaneously, but they also can happen in, let's say like the same communities and sometimes when people are, are exposed to or have access to the same foods. And so that's why it's not entirely clear, like, you know, if we, let's say if we're, we're focusing on humanitarian aid and like what types of foods do we need to get into an area to prevent Kwashiorkor more specifically, it's not quite as clear as that, except that protein is definitely an important part of that. Um, but it's not, it's not as clear cut as like Yeah. It's just not as clear cut as like protein malnutrition equals

EW: Right. Okay. Okay.

EAU: Um, it's also more difficult to estimate in terms of the, um, distribution of it. We don't have as good of a handle on it. It does tend to be even more severe than marasmus alone. Um. And is that because there's this like maladaptive component to it, we see like increases in oxidative stress in kwashiorkor compared to marasmus. Um, we see even more microbiome changes. Is there a microbiome component? There's like a lot of of questions, but

EW: What you mean by maladaptive response though? Like.

EAU: I mean like you aren't, they, they aren't breaking down and using the protein that they do have in a way that would like sustain them for longer best way that I can.

EW: Okay.

EAU: Yeah. There was a paper that came out in the Lancet not too long ago that was more specifically looking at like one type of metabolism called one Carbon Metabolism, which is one of these many biochemical pathways. And it's thought that maybe that is affected more severely in kwashiorkor compared to marasmus. So maybe it's that, that we're not using this one pathway as well. Why we dunno.

EW: Hmm.

EAU: But overall severe acute malnutrition, like both of these combine affect up to 17 million children or more worldwide and untreated, once a kid meets criteria for severe acute malnutrition, it has a mortality rate of 10 to 15% per month.

EW: Yeah

EAU: So the overall effects of this are really profound. Physically, it's manifest like you see it as this loss of the subcutaneous fat that's gonna be like the last fat that your body tries to hold onto, and that's what gives you a very gaunt appearance. And then you're gonna have this muscle wasting, which is also going to come with weakness because your muscles are literally like being. Eaten away by your own body, your skin becomes dry and wrinkly. Your hair becomes sparse and thin. The cheeks look very sunken because you've lost the cheek pads. This fat that's in your cheek, physiologically, your heart rate slows down. Your blood pressure is very low, your body temperature is low. Oftentimes, especially towards the most severe stages, appetite is gone, which can make it really hard for people to start eating again.

EW: Yeah.

EAU: And sometimes when they do, they're faced with nausea, vomiting, diarrhea. And that's because during this process, your digestive system is essentially shutting down.

EW: Right?

EAU: Starvation affects every single organ system in our body.

EW: Mm-hmm.

EAU: Glucose homeostasis is disrupted and so we often see hypoglycemia. Um, and that's especially true in kwashiorkor compared to marasmus or wasting. So again, something maladaptive happening there. We also, and this one's really important, see huge alterations in our immune system Function

EW: It's one of the biggest, yeah.

EAU: is one of the biggest because many people, especially kids with severe acute malnutrition, will end up very sick with life-threatening infections. And cause of death is often from infection and not directly from starvation itself.

EW: Right, right.

EAU: But this is directly because of a secondary immune deficiency.

EW: Right.

EAU: It's so, it is the starvation that is putting you at risk for infection.

EW: versus proximate cause type Yeah. Yeah.

EAU: but this immune deficiency comes from a combination of different things. There's disruption in all of our major barriers, right? There's disruptions of your skin integrity, of your respiratory barrier, of your gut barrier, but then we also see an increase in the activation of inflammatory pathways. We see T-cell dysfunction. We see a reduction in antimicrobial activity of most of our immune cells. And then, like I mentioned, we see this like off lining of our entire digestive system because it's not doing anything. And so our body is trying to preserve energy. We see our liver, our pancreas, our biliary system, our intestinal tract, essentially not functioning at their typical capacity. We also see huge changes in the gut microbiome, which can sometimes include bacterial overgrowth in the small bowel.

EW: Huh.

EAU: Um, especially in kids, we can get impairment of thyroid function and cortisol and growth hormones, which can have profound effects for the rest of their life.

EW: I mean, so many of the aspects of starvation, whatever. Yeah. At what point in your life it happens it can, it will stay with you forever.

EAU: Forever, forever, forever. Um, absolutely. And then there's changes in our brain functioning as well, and not just an increase in lethargy and irritability, but also the psychological effects, which are really profound and honestly not quite as well characterized. But I know, Erin, you'll talk a lot more about some of the initial data that we have on this from that semi starvation experiment. There was also a more recent review paper that highlighted several hundred studies, not all of which were a lot of which were in that kind of artificial type of environment. That's where a lot of our data comes from. But there was also at least some papers that were looking at the effects of starvation psychologically, um, in more unfortunately realistic situations like in areas of famine or chronic starvation and things like that. Um, and we consistently see increases in depression, anxiety, higher psychological distress. We also see increases in competitive behavior and social withdrawal.

EW: Yeah.

EAU: Um, and of course, in most situations of chronic malnutrition or acute starvation that we see in our world today happen after natural disasters, armed conflict. And these are situations when lack of access to food is not the only stressor.

EW: Compounding trauma.

EAU: exactly. And there's not a lot of studies that have directly looked at all of those compounded effects, but we can often, unfortunately, see them play out on our cell phones from videos.

EW: Mm-hmm. Mm-hmm.

EAU: Um, yeah. Many of these changes also have lifelong effects and unfortunately we don't even have all that much data on it. We have really clear data on the profound effects of starvation during pregnancy on the fetus, and on growth of those babies thereafter.

EW: Mm-hmm.

EAU: We don't have as much long-term data on the effects of malnutrition, um, but there are at least some that, like exposure to severe malnutrition, especially in childhood, is associated with increased risk of cardiovascular disease, hypertension, dysfunction of your glucose metabolism, and cognitive and developmental delays

EW: Forever.

EAU: forever. And you had mentioned, Erin, about treatment.

EW: Yeah.

EAU: And it might sound like treatment should be straightforward, right? If the problem is lack of access to food, get people access to food,

EW: Yeah. It's, Nope, not

EAU: it, it's not, it's not straightforward for a lot of reasons, right? Um, in the context of starvation, both like acute food insecurity and more chronic food instability, we do rely on food. Like that is the number one thing. And a lot of times humanitarian programs and things like that are gonna rely on what's called ready to use therapeutic food or RUTF. And this is something that has been specially formulated based on studies to try and hit at those most important nutrients, right? We have a good amount of proteins, we have all of the essential amino acids, we've got micronutrients, which are really important even though I didn't focus on them, um, in severe acute malnutrition specifically. It's usually treatment with this like ready to use therapeutic food and often a short course of antibiotics if you've gotten to the point of meeting criteria for severe acute malnutrition.

EW: Right. Yeah.

EAU: Um, and it used to be that the treatment of this, especially like the most severe forms and in times of crisis or famine, it used to rely almost entirely on these like centralized treatment centers, which were almost always set up by external, you know, NGOs and nonprofits.

EW: Mm-hmm.

EAU: But it has really shifted for the better to more community-based care because A, that's gonna get access to a lot more people. B, it's gonna mean that caregivers can stay, especially with their children and their other children who

might not be as sick as the ones who need the most help. Um, but there is always in. Areas of like mass food insecurity and starvation. There will always be people who are sick enough, whether from starvation alone or the combination of starvation and infection or other underlying illness that they do need hospitalization. And that's specifically because of a risk called refeeding syndrome.

EW: Yes. Yeah.

EAU: And basically this is that as you rapidly increase nutrient intake, when you've been deprived for so long, your body switches from this prolonged state of breakdown to all of a sudden being like, we've got food we need to build up. So we switched from what's called catabolism to anabolism. So instead of breaking down our body, we're building up storage. This leads to a pretty huge surge in insulin secretion 'cause that's one of our main hormones involved in storing energy.

EW: right.

EAU: During starvation, it's not that we have absolutely no insulin, but our insulin levels are incredibly low,

EW: Mm-hmm.

EAU: and this is going to stimulate the uptake in storage of glucose, which can result in really severe hypoglycemia in the case of prolonged starvation because you don't have that much stores to begin with. But it also, because of the effects of insulin, stimulates the uptake of a bunch of different electrolytes into ourselves. It shifts electrolytes into our cells, including potassium, magnesium, and phosphorus. And this can result in really dangerous electrolyte abnormalities that can cause things like heart arrhythmias, seizures, respiratory failure, and even death.

EW: How do we prevent that from happening?

EAU: I mean, first it's monitoring, um, and then it's repleting those electrolytes and the sugar if needed.

EW: How do we do that

EAU: Uh, by giving people that, whether it's through IV or through eating, so that they're getting enough potassium, making sure that they're getting enough magnesium and phosphorus and fixing electrolyte shifts

EW: those levels essentially. I mean, I imagine that would be very difficult to do in situations where, you know, there's already a, there's already aid is being blockaded.

EAU: Right. Exactly. Well, and so many of the areas where we see, especially like acute disasters, the healthcare infrastructure is not there either, right? Um, so yes, so Refeeding syndrome is a very real risk if you are not able to identify it and manage it.

EW: And those who are most vulnerable to Refeeding syndrome are those who are also at the most extreme of end of malnutrition. Or can it really happen to anyone who's been in a semi starved or like experiencing chronic hunger for a while?

EAU: Yeah, that's a really good question. You don't necessarily have to meet criteria for severe acute malnutrition to be at risk Refeeding syndrome. Um, it is, it is really this prolonged risk. So often people might have meat criteria for severe acute malnutrition, but not necessarily in order to potentially have Refeeding syndrome.

EW: Okay.

EAU: Yeah, it's something we unfortunately see a lot actually in the hospitals in the context of like restrictive food intake disorders like anorexia and things like that. It's not uncommon to see refeeding syndrome in, in those contexts as well.

EW: I see.

EAU: And globally, millions, millions of children face food insecurity, especially in low and middle income countries. It is estimated that at least. 10% of deaths in children under age five globally are due to severe acute malnutrition. And there are estimates as high as 45% of deaths in kids under age five being at least in part due to under nutrition. Meaning it's a combination of their susceptibility to infections and all of these other things as a result of undernutrition.

EW: I mean, starvation is not just a simple lack of food,

EAU: Correct, correct.

EW: right?

EAU: Um, right. Especially, and we'll talk a lot more about this next week, but so many of the situations that we see

EW: Mm-hmm.

EAU: kind of acute disruptions in food supply, we also see displacement. also see armed conflict. We also see crowding. We also see lack of, or dismantling of, or disruption of clean water facilities, sanitation facilities. All of those things are going to put people at higher risk of the spread of infectious disease. And we know that they are more susceptible to infectious disease. We see things like outbreaks of diarrheal diseases, which can be very devastating cause dehydration and electrolyte imbalance when you are already facing malnutrition. Um, and even when we talk about the global estimates on kids who are affected by malnutrition or wasting, those estimates tend not to capture the groups of kids and adults who ef face acute malnutrition because of things more acutely like natural disasters or conflicts. And these kind of more emergency situations, those are often actually not reflected in the larger statistics when we talk about the burdens of severe acute malnutrition, um, which is grim. And we'll talk more about those acute famine situations next week. But Erin, you tell me a little bit more about how we learned what we know about these effects of starvation on our bodies?

EW: I can tell you about one way we learned. Yes.

EAU: Thank you.

EW: The brochure read, "will you starve that they be better fed?" More than 400 people said that they would. Of those 100 were interviewed and 36 were selected to participate in what would be known as the Minnesota starvation Experiment. So in 1944, as World War II entered its fifth year, researchers in Europe and the US grew increasingly aware of the dire situation that was facing much of war torn Europe and the of the horrific and brutal conditions in Nazi concentration camps, millions of people who had gone months, even years without access to enough food and clean water, adequate shelter and clothing and healthcare leading disease to spread unchecked. People realized that when this massive global conflict came to an end, which seemed more and more likely as the months went by, massive numbers of relief workers would be needed to deliver food and resources in liberated cities and camps. There was no

agreed upon plan for how best to distribute these resources, like what and how much food to give a starving city what kind of food.

EW: In November of 1944, after years of lobbying for funds to study the effects of starvation, physiologist, Ancel Keys was finally granted the opportunity to begin his study. He distributed those pamphlets that say, you know, will you starve that they be better fed? He distributed them to thousands of conscientious objectors who after being drafted into the war, had exercised their right to refuse service for moral or religious reasons.

EW: Um, side note, before I forget, I wanted to mention that this is not, this experiment is not Ancel Key's only claim to fame or even his biggest claim to fame. He also developed K rations for American troops. So these were these ready to eat non-perishable meals, breakfast, dinner, and supper, and, um, that soldiers could carry around with them. And I, uh, there are, there are YouTube videos of people trying these out like today, like, uh, unboxing and like reviews of the different types of K rations. I'm like, those are 80 years old. Uh, I mean, I, I think they were also made up through, uh, the 1950s. I'm not sure. Don't quote me on that. The keeping it in the podcast anyway.

EAU: old.

EW: Old. And um, and he also, in addition to K rations, he, along with his wife, popularized the, uh, Mediterranean Diet.

EAU: I saw that too. I was like, wow. Keys

EW: Keys. Keys, yep. He was kind of an influential guy. How about

EAU: kind of. Yeah.

EW: But anyway, so Keys was interested in starvation, not only in terms of its effects on the body and the mind, like what is actually happening during starvation, but especially how best to feed someone, to treat someone to treat the starvation without causing further harm. And also what, while making efficient use of limited resources, like the resources were limited, most of Europe was under rationing anyway. And so he designed this experiment where he took 36 young healthy men and put them on a semi starvation diet. And on this podcast, we are, I think, fairly accustomed to thinking of the word volunteer in quotes, like especially when it comes to early 20th century medical experiments. But in this case, volunteer seems to truly mean volunteer and Ansel. Yeah,

EAU: I feel like that sets this apart almost more than anything.

EW: absolutely.

EAU: That he did not experiment on people unwillingly.

EW: Right. He, he didn't like, he was really, I think, very, um, deliberate about what he was doing as were the men who participated. Like Ansel Keys was, seemed truly motivated by the desire, the passion to reduce suffering in people around the world. And many of the men who participated were later interviewed in like the early two thousands about their experiences. And they all said that if given the chance, they would do it again. Which is, I think that's like, that's, they were very proud of their contribution because I think to be a conscientious objector during World War ii, it came with many complex emotions that some of the men talked about. One man said quote, you know, "the sense of not sharing the fate of one's generation, but of sort of coasting alongside all of that, you couldn't feel you were part of anything terribly significant in what you were doing." Quote. And so this was kind of their way of like contributing to the effort to defeat fascism without compromising their morals, which, yeah. So the experiment started in November, 1944 with a three month control period during which the men all received a standard diet of 3,200 calories of food a day, or kilo calories. I'm just gonna say calories from this point forward, because that's how we tend to think of today yeah. So 30 started with three months, 3,200 calories of food a day. Um, some of the men, like I think are the firsthand account. Jim Graham, he actually needed more, he was losing weight on that 'cause he was quite an active. Person anyway. Yeah. So then there began after those three months, a six month period of semi starvation. So it started on February 12th, 1945. And this, the semi starvation was a daily caloric intake of roughly 1800 calories a day. So there were two meals a day, one at 8:00 AM and one at 6:00 PM except on Sundays where they got, I think just one larger meal. And the food tended to reflect what the most impacted areas of Europe might be consuming. So things like potatoes, turnips, brown bread, stuff like that. Breakfast for example, might consist of a small bowl of farina, two slices of toast, a dish of fried potatoes, some jello, a bit of jam, and a small glass of milk. And initially the men were allowed to eat gum, but that stopped after some of the guys were going through like 40 packs a day. A day just for something to like put in your mouth. Yeah. And the men were also expected to walk 22 miles each week. And so this was, and they had to like record this. I think, I actually don't know how they, how they tracked this, but the, the idea was that they would be consuming, uh, fewer calories than they, than they expended. So it was supposed to be like a 3000 calorie expenditure daily. And they were only intaking 1800 calories of food.

EAU: So they had to, they had to remain active enough that that wasn't,

EW: Yes. Yeah. Uh, but other than that, you know, their movements weren't too restricted. There was a buddy system that was instituted at, at one point, um, but they were given, you know, various administrative or housekeeping duties. They attended political science and language classes as prep to become international relief workers when this was over. And the goal was to have participants lose two and a half pounds a week. Which is a lot. So that at the end of six months, they lost 25% of their total body mass. Uh, everyone was routinely weighed. Their strength and their endurance was tested. Uh, blood was screened, other body measurements were taken. And they were also routinely given intelligence and personality tests just to kind of assess like psychological status and results from their weekly weigh in were posted at the end of each week. Uh, could cause tensions to run high. Some people would just, uh, avoid it until they absolutely had to see how much they were getting. It would determine how much food you got to eat the following week. And so one of the men, yeah, one of the men, Daniel Peacock recalls that quote, " we were given our food along a cafeteria line and if the guy ahead of you is given five slices of bread, that's pretty hard to conceal. And if you are only getting three, that's pretty touchy." End quote.

EAU: Hmm.

EW: They were also all required to keep a journal to keep track of their mental and physical progress. Like, you know what some of the guys described how when they had to cross the street when they were like out on, you know, their walks, they would wait until they encountered a driveway so that they wouldn't have to step down or step up in on the curb they were just had no energy. They noted how they lost any sex drive whatsoever. Pretty quickly. Quote, "I have no more sexual feeling than a sick oyster." Wrote one man, sick Yeah. And they became obsessed with food quote. "Eating became a ritual. Some people diluted their food with water to make it seem like more others would put each little bite and hold it in their mouth a long time to savor it. So eating took a long time." End quote. There were a, there was a lot of fascinating diary snippets that I encountered, so I'm gonna read you a few just from like a few of the different months because you can see sort of a little bit of like the month by month. Yeah. Month two quote, "I just don't have any desire to do the things I should do or the things I want to do. Instead of writing a letter, I read a newspaper. Instead of studying, I read a pamphlet. Instead of cleaning, I putter around making excuses such as, well, I really won't have enough time to do the complete job. I'll do it later." End quote. And then month two, "I purchased a tube of toothpaste yesterday. Finally got around to using it for the first time last night. Had a desire

to eat the paste, but controlled it." Month five. "I also found myself becoming senselessly irritable, particularly when I watched some of the bizarre eating habits of others. One mixture that came near flooring me was potatoes, jam, sugar, gingerbread, all thrown into a bowl of oatmeal and used as a sandwich spread. I hate to see guys picking around with this or that to make a superb sandwich all the time, letting their soup get cold." And month six "stayed up until 5:00 AM last night studying cookbooks. So absorbing, I can't stay away from them," which might be our firsthand. He did mention becoming obsessed with cookbooks.

EW: After the six months of semi starvation ended on July 29th, 1945, there was a three month period of refeeding the men had lost, on average the goal, which was a quarter of their body weight. Their hearts had shrunk by almost 17%. They beat a lot more slowly, like their pulse was a lot slower. Blood pressure dropped tremendously. They became anemic. Their lung capacity had decreased by 30%, and a few experienced pretty severe neurological symptoms that had to be treated like separately. For the refeeding portion, the men were placed into different treatment groups based on caloric intake, protein levels, and supplemental vitamins. And the men began to receive daily calories ranging from 2000 to 3000. But immediately, like in the weeks that followed the refeeding, their weight continued to drop, kind of like almost alarmingly because the edema that they had developed during the semi starvation portion had been disguising just how much weight they had truly lost. And so six weeks into refeeding, the group receiving 2000 calories had only regained 0.3% of the weight that they had lost.

EAU: Wow.

EW: Mm-hmm. Uh, and even the group that was receiving the most calories, which was 3000, had regained after six weeks, 19.2%. They still complained of all the same things during the semi starvation period. Edema, depression, exhaustion, aches and pains, a bottomless pit of hunger. Apathy was a big one. Irritability and mood swings. Calories were upped. Again, I think Ancel Keys was like, why? Why isn't anyone regaining any weight? And finally, that's when improvement seemed to be like actual, actually made protein and supplemental vitamins, at least in this experiment, didn't seem to make a difference. And the real lesson that kind of emerged was that 2000 calories a day was simply not enough for rehabilitation, or at least like rehabilitation on any sort of, uh, you know, timescale. For people of this body size and activity levels, they needed at least 4,000 calories.

EAU: I feel like that's so important. 'cause it just shows that like when you have been subjected to under nutrition for so long, you can't just go back to like we think today of 2000 calories as like a standard diet or whatever.

EW: Right.

EAU: You can't just go back to, you can't just have the bare minimum. Your body has nothing and it's going to try and build that up and it's not going to be able to

EW: It's not gonna be able to, yeah. There's such a recovery process in Yeah. And so the ex, when the experiment ended, which was in November, 1945, normalcy still hadn't returned for any of the men. They were allowed to at that point, when the, and then the 12 months was all over, the men were allowed to eat whatever and how much they wanted. Some began to eat 10,000 calories a day because they just felt like they will never, they could eat a huge meal and still feel. Just empty. Yeah. Uh, others ate so much that they had to go to the hospital because they would be vomiting and it was, yeah. Some had to be treated for that. Food anxiety remained for with these men for a very long time, and their bodies, you know, their heart and their lungs, it took, they took a lot longer to return to baseline than anticipated.

EAU: Hmm

EW: Within a few months of the experiments, end keys and his colleagues wrote up, wrote up a pamphlet to distribute to aid workers and it proved to be crucial after the war ended in delivering appropriate aid. And it's on the internet archive, if you're curious. Um, I'll link to it. It went over physical changes, behavioral changes, refeeding, how to help people cope with what they had gone through. There was a really interesting thing, this is when like communal feeding areas were still like very much a thing and it would be like, do not allow people to stand in line. Like it is incredibly demoralizing. You know, there was like a lot of really interesting and who knows how much of this was like from the experiment or just like, this is what we think, but it was a really considerate sort of like, what is the mental, not just about food, but it like what these, considering what these people have gone through, like a more empathetic approach to how can we relieve the suffering. Yeah. Also in 1950 Keys published a two volume whopper of a book titled The Biology of Human Starvation. It was almost 1400 pages and, um, yeah, I, I didn't read any of that, but I'm sure it's out there.

EW: But the, the Minnesota Starvation Experiment was really groundbreaking for being among the first to systematically study what happens to both the body and the mind during long periods of semi starvation and how to rehabilitate a starving person. It wasn't the first, so there were a few, actually, that also happened during World War ii. There was the Warsaw Ghetto Hunger Study in 1942, which was kind of done surreptitiously. And then there were studies in the Netherlands in 1944 to 1945. There was actually a fair amount of starvation research. One author described World War II as quote, "a cornucopia of starvation research, a wealth of hunger" end quote. Um, yeah, the, the Minnesota Starvation Experiment marked a necessary and crucial step forward in our understanding of how to deliver aid to victims of mass starvation. But for many, it came too Late World War II in Europe ended on May 8th, 1945, and in Japan a few months later on August 14th, months before the study ended, thousands of concentration camp survivors died of Refeeding syndrome in the weeks after the camps were liberated. Could they have been saved if the study had started earlier? I don't know. To me, the real question is why wasn't there any interest in the effects or treatment of starvation until, until this time, until World War ii? One English officer remembered meeting with public health advisors in January, 1945, which was the month that Auschwitz was liberated. "It was frightening to realize how little any of us knew about severe starvation. In our lifetime, millions of our fellow men had died in terrible famines in China, in India, in the USSR, without these tragedies having yielded more than a few grains of knowledge of how best to deal with such situations on a scientific basis." The opportunity was there. It had been there to come up time and time again. Modern science existed. Western medicine simply lacked interest or a sense of urgency in understanding this problem. Maybe it was a little bit of hubris mixed up with a sense of superiority. Like, we've got our stuff figured out. It won't happen to us. We don't

EAU: not happening here. It's happening over there.

EW: Yeah. And so when starvation came to Europe, no one really knew what to do and it didn't come alone. It rarely does. Starvation is just one component of a famine. It rides alongside disease, fear, violence, despair, and a perpetual sense of uncertainty of not knowing when anything will end. Things that can't and shouldn't be captured in a medical experiment like the Minnesota starvation experiment.

EW: And I wanna end with a quote from a paper by Sharman Apt Russell, quote, " the Minnesota experiment itself did not reproduce the cold that Europeans experienced in World War ii. The lack of fuel for cooking, food and heating, the house, the lack of warm clothes, the lack of shoes, it did not

reproduce the fear, the knowledge that you might not at any time that you might be humiliated or injured or tortured or killed. It did not reproduce the murder of a neighbor, the corpses in the street, the inexplicable loss of human decency. It did not reproduce the death of your son." End quote. Famine is so much more than starvation, and starvation is so much more than a lack of food. And so that is kind of where I wanna end things today. So that next week, that's sort of what we'll talk about is like the bigger picture that encompasses all of this. So, yeah. Yep.

EAU: make sure you turn in next week.

EW: in next week. In the meantime, um, there's some sources that, uh, we could share. So, so many, so many. Uh, I wanna shout out just two in particular. Uh, there, there are several more that will be on our website, but one is by Charmin app, Russell, the Hunger Experiment. And then another is by Calm and Seba titled They Starved so that Others Be Better Fed. Remembering Ansel Keys in the Minnesota Experiment,

EAU: I have quite a lot of papers. Um. I also had a book, I read a book, a few chapters of a book called Hunger, the Biology and Politics of Starvation, uh, published in 2010. It was fine. Um, it's like more detailed than you need in all honesty, but it does have some good, just like overview parts of the, the biochemistry and things. I really enjoyed A Nature Reviews disease primers paper from 2017 called Severe Childhood Malnutrition. Um, and then a couple of different, there was a annual reviews in physiology, the comparative physiology of food deprivation from feast to famine. That one was really good for some of the like biochemistry. Um, if you want details on biochemistry too, there's also a, Stanford has like a PDF of literally every biochemical like metabolic pathway. That's just kind of fun to go through and see how they all interconnect and which ones versus not doing at any given time. But we'll post the sources from this, uh, week's episode and every single one of our episodes on our website. This podcast will kill you.com under the episodes tab.

EW: We will thank you to Blood Mobile for providing the music for this episode and all of our episodes.

EAU: Thank you to Leanna and Tom and Pete and Brent and Jessica and Mike, and I'm sure I'm forgetting people, everyone at exactly right. Network.

EW: uh, thanks to you listeners for, you know, listening, for tuning in wherever you're tuning in. However you are, let us know what you think. And a big thank

you, of course, to our generous patrons. Your support really, really means the world to us.

EAU: It does. Thank you.

EW: Yeah. Well, until next time, wash your hands.

EAU: You filthy animals.