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S1E4: Bloodsucking Vectors

Hello, and welcome to BioTA, I'm your host, Phil Gibson

In this episode, I am excited to welcome my first guest to the podcast, Dr. Heather Ketchum. Dr. Ketchum is a Medical-Veterinary-Forensic Entomologist who specializes in the field of Acarology, the study of ticks, and the field of forensic entomology, which involves the study of maggots.

Her area of specialization fits with the topics of viruses and disease we have been exploring in recent episodes because ticks are incredible disease vectors. A vector is an organism that transmits pathogens like viruses, bacteria or parasites from one host to another. Ticks come in second only to mosquitoes in terms of their ability to transmit disease and number of diseases they cause in humans each year (de la Fuente et al. 2008). It's not just humans, either. Ticks spread diseases in wild and domesticated animal species too.

When we think about food webs and the roles of different members of ecological communities, we often think about the big things: grazers, carnivores, and omnivores. But we should also be aware that there are a lot of little things out there like ticks, and the diseases they spread that can have a significant direct effect on host populations that can then lead to a cascade of consequences that ripple throughout the ecosystem.

So, what makes ticks so good at transmitting diseases? What specializations, adaptations, and strategies have evolved in ticks that make them such effective disease vectors? Let's find out as I welcome, Dr. Heather Ketchum.

[00:00:00]
Dr. Gibson: Hello, Dr. Ketchum, and welcome to BioTA. Thanks for joining us.

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Dr. Ketchum: Thank you for having me.

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Dr. Gibson: So let's start with a basic question here. What exactly is a tick?

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Dr. Ketchum: A tick is an arthropod, and arthropods have an exoskeleton. So if you step on them, they crunch. But most people think that ticks are actually insects, and they're not. Insects have three pairs of legs and antennae. Ticks have four pairs of legs, a pair of chelicerae and a pair Pedipalp, and no antennae. Ticks are actually more closely related to spiders and less related to insects.

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Dr. Gibson: I heard a funny word in there, Pedipalp. What is a Pedipalp?

[00:00:44]
Dr. Ketchum: A Pedipalp is also called the palp. What those are, are essentially some people confuse them with the first pair of legs on a tick. They're using these palp as sensory structures when they go to take a blood meal. Their palps are actually what gets splayed out to the sides. They don't enter into a host, but they splay out to the side while the chelicerae are inserted into the host when they take their blood meal.

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Dr. Gibson: It's the chelicerae that's what they stick in to suck the blood out?

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Dr. Ketchum: Yes. The chelicerae have hooks on the end, they look like little scissors. They're like a opposable scissors that go back and forth where they can literally dig down into your skin and the teeth that are on the chelicerae will anchor the tick into the host. Then they have salivary glands that have adapted, and there's several different types of salivary glands in ticks. One particular type will release a cement. That cement is what anchors the tick into the host, and that's why ticks are so difficult for us to remove either off of ourselves or our animals.

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Dr. Gibson: Wow. I did not know that they actually sort of glued themselves in after they chew their way into you, that's interesting.

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Dr. Ketchum: Yeah. It's even more fascinating when you think about, well, when they're done feeding, when they've had their blood meals. They fed for several days in most instances. Then they have another salivary gland type that will dissolve the cement. Then they can back out of the feeding lesion, and drop from the host.

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Dr. Gibson: When we're thinking about ticks, how long have they been around? Were there like ticks that would attack dinosaurs?

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Dr. Ketchum: That's a great question. Up to about 20, a little over 20 years ago, we didn't really have a clear picture on how old ticks are. But a group of scientists found some ticks preserved amber in New Jersey. They discovered that these ticks were approximately 90 million years old, which puts them active in the Cretaceous period. The conclusion there was that ticks were likely parasitizing dinosaurs during that time.

[00:03:02]
Dr. Gibson: So there were ticks on dinosaurs. It wasn't just something that came along with mammals and that kind of thing?

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Dr. Ketchum: Correct, yes.

[00:03:09]
Dr. Gibson: Let me ask you this, you're an associate professor at a university in the State of Oklahoma. How many different tick species do you have in that region? Are there a lot of ticks there?

[00:03:21]
Dr. Ketchum: Yes. Well, relatively speaking, in our region, we had two groups of ticks. We have hard ticks and we have soft ticks. There are only about a dozen combined hard ticks and soft ticks. But there are more hard ticks than there are of soft ticks in the US, especially in our region. But we have one species here in particular that dominates over all tick species and that is mowed lawn star tick, that's Amblyomma americanum.

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Dr. Gibson: Where do you find those?

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Dr. Ketchum: Those actually and as far as Oklahoma goes, they're all over Oklahoma. As far as US distribution goes, they are as farOka North now as Canada and as far South all the way down to Mexico. But they draw a line at about the Rocky Mountains, so they're East of the Rockies and all the way to the East Coast. Their distribution continues to expand.

[00:04:30]
Dr. Gibson: Just thinking about this tick in particular, what's a typicalnot day like in the life of the tick?

[00:04:36]
Dr. Ketchum: Ticks are actually pretty lazy. [LAUGHTER] During the mornings, you can find them questing on the side of a trail, which basically what that means is they're seeking a blood meal. In the early morning hours especially, they're much

more active in the early morning hours where it's not too hot, and it's not too cold, and it's very humid out. What this ticks do is they climb up to the top of the vegetation. Let's say it's some grass or some weeds. They'll crawl all the way up to the top. Imagine that they've been at the bottom or the base where the soil in the in the grass are meeting, they'd been hanging out there. Then morning arrives and they crawl up to the top of the blade of grass, and then they start their questing. What that means is that they're actively seeking a host by sticking their front legs up in the air and waving them. Some people mistake those as antennae that you would see on an insect. But remember, ticks are not insects. They have sensors on that front pair of legs that are detecting carbon dioxide. When a host is near, what happens is that they quickly climb up to the top of the blade of grass. The host walks by and the tick get brushed onto the host. Ticks don't jump onto a host, but they have to be brushed onto a host by the host actively walking by. When they're not questing for that blood meal, then if they don't get a host to feed on, they crawl back down the blade of grass, and they just are inactive at that soil grass interface. What they're doing there is just absorbing the moisture out of the air. Ticks have a very large problem with drying out. They have a large surface area to volume ratio. If they're not able to absorb the moisture from the air to replace the moisture that they're losing to the environment, then they dry out, and they die. If a tick is successful in finding a host, then it tries to find a protected place on that host where it's warm, it's moist. If it's on an animal, hopefully, it's in a place where it's not likely to be groomed off. Maybe in the axillaries is a really good place, or the groin area, or around the neck on a dog, let's say. That's where they settle down, and they start to obtain their blood meal. Once attached, they remain attached for several days until they complete their feeding at which point, they'll drop to the ground.

[00:07:24]
Dr. Gibson: After they've had this blood meal, how long will it take till they need to eat again?

[00:07:29]
Dr. Ketchum: After they take a blood meal most of our ticks here in the states are what we call three host ticks. After they've gotten a blood meal from one host and they dropped to the ground, they'll molt to the next life stage. Once they molt to the next live stage, which takes depending upon the time of year in the season that we're in, it could take several months before they become that next life stage, and then they have to obtain another host again. Then once they've had a blood meal from that host, then they'll drop to the ground, and molt to the next stage.

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Dr. Gibson: Wow. That is an interesting life cycle, that's really interesting there.

[00:08:11]
Dr. Ketchum: They only undergo one generation per year.

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Dr. Gibson: Well, now that we're talking about the blood meal, let's get into thinking

about them as a vector. How do ticks transmit diseases, and what makes them so good at doing this?

[00:08:30]
Dr. Ketchum: There's a couple of really good reasons why ticks make great vectors and that they're able to transmit bacteria. They're able to transmit viruses and some protozoa. The reason for this is that the pathogen itself is able to survive inside of the tick. Once the ticks feeds on an infected host, then that pathogen can replicate itself in the tick.

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Dr. Gibson: Does that hurt the tick? Does the tick get sick or anything?

[00:09:01]
Dr. Ketchum: No, not at all. The ticks are not affected by the pathogens at all. Ticks have an immune system, but the immune system does not fight off these pathogens. The pathogen does not make the tick ill, which is a great relationship, right?

[00:09:21]
Dr. Gibson: Yeah.

[00:09:21]
Dr. Ketchum: If that pathogen can replicate itself inside of that tick, and then you go from let's just simple numbers. Go from 10 virus particles to a hundred thousand virus particles in a few days. Then that tick, once it finds another host, now it gets to infect that host with a hundred thousand virus particles rather than the 10 that it had initially been infected with. So that makes them incredibly successful. The other thing that makes ticks really successful is the fact that the pathogens can be transmitted from one life stage of the tick to another. Most pathogens will be transmitted, what they call transstadially. If you have a larval tick, pick up a pathogen from an infected host. The larval stage is the stage that hatched out of the egg. Once that larvae becomes infected after its blood meal, then when it molts to become the next life stage, which is a nymph, then that nymph is already infected with the pathogen. It does not need to obtain the pathogen from another host, it's already infected. Then the same thing happens once the nymph obtains its blood meal from a host and molts to an adult stage, then the adult is already infected. That gives every chance. There's three different life stages there that have the potential to infect a host assuming that larvae was infected to begin with. But it could be any life stage that becomes infected with a pathogen. There's very few pathogens that are what we call transovarially transmitted. In other words, transmitted from the female that lays her eggs. So once she lays her eggs, her eggs are typically not infected because we just don't have a lot of transovarial transmission in ticks, which is a good thing because we would have a lot greater number of tick-borne diseases if we had that type of transmission.

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Dr. Gibson: Well, speaking of tick-borne diseases, what are the main ones that

people are concerned with these days?

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Dr. Ketchum: It depends on where you live. [LAUGHTER]

[00:11:54]
Dr. Ketchum: In Oklahoma it is Rocky Mountain spotted fever. That's what physicians are concerned with, that's what health departments are concerned with. Unfortunately, the general public believes that it's Lyme disease. There is no Lyme disease in Oklahoma. It is Rocky Mountain spotted fever. We do see a bull's eye rash on people in Oklahoma and that's one of the clinical signs of Lyme disease. But just because you have a bull's eye rash does not automatically mean that you have Lyme disease. We're seeing a bacteria called Borrelia, which is a similar species to what causes Lyme disease Borrelia burgdorferi, and this rash is not caused by Borrelia burgdorferi here in Oklahoma. It's a Borrelia species, but the species that scientists once thought was causing the rash is not actually causing this rash. They know that the vector for this Borrelia species is our lone star tick. But the lone star tick does not transmit Borrelia burgdorferi which again is the agent that causes Lyme disease. In terms of people in Oklahoma, it's Rocky Mountain spotted fever. If you live on the East Coast, then they are primarily concerned with Lyme disease on the East Coast.

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Dr. Gibson: Then anything on the West Coast in particular, is it still just more Rocky Mountain spotted fever or a whole different set of diseases?

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Dr. Ketchum: Yeah, it's a whole another set of diseases. They do have Lyme out in the West Coast, but you don't see as much as what you see the Rocky Mountains and East of the Rockies.

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Dr. Gibson: Those are examples of diseases in humans. What about other animals like dogs and cats and things?

[00:14:02]
Dr. Ketchum: In Oklahoma, especially, there is a tick borne disease that is very common in dogs and it's called the Ehrlichia or Canine ehrlichiosis. It's caused by an Ehrlichia that's transmitted by ticks.

[00:14:20]
Dr. Gibson: Now, what is an Ehrlichia?

[00:14:22]
Dr. Ketchum: Ehrlichia is like a bacteria. Similar to a bacteria. What happens when these dogs are infected is that, one, you may not know until your dog is limp. It's still alive, but it's limp, it's hemorrhage internally. You rush him to the vet and the vet gives them an antibiotic, simple treatment. Gives him a shot, starts an IV or gives him a shot either way of some doxycycline and that dog who was once appeared to

be lifeless, will sit up on that table and start wagging their tail. It appears to look like, oh, it's a miracle, you know that this dog is now fine. The reality is that the dog is now infected for life. The antibiotic treatment is a long treatment. It's a couple months worth of antibiotics and even then they still have a low level of infection. It's something that you have to keep an eye on for your dog, and the main symptom is hemorrhaging, their gums will hemorrhage, they'll get hemorrhaging on their belly. Soon they just becomes so lethargic that they just don't move at all. That's super common here in Oklahoma. It's something to keep an eye out. There's no vaccine, there's only a treatment and that's the simple antibiotic treatment. But the key there is just to be sure that you do take checks on dogs and remove any ticks that you find on your dogs.

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Dr. Gibson: But I've got just a couple more tick based questions, these are a little bit more practical. First of all, what is the best way to avoid ticks or at least reduce problems with them.

[00:16:13]
Dr. Ketchum: This is the best way. First off, you need to be aware of your surroundings. If you are an outdoorsman, and by the way, you don't find all ticks outdoors in the woods, we can come back to that in a minute. But let's say you're an avid hiker and camper, then your best part there is to stay on the paths and the trails that have been created for you. Because if you stay in those areas, then you're avoiding the tick habitat. That's the big picture here is avoid the tick habitat. Stay on the cleared trails, stay away from the taller grass. If you put down your tent, you want to be sure that you're putting your tent in an area that's free of a tick habitat. If you want to put your tent in the grass then I suggest that you take a white cloth and you drag that area where you want to put your tent with a white cloth and see if there are any ticks on it. Because when you come across ticks, you typically don't come across one or two, you come across very large populations, and these distributions where we find ticks are very spotty, so if there are no ticks in that particular quadrat that you're looking at to put your tent down, then you're probably pretty safe. You can also dress appropriately by wearing long pants, tuck your pants into your socks. It may look a little funny, but at least the ticks when they're crawling up your legs, they can't get underneath of your pants and access your skin and crawl up your legs that way. Some people will also use tape. Again, it doesn't look great [LAUGHTER] but it's very effective. Even when I'm in areas and I'm either just out for a hike, I've known to even wrap tape. I use duct tape, any masking tape would also work. Put a layer sticky side down, where your socks and your pants meet, and then take an extra layer of tape with the sticky side out. That way, any ticks that are crawling up your legs will stick to that tape. Now, if you don't want to go to that extent which is understandable, a lot of people don't want to, then you can also use a tick repellent. Any kind of repellent that has DEET in it. DEET can be sprayed on your clothes, it can be sprayed on your skin, and you want a DEET concentration of 20-40 percent is usually the recommended percentage of DEET. You can also spray your clothing with permethrin. But do not use permethrin on your bare skin. It's not recommended that you do that. Permethrin can be found as an

active ingredient in a lot of repellents. You can do that as well. I mentioned that, ticks are not just found in areas of tall grass out in the woods, they're not just found in the woods. If you live in an area where the woods come up right up to your backyard and then you have a grass, you have your backyard that's nicely a manicured lawn, then one of the things that you can do is keep your your lawn mowed short. If you keep your lawn mowed really short, then that micro habitat, that area where the grass blade and the soil interfaces where the ticks hangout and they absorb the moisture from the air, those ticks are likely to dry out when that grass is really short because you're removing their micro habitat. Another thing you can do is put gravel around the backyard along maybe outer perimeter of the backyard. If use gravel ticks don't like to crawl across the gravel. That's not going to prevent the wildlife from coming into your backyard and ticks dropping off from the wildlife, but it'll prevent ticks from walking from the woods onto your mowed lawn. The other thing is don't feed the wildlife. [LAUGHTER] Don't have a deer feeder. Some people like to feed the deer in their yard. When you bring the deer in, you're also bringing in the ticks that are feeding on the deer and the ticks drop at the deer feeder. You don't want to do that. Same for bird feeders. Don't, bring the birds because you bring the birds you're also bringing the ticks. Lastly, what you can do is inspect yourself for ticks whenever you've been out and about and you think you've been in a habitat that might have had some ticks in it, and inspect your dogs. We call them tick checks. That's the best way. The sooner you remove a tick from you and your animal, the less likely you are to have a pathogen that will infect you.

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Dr. Gibson: The last question I've got for you is, what's one thing about ticks that you wish everybody would know or something that you know about ticks that you just have always enjoyed sharing with people about them.

[00:21:57]
Dr. Ketchum: In a laboratory setting, the thing that amazes me and that grab my attention about ticks and made me excited to study them, was that ticks can go an entire year without a blood meal. To me, that's pretty fascinating. I can't go much over three hours without something to eat and a tick can go an entire year without that blood meal in the laboratory setting. That is absolutely amazing that they can survive that long, and that's assuming their relative humidity is set at about 70-80 percent so that they're still able to absorb the moisture out of the air, but they don't have a nutrient source. The blood meal is all they have. To be able to survive that long without a nutrient source, to me, it was absolutely amazing and that inspired me to study them.

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Dr. Gibson: Well, that was going to be my next question is, what is it that draws someone to study? I mean, I've got to open this up a little bit more. You don't just study ticks, you also study maggots. What is it that really drew you to this field of medical veterinary forensic entomology?

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Dr. Ketchum: Yes. I'm a bit unusual, I guess in that sense. I thought I wanted to become a veterinarian and I decided there are certain aspects of veterinary medicine that I did not like. I knew I had an interest in parasites so I thought, well, how can I tie parasites with animals? What kind of fields could I study there? Then I got to start studying a protozoan parasite on monarch butterflies and I thought, hey, this is really cool, and how can we prevent these monarchs from dying? From there, I started reading about ticks and thought, wow, these ticks are fascinating. During my graduate work, I started working with one of my mentors who was not my advisor for my research, but just a mentor I sought out. He started forensics class, a forensic entomology course. I immediately was in because I just thought, wow, this is a different arena to some extent, but it's the opposite side of things where with medical veterinary entomology, you really don't want your people and your animals to die from these diseases. But then if they do die, well, now you have the maggots to clean up the mess. I think maggots are really cool in what they do and they're essential to the decomposition process.

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Dr. Gibson: Now that we've opened up that area of this, I've got two questions. One, before we get into the maggots, what kind of classes did you have to take? What are some things that you would recommend maybe that people think about or plan for if they are curious about this direction for a career.

[00:25:18]
Dr. Ketchum: Definitely a strong foundation in general biology and ecology and from there if you wanted to see if you really were into this kind of work because it's fun. Some people think it's really gross, but I would suggest a parasitology class. I took one as an undergraduate student and that's where I found out that I really had a passion for parasites and I thought that their evolution with our host was absolutely amazing. If you find something like that, that captures you, start there and then depending upon your university and what school you go to, you may also have an opportunity to take courses in entomology and study just general insect biology. From there, there are universities that also offer the medical entomology classes and veterinary entomology courses as well. After you get those basics and that foundation out of the way first, the biological foundation and your basic chemistry out of the way, then start looking at more specialized courses in parasitology and entomology.

[00:26:35]
Dr. Gibson: Great advice there. Back to the maggots. What is it that people can learn? We see these different TV shows and things where they bring in somebody who does the forensics. What is it that the maggots are telling them?

[00:26:51]
Dr. Ketchum: Maggots can tell us quite a bit actually. First and foremost, and probably one of the most important contributions that maggots make is the determination of what's called a postmortem interval in homicide investigations or even a suicide. What that is, is it's the time between death and when the body is

discovered. If we collect these maggots, we can determine what species we have. Based on the species, we know how long it takes them to develop under certain temperatures and relative humidities and precipitations and then we can work backwards just to determine how long that that body has been there. We can also use maggots to determine if there was any drug involvement in a case. For example, if an individual died of an opioid overdose, we can take maggots and let's say that the Medical Examiner could not do a toxicology screen on the liver. Maybe the body was so badly decomposed that it was not possible to do a toxicology screen. Then we can take the maggots and we can isolate drugs from the maggots themselves because remember the maggots are feeding on the individual that's decomposing. You can isolate a lot of different chemicals from those maggots. That makes them very useful in that regard too.

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Dr. Gibson: Even with that, it seems like that shows the importance of good notes, taking your data the proper way, just good fundamental scientific principles there.

[00:28:39]
Dr. Ketchum: Exactly. In forensics, in general, they're trying to strengthen the science of forensic science and forensic entomology being a sub-discipline of that. It's incredibly important that we're properly collecting data and analyzing that data correctly because it's about the science. It's not about who done it, it's what the science can tell us.

[00:29:09]
Dr. Gibson: Well, that brings us around the last question I've got for you. You teach a course in forensic entomology and so tell me a little bit about that class. I think we may have some teachers who are listening in on this. Just a little bit about what you do and how you approach that and the things you're trying to accomplish in that class.

[00:29:26]
Dr. Ketchum: Yeah. That class has been a fun class to teach because it's so applied. What I can do in that course is set up mock death scenes using pig carcasses and students investigate their death scenes that they're assigned to. When they go out to their death scenes, they have to interview witnesses and these are mock witnesses who, just like the real world, don't always cooperate. [LAUGHTER] So they get that experience of, huh, it's hard to ask questions and I also have to ask the right question to get the right answer that I'm looking for. That's one aspect of it. Then the students collect their insect evidence from their death scene and analyze all of that, including weather data and then they have to draw a conclusion. They have to determine the post-mortem interval for their victim. The last thing that they do is they present their case to the jury. We have a mock trial and they present their data and they get questioned by the prosecutor, they get cross-examined by the defense attorney and get some pretty intense questions on their methods and why they did things the way they did it and why their calculations were such. It is a real world experience as close as I can get it to the real thing. It's a lot of fun and

students love it. But I think the hardest thing for students is the smell of decomposition.

[00:31:15]
Dr. Gibson: Yeah, having participated in one of these in a summer day in Oklahoma, it is an interesting multi-sensory experience to be sure. Well, Heather, thank you so much for talking with us all today and sharing all this great information. It's been a real pleasure to talk to you about this. Thank you very much.

[00:31:34]
Dr. Ketchum: You're very welcome. Thank you for having me.

That wraps up my interview with Dr. Ketchum. For more information about ticks and other resources for this episode, please visit my website.

Thanks for listening.
Have a great day.
And take very good care of your genetic material.

Thanks to Dr. Ketchum for taking time for the interview.

As always, thanks to Terri Gibson for help with this episode's development.

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All opinions expressed are those of the author alone.

A great reference for information about ticks

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