This Week in Virology

with Vincent Racaniello, Ph.D. and Dick Despommier, Ph.D.

Episode 4: Rabies

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Vincent Racaniello: I'm Vincent Racaniello.

Dick Despommier: And I'm Dick Despommier.

Vincent: And we're back in Dick's office once again. We missed a week. I'm very sorry about that.

Dick: Yeah. I felt a little left out about that, also.

Vincent: Our schedules just didn't permit it. But we'll try and work around that in the future. It was a very important week because the Nobel Prizes were given out that week.

Dick: Exactly.

Vincent: The Nobels were good for virology, which is why we should talk about them at least briefly. And they were also good for Columbia.

Dick: Right.

Vincent: So in medicine three virologists received the Nobel Prize. Two from France from the Institute Pasteur for discovering the virus that causes aids, HIV, and those virologists were Francoise Barre-Sinoussi and Luc Montagnier. And interestingly, the other virologist, the American, Robert Gallo, was not named as a recipient.

Dick: No he wasn't.

Vincent: Very big controversy. He originally claimed he had isolated the virus. It later turned out not to be true. And then the other half of the award was given to Harald zur Hausen, who is a German scientist, who isolated the human papillomavirus. These were both discoveries made in the 1980's. And of course the human papillomaviruses are important agents for cervical cancer and women and we now have two very good vaccines against this virus so it's a very important discovery. We'll talk about this vaccine in some coming session. It's rather controversial. And of course discovering AIDS is huge. So these individuals very much deserve these awards. Within the next few days the chemistry award was given out to three scientists, including one here at Columbia, Martin Chalfie, for their work with a jellyfish protein called green fluorescent protein. Amazing. Who would have ever guess. Have you ever gone to a bay and just swept a net under the under the water at night? You'll see fluorescence. When you push the jellyfish around they glow transiently. It's a single protein that makes them glow and these scientists identified that protein and cloned the DNA encoding it and showed you could put it in other organisms and have them turn colors. In fact Marty Chalfie put it into the worm, *C. elegans*, initially and made them glow. And now it's used as a tracer in all kinds of biology.

Dick: Including virology.

Vincent: Including virology. You just need the protein; nothing else. You shine UV light on it and it makes a color. They now make transgenic animals. You can buy transgenic fish at pet stores with these different colors. You have green variant. You have red and blue. You have pigs that are transgenic for this. They have snouts that are colored as a result. It's a huge discovery. Both very well merited awards. What do you think, Dick?

Dick: Absolutely. In fact I'm a good friend of Marty's and I had the rare privilege of calling him the morning he won his Nobel Prize. And just as a little side story, Marty actually slept thru the phone call from Sweden. He was unaware he had won this price. So I actually heard this on NPR in NY, WNYC, so when I came to work I was so jazzed up about this that I just called him right away. I looked his number up in our directory and called him. And I got right thru to him right away, which I thought was unusual because I thought he should have been inundated with phone calls at this point. But it turned out he was like milliseconds of discovering he had won the Noble Prize by going on to his computer and seeing his name on Yahoo news. So Marty and I sort of yelled at each other all kinds of congratulatory statements. He, of course, expressed great surprise and great joy at the fact that he had been awarded this price. And I thought to myself Marty Chalfie's life has changed forever at this moment.

Vincent: Of course.

Dick: Of course he's the chairman of our biological department and we must say that he's been recognized for this for some time. This was a fourteen-year-ago discovery that has now seen its way into every single major area of molecular biology. It's quite remarkable.

Vincent: Yes. So, we've quite a few recent Nobel laureates here at our august institution besides Marty. We have Richard Axel and Eric Kandel. And I believe there was an economist several years ago who died a day after receiving it.

Dick: It was Robert Merton.

Vincent: He was driving to a conference a day or so after the reward and had a heart attack in his car. At least he was happy.

Dick: I tell you that's the way to go.

Vincent: It is the way to go. Now today we are talking about rabies and its agent, rabies virus. Dick mentioned this last week, or two weeks ago, and I seconded it because I had seen just before a short piece in the *New York Times*, Sept 27, about an outbreak of rabies in Malawi, which is a country in Africa, with very nice fish, African cichlids.

Dick: I teach a course here, called Ecology 101, to sort of bring our school of public health students up to date. There are two lakes that are quite interesting in this regard. There's Malawi and Lake Tanganyika. They're not connected directly. The interesting part is that they both have cichlid fish. If you line up the species of cichlid fish you will find what they call a perfect trophic parallel evolutionary trend for mouth parts for these fish. They occupy the same biological niches in both lakes and these lakes are both ancient lakes. These lakes are like millions of years old so they've had lots of time to evolve and they are all warm water. It's so interesting that even the striations on the sides of these fish even though they are totally different genera of cichlids are almost identical. It turns out the mouth parts are under the control of a single gene.

Vincent: And this is because the environments in the lake are so similar.

Dick: Exactly. Correct. So you start mutating this gene and you get all these mouth parts. Well, what does that sound like to you, Vince?

Vincent: Viruses?

Dick: No. It's a broader question. It actually mimics the same situation for Darwin's finches. Darwin's finches can be controlled in terms of beak size and strength by a single gene. And if

you mutate that gene in chickens you can get all of Darwin's finches represented in domestic chickens.

Vincent: Dick, is evolution a theory or a fact?

Dick: Well, you know you teach this stuff enough and you start to consider it as a fact.

Vincent: It is a fact. It's a law, Dick. Repeat after me, "Evolution Is A Law."

Dick: It's rigidly controlled.

Vincent: Right. But we're diverging here.

Dick: We are, we are.

Vincent: The thing I remember about cichlids is that the water is slightly salty, right? So the tanks where you grow them have to be the same. Anyway, in Malawi a cow got sick. It had rabies. It died. Veterinary officials said get rid of it. Instead the butchers chopped it up and sold it to people and they ate it and got rabies. So I thought this was interesting. It says here that about 800 people got the rabies vaccine, so hopefully most of them will live. Rabies is still a prevalent disease. In the US in 2006 there were almost 7000 cases in animals. Only three human cases, which is down from about one hundred or so in its peak years in the US. Mostly it's in wild animals like raccoons, bats, skunks, and foxes. I would say globally it's present in many, many animals; wouldn't you say?

Dick: Absolutely.

Vincent: These are reservoirs. They carry the virus and then pass it on to accidental hosts like humans or domestic dogs. If you are bitten by an animal that is rabid you will get the virus because it's present in the saliva of the animal and it spreads to your brain.

Dick: If you go back to Malawi, and the other African countries you'd think that the wild dogs would be the main source of this virus because there are these beautiful wild dogs that hunt in packs. They're a matriarchal society, so to speak, and the female dog runs the pack, but in fact it turns out it's these domestic dogs that are running loose in villages that carry the virus and spread it from person to person.

Vincent: Yes, well in Malawi the disease is enzootic. Do you know what that means, enzootic?

Dick: You'll tell us, won't you?

Vincent: Always present in animals - Enzootic. Zoonoses are diseases spread from animals to humans. We've talked about a few of those. And enzootic diseases are always present in the animals. And of course if they're epizootic, there's a huge outbreak in the animal population. There are 55,000 deaths annually in the world from rabies and this is unfortunate because it's totally preventable.

Dick: And it's a horrible way to die.

Vincent: Yes. We don't immunize everyone from rabies because the risk isn't sufficient. Only people who work with animals: veterinarians, animals handlers get immunized.

Dick: So who does get immunized, then?

Vincent: Well, if you're a vet you get immunized.

Dick: No, I mean other animals.

Vincent: Yes, wild animals are. There are many, as you know Dick, immunization programs to

immunize wild animals. So the reservoir for this virus is wild animals, essentially: foxes, bat, etc. The animal differs depending on the country. And they pass the virus on to humans or domestic dogs. And so because of this as you know there has been a large program in many countries to immunize these animals which is very unusual. You don't usually think about vaccinating raccoons in the woods. Tell us about the countries like Mexico that do this.

Dick: There's lots of evidence that suggests that if you take these oral baits, as they are called, and lace them with the rabies vaccine, which survives this process and drop them from low flying aircraft at the ecotones…

Vincent: The ecotone being?

Dick: The zones where two ecosystems come together.

Vincent: Like humans and wild animals.

Dick: The border between Mexico and the United States is one giant ecotone and it's maintained by rivers and in this case by some fences, also, that stop coyotes from coming across. So how would you prevent rabies from spreading from, say northern Mexico and the southern United States? The way it's done the military actually takes a role in this. While they're patrolling the boarder for other reasons they are asked to throw these oral bates out of low flying helicopters to create an ecotone immunization zone between the country of Mexico and the United States and it actually works.

Vincent: So the coyote eats the bait gets the vaccine and is immunized.

Dick: So it passes over the boarder, goes out and has a few meals, comes back and reports back to his family. You know the same thing happens in Europe a lot. The Czech Republic, by the way, used to have tons of rabies. After the use of this oral bait technology, almost no rabies.

Vincent: Yeah, I know some of these vaccines were tested in France, dropping the bait from airplanes. Raccoons would eat them. You'd go in later and check the raccoons and find antibodies; less viruses. It's one of the only examples I can think where we have immunized a wild reservoir for the virus rather than immunize people. Very interesting. Very effective in many countries at reducing rabies.

Dick: So Louis Pasteur is our hero here, isn't he?

Vincent: What did Louis Pasteur do? He made the very first rabies vaccine.

Dick: Louis made the very first vaccine. Unfortunately he used rabbits. He used the spinal cord from rabbits to get the virus out. And a little contaminant of the spinal cord was present in his vaccine which of course induced an autoimmune disease against your own spinal cord .

Vincent: A very painful experience.

Dick: Extremely painful. What I was going to say was a lot of the consequence of life is that in many places now hunting has been banned probably because of an encroachment factor of human population just getting too dense to allow for hunting. So fox hunting in Italy was banned about fifteen years ago. The consequence of that was more foxes and they crossed the boarded into France reintroducing rabies. That's a reemerging infection in France. The problem now is how do you get rid of rabies in France because it's in the domestic foxes and it's in the local wild foxes in France. And they way we do it is the same way we do it over the boarder of Mexico. Except we give this laced bait to the hunters. In France they are allowed to hunt those foxes. So they go along the edge of the woods, which is that ecotone. And the foxes eat the bait and you know the rest.

Vincent: Great idea. So let's talk about contracting rabies. So typically you acquire it from an animal that bites you. In the old day in the US it used to be a rabid dog. That's much less

frequent now because we immunize our dogs and cats. So in 2006 there were only three human cases of rabies and I'm not sure if they came from any dog at all. So we immunize our pets, which is not done everywhere. But in the old days you'd be bitten by a rabid animal. Nowadays you might be bitten by a wild animal or a bat. You can even go into a bat cave and contract it from the aerosol, the bat saliva -- the inhalation of rabies.

Dick: There's one other way here, too. We're getting close to Halloween. We must mention that vampire bats do exist.

Vincent: Yes, there are vampire bats.

Dick: There are tons of them throughout Central America, Mexico and down thru South America. In fact in South American there have been numerous outbreaks in small villages in the province of Piauí, which is the northern province of Brazil, from little kids sleeping in huts or houses that have their windows open. The vampire bats would prefer to feed on cattle, but after the cattle are slaughtered, it leaves only human victims around. So these little kids contracted rabies while they sleep. The bat actually has an anesthetic that it applies to the little slivers of cuts that it makes in the flesh of these animals, including humans, so you cannot feel this happening and that's one of their little secrets.

Vincent: The children remain sleeping.

Dick: They remain asleep. The bat bites them… It's so sad.

Vincent: I have a story to read about that. There was an incident not too long ago in the US where there was a young child in a house. The parents were awakened and went into the child's room and a bat was flailing around. They say usually if you see a bat acting erratically its usually rabid because they try and get out of the window right away. Bats will come into houses. They sometimes live in attics and so forth. So they caught and killed the bat and threw it into the back yard. They didn't see any bites on the child and the child had slept thru it and so they assumed the child had not been bitten. Unfortunately within a few weeks the child died of rabies. So at that time health officials went into the back yard and retrieved the bat and in fact it had rabies virus.

Dick: What were they looking for when they retrieved the bat?

Vincent: Well, they were looking for virus.

Dick: How did they look?

Vincent: Well, nowadays they probably look by polymerase chain reaction.

Dick: True, but in the old days...

Vincent: They probably looked by isolating virus, taking an extract of the bat and putting it in cell cultures. The rabies virus grows quite well.

Dick: Allow me to go back even further.

Vincent: Would you like to look for antibodies.

Dick: No, no; I want to look for an inclusion body in the brain called a Negri body.

Vincent: A Negri body, the kinds of thing they look for in the dead crows. Yes, you could do some pathology.

Dick: Let me explain to you what happened to me as a child, as long as we are being anecdotal about this.

Vincent: You grew up in New Orleans

Dick: I was born in New Orleans, but didn't grow up there. When I was a little kid visiting my grandmother I was playing with other kids in the back of her apartment house which, by the way, was the quintessential Tennessee Williams type of setting, a big wooden building with lots of palm trees, and banana trees growing in this big courtyard that kids used to use as their playground. Well it was a great place for rats to hang out, too. So I see a rat walk out from between two of these buildings, a very slow rat, so slow as a matter of fact that I just walked over to it and picked it up by the tail. This was a Norwegian Rat. This was a *Rattus norwegius* rat, and the rat didn't run away when I walked over to it.

Vincent: It was rabid.

Dick: Was It?

Vincent: If they don't run away, they are probably rabid.

Dick: This was a sick rat. There's no question about it, though as a little kid how would you know about it. So I picked this rat up by the tail and the rat reflexes back and bites me on the index finger on my left hand. Now, this is a radio show, so tell me what you see on my index finger?

Vincent: I see a nice scar.

Dick: You see that nice scar there, Vince? The teeth of this rat went right down to the bone.

Vincent: It's quite a scar.

Dick: It's quite scar. It's my rat scar.

Vincent: So they took you to the doctor.

Dick: It's hard to remember as a seven year old kid. But I tell you what they did do. The kids pulled this rat off my finger and pounded the head of this rat into the ground. With a big stick.

Vincent: So they killed the rat.

Dick: They not only killed the rat, they destroyed any possibility of taking the head to the Department of Health and looking for Negri bodies.

Vincent: So it was not checked for rabies.

Dick: So here I am in the emergency room with my mother talking to the doctor and doctor says to my mother, "Well, he probably wasn't bitten by a rabid rat. We're going to take a chance and pretend that he wasn't bitten by a rabid rat, because if he…" well I've got 23 injections ahead of me from this vaccine and Lord knows what would happen to me. So the physician assumed, not being able to check, that the rat was sick from other causes. In fact it turned out to be true.

Vincent: That was probably a risk your parents shouldn't have taken. When you're bitten by an animal, the first thing is to get the animal and look for rabies.

Dick: Of course.

Vincent: In the old days the rabies vaccine was so painful that it was preferable to check the animal first.

Dick: That's why they didn't want to do this.

Vincent: And if you couldn't get the animal, you'd undergo this series of rabies immunizations.

Rabies is unusual because if you are bitten by a rabid animal, the virus is present in the saliva, gets into your blood, travels up your nerves and makes its way to the brain.

Dick: It takes awhile.

Vincent: It takes time so you have time to immunize. So the rabies vaccine is a series of immunizations at various times after exposure. I don't remember the exact days -- I had them in fact written down, but I've lost them. Dick, we need to get more organized. Oh, here they are. The CDC site: one dose of vaccine administered day 0, 3, 7, 14 and 30 in the deltoid region or the anterior lateral area of the thigh muscle. Do not put it in the buttock region. In the old days the vaccine was injected intra-abdominally. You had to put about fourteen shots in. It was a very dirty vaccine. It caused a lot of reactions and they need a big area to inject it into. It was extremely painful I'm told, never having had it. Nowadays the vaccine is grown in cell cultures. It's not reactive. It doesn't hurt. In fact nowadays you'd immunize someone right away because the vaccine isn't so painful. There're fewer doses. Any kind of bite by a wild animal, if you can't check the animal, you get immunized. The problem with rabies is that it's nearly always 100% fatal. There are only six cases of humans that have survived after rabies.

Dick: By the way what does that tell you about the biology of this virus?

Vincent: It tells me that this is not at all adapted to people. It may be better adapted to its wild animal host, but it does make them sick as well. They do get rabid. But in humans the virus is essentially not growing in them, except accidentally, so it hasn't evolved to be less pathogenic. But the good news is we can prevent it with this vaccine, so if you're bitten by any wild animal, if the animal runs away, by all means go get immunized. If you're a spelunker, someone who likes to explore caves, you have to be careful, because the bats even it they don't bite you they can still give you rabies because it comes in their saliva as they are flying around the cave. It makes an aerosol and it can infect you. So the vaccine is available and it has done great things for animals and humans in preventing this. Now, we're not immunized routinely against rabies. It's only given only to people who are at risk, like if you're veterinarian and, of course, animals; wild animals as well. Let's talk a bit about the disease. People should know a little bit about that. As I said if you're bitten the virus enters your body and it begins to spread via nerve from the bite site to your brain. It takes time to do that. It takes days, which is why we can immunize and stop the infection. It's one of the few infections that are like that.

Dick: It also says that our nervous system is totally connected.

Vincent: It is absolutely connected. Everything is wired to your brain. Now if you're bitten on the face, it's a shorter distance and there's less time. So, if you're bitten it's better to be bitten on your toe and you'll have a long time to get vaccinated. Once the virus gets in your brain, it multiples in the gray matter. It causes an inflammation we call encephalitis very much like the West-Nile-induced encephalitis. Symptoms of rabies are very different. Initially you're feverish and achy, but then you become confused and hallucinate. You become extremely afraid of water: hydrophobic -- that's a rough word -- hydrophobic, sensitive to having your face touched. You go into convulsions and you die.

Dick: It's a horrible way to die.

Vincent: So these people in Malawi who ate the infected cow, they have a good chance, as long as they are all immunized, at surviving, but that is an unfortunate incident. You shouldn't be eating infected beef. Talking about bats, here's another story: you know how much I love stories. In Montana just last month a parent brought a dead bat into an elementary school for show and tell. Of course someone at school said this is not a good idea and the bat was checked and found to have rabies. So all the children were immunized.

Dick: All the children touched the bat.

Vincent: That would be enough to get some virus in you.

Dick: As long as you're on that subject of bats let me give you some bat statistics.

Vincent: Are bats bad? Should we be scared of them?

Dick: I'm not. I think bats are great. In fact bats clean up the environment by eating lots of vector species of mosquitoes and stuff. So I think bats are wonderful animals. In fact one-fifth of all the mammals of the world are bats. However, that having been said, there about 1150 species of bats out there. That means that they radiated quite early on in the evolution of animals, right? Listen to this list: rabies, nipah, ebola, SARS, hendra, menangle virus and something called Australian bat lyssavirus which is a rabies-like virus.

Vincent: Why are bats such prolific carriers of virus?

Dick: That's the $64, billion dollar question, Vince. I really don't know.

Vincent: This is only a subset of all the known viruses, of course.

Dick: But look at all these nasties.

Vincent: Well, I think the nasties are there because our attention is drawn to them, but there're probably other viruses in these animals that are not a problem.

Dick: Would you predict that since we don't know enough about those 1150 species of bats that maybe an emerging infection is likely over the next couple hundred of years if we keep encroaching on these wild bat populations

Vincent: Of course, absolutely. What needs to be done is sample bats for all possible viruses.

Dick: Absolutely.

Vincent: There are ways to do this, as you know. We have thousands of viral sequences on glass slides. We can take material from a bat and find what viruses are in these animals. I think this should be done for many species and see what the steady state level of all the known viruses are for these animals. Because you're right; there are probably other viruses in bats and in raccoons and in foxes and we don't look for them. In many cases they don't cause disease. That would go a long ways towards explaining the origins for many human viruses. We tend not to look until there's a problem. So here, for example, in the bats all these viruses are issues, but what else is there. What's happening in other animals? The bat is a big issue for rabies. It may be for many viruses, in fact. It may that this animal is particularly permissive, but we really don't have enough data to answer this a question. Did I mention there are 55,000 deaths a year for rabies?

Dick: No, I think you should mention it again.

Vincent: It's not an insignificant number and it's really inexcusable because we do have the vaccine. You can imagine in poor countries if someone is bitten it is very difficult for them to get the vaccine so they would die even though their death could be prevented, so this is a matter of health care.

Dick: I want to ask you a basic virus question, now. We need to cover all the bases here. We've talked in the past about how viruses gain entry into your cells. And this virus seems to gain entry into all mammal cells. So what does this say about the receptors with regards to this?

Vincent: As you know you need many things for a virus to grow in a cell. You need a receptor first of all. So the fact that this virus can grow in many animals means the receptor is on all of them. But beyond the receptor once the viruses gets into the cell you also need other components of the cell to grow and apparently those are also found in many different species. Now this is not to say that all rabies viruses are the same. In fact the kinds of rabies of viruses that circulate in different animals are slightly different, but they vary slightly; probably not enough

to influence the components in a host that would be needed for them to grow. So this a virus with a very broad host range.

Dick: The vaccine itself, though, takes advantage takes advantage of the fact that you can use molecular vaccine in this case. This is not a live virus, obviously.

Vincent: This is a killed vaccine, but it's simply propagated whole virus infection of cells. Now the vaccine given to wild animals are glycoprotein vaccines. They take one protein of the virus, produce it, and lace the meat with it. That's a molecular vaccine and works very well. And those kinds of vaccines are very easy to use in wild animals because we don't have the regulatory requirements for testing. It's much easier to get them produced and used in the wild. But the human vaccine is a whole virus vaccine, which is inactivated. I'm sure that in coming years that will evolve into different form as we get better at making different kinds of vaccines.

Dick: The shame of it all is that most viruses don't allow for this kind of an easy production scheme. A lot of them require wild viruses, such as yours that you were discussing before, like polio where it's an attenuated, or live virus vaccine, or killed multiple stain whole virus vaccine, but in this case you have a single protein that you can isolate out and actually be quite effective.

Vincent: In fact that we have wild animals to test it on.

Dick: Exactly. Would you care to broaden that concept to say that if we were funded at a proper level, and we're never funded at a proper level, that similar vaccines could arise out of viruses that today have escaped that group?

Vincent: Absolutely. The problem is it's a matter of cost. For all the human infections, viral infections we prevent, we have very good whole virus vaccines. So the subunit vaccines are the vaccines consisting of a single protein are expensive to make and test and there's no motivation to do so when you have very effective and cheap vaccines, so that's the problem. Perhaps in the future for very dangerous viruses that aren't grown very easily and which are too dangerous to grow under production conditions, I could imagine vaccines against those would be quite different. Dick, you have a map here in front of you for the distribution of rabies: raccoon, skunk, fox. So if you're in areas in contact with these animals, should you worry? If you go camping a lot do you worry a lot? They don't usually come to you.

Dick: The ones I worry about are the ones that don't act like wild animals.

Vincent: They're sick.

Dick: Yeah; they come right over to you.

Vincent: Like we said, if a bat comes into your house and it has rabies it is likely to behave erratically. And again, walking in the caves. So it's not a huge risk. You have to be aware that if you're bitten you should have the animal examined.

Dick: This is why little kids get bitten more often than adults. It's the same reason little kids acquire the H5N1 strain of influenza. This is an influenza virus that attacks birds. The bird gets sick but doesn't die right away. The little kid goes over there and takes pity on this poor dying animal. He picks him up, tries to pet him and make it feel better. Little kids suffer greatly from this because, A, they get the influenza virus and, B, this animal is not friendly at all and turns out to bite and the little kid suffers. This gene that we've got for empathy and sympathy and altruism towards our fellow wildlife animals sometimes can backfire.

Vincent: Yeah, Dick, are you saying we should select so people can be worse ?

Dick: No, but I think that a good public education program at a lower school level to teach kids the difference between an animal that you should friendly with and one you shouldn't be would be a very helpful thing.

Vincent: Maybe a podcast?

Dick: Maybe so.

Vincent: Can rabies be eradicated?

Dick: You mean wiped off the face of the globe.?

Dick: Well, Vince, I think you know the answer anyway. No, of course not, because rabies virus exists in other animals besides humans. So any time you have that situation in which it's the normal inhabitant of all these other wild animals you'd be better off eliminating humans from the scene rather than eliminating viruses from those animals.

Vincent: One last anecdote. Last summer a shipment of dogs and cats came from Iraq to Newark Airport.

Dick: I remember hearing about it. Why don't you give us the details?

Vincent: These were pets of US servicemen. They had finished their tour of duty and adopted some pets and came to the US and they wanted their pets. The Government thought this was a good idea because it's bad enough being there, so they brought these pets back. They were held in quarantine for a while. One of these dogs became ill. It had rabies. Again, in many of the countries the dogs and cats are not immunized so you have to be careful about importing animals. It's a very touchy issue and you have to make sure they don't have rabies. In fact I think they should be tested. These weren't, but were just kept quarantined because eventually if they have rabies, they will become ill. Dick, we actually had some feedback from one of our previous episodes. I received a comment.

Dick: Hopefully you can tell us what that feedback was.

Vincent: It's from Rajeed. "Hope one week you will discuss Chikungunya." Chikungunya, of course, is a virus born by mosquitoes and is spreading around the world.

Dick: We've done two already. We've done West Nile and Dengue, so we might as well do all three.

Vincent: Anything else on your mind?

Dick: Not at the moment.

Vincent: So then let's wrap this up. Send us your questions and comments to TWIV at TWIV.TV.

Dick: What're we going to do next week?

Vincent: You're the guy. You tell us what we should do next week.

Dick: I think we should get Saul Silverstein to tell us about herpes.

Vincent: HPV? You remember Harold zur Hausen won the Nobel Prize very recently. Maybe we could get Saul to talk to us about HPV. All right, I'll have to get another microphone; no problem.

Dick: Herpes simplex.

Vincent: We'll have Saul Silverstein next week. He's a virologist. Works on herpes viruses. These days he's working on varicella zoster virus, which I had within myself not too long ago. We'll save that till next week. And he also works on human papillomavirus. We'll try to bring in some other people to make it interesting. Ok, Dick. See you next time. Ciao.

Dick: See you next time. See you.

Transcribed by Jim Vandiver