This Week in Virology

with Vincent Racaniello, Ph.D.

Episode #202: Huskers Go Viral

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Aired 07 October 2012
http://www.twiv.tv/2012/10/07/twiv-202-huskers-go-viral/

Vincent Racaniello: This Week in Virology, the podcast about viruses, the kind that make you sick.

It's time for This Week in Virology, this is episode 202. It's recorded on October 5th, 2012.

Hi everybody, I'm Vincent Racaniello and this is TWiV, the podcast all about viruses.

Today we're on the road again, we're in Lincoln, Nebraska at the University of Nebraska, and we're at the 12th annual Virology Symposium.

We just heard three great talks. I'm not including mine. I can't judge myself, you guys can do that. There were four talks today. Now I thought it would be nice... Here there is a center for virology; it called The Nebraska Center for Virology.

It's got just over a dozen virologists, which is just great to have all these virologist in one place. So I thought we'd do a TWiV here and highlight some of the diversity in virology.

I've got three individuals up here who kind of represent the gamut of virology at the center. Let me introduce them to you so we can start talking.

On my right, this is the fellow who actually suggested we do a TWiV here; he is a professor at the university and co-director at the Center for Virology, James Van Etten. Welcome to TWiV.

James Van Etten [Jim]: Thank you. Glad to be here.

Vincent: Thanks for asking. I didn't think he knew about TWiV.

At first he invited me to the symposium and then said do you want to do your little podcast there? I said sure, it's a good idea. So, thanks a lot.

To his right is the Director of the Nebraska Center for Virology, also a professor here, Charles Wood.

Charles Wood: Thanks you, good to be here,

Vincent: My pleasure. By the way, this is my first time ever in Nebraska is here.

Charles: We brought you great weather.

Vincent: And last but not least. All the way on my right, also a professor here, Jack Morris. Welcome.

Jack Morris: Thanks for attending. I'm looking forward to this.

Vincent: You're a TWiV fan, aren't you?

Jack: I am a TWiV fan. Yep.

Vincent: How did... We also have a nice audience here. Two-hundred fifty people, would you say?

How many of you have heard of TWiV? Can you raise your hand?

Jack: Wow.

Vincent: That's pretty good, almost half, not quite half. Next time it'll be 100%.

I know every time we do these on the road it gets bigger and bigger.

So welcome to the recording. As you know in TWiV we try to bring virology to everybody.

I talked a little bit about TWiV earlier and I forgot to mention that it's not just for virologists.

We did a poll not too long ago of a 1000 people. Only 35% identified themselves as scientists. Okay, so the rest are non-scientists… all different sorts.

But this is bringing virology to everybody. We even have high-school students listening in on us.

Okay, let's talk about viruses, that's what we do here.

First thing is to find out how everybody got here... to this place.

Let's start with you Jack. What I know about you is that you are Canadian, right?

Jack: Yes, I did make that point a little bit earlier.

But actually I came here in, I think it was 70, no, yeah, about 1970 as a graduate student.

I had been, ah, working at McGill, did a master's degree there.

I stumbled in to doing plant virology. And the fellow who was doing plant virology there was from the University of Nebraska.

He had worked with a couple of famous plant virologists, Ellen Ball and Myron Brakke.

And so it was mainly for that reason that I ended up coming here to go to graduate school.

And spent a couple of years here.

Did a couple of post-docs in Vancouver, and... my first job at the University of New Brunswick, and then I got an opportunity to go to UC Berkley.

I spent 15 years there. I built a program in plant virology there.

Then an opportunity came up to come back to the Director of Biological Sciences at Nebraska.

I said, oh, well, I looked at... I talked to my wife and I said, what do you think?

We liked it here. And so... well, we came back.

Vincent: So how long have you been here now?

Jack: So it's been about, since 1990, about 22 years.

Vincent: Alright. Very Good.

And throughout your career you've mainly worked on plant viruses?

Jack: Worked on plant viruses, worked on viroids, and did some work on insect viruses for a number of years.

So I've had a pretty diverse set of interests in different types of viruses.

But mostly on structure and function of small RNA plant viruses and on plant defense systems.

Plants have an immune system.

Vincent: Alright, will come back to you.

Let's find out Charlie and I have some history in common.

Where are you from originally?

Charles: I was from Hong Kong originally. I spent most of my life in this country.

We kind of crossed paths a little bit.

Vincent: So you got your PhD at Columbia, which is where I am now but we didn't overlap at all.

Charles: I guess I was a student there at Columbia with Elvin Kabat The late Elvin Kabat.

So I was trained as an immunologist not a virologist.

But then, of course, at that time I hated virology, you know, because Harold Ginsberg was there as the chair. And you know Harry Ginsberg.

He was a strong arm person, adenovirus.

Vincent: Harry hired me, yeah.

He has to have some good taste, right.

At that time I still wanted to do immunology after finishing PhD.

So I ended up at MIT. I worked at Susumu Tonegawa. And we moved from Basel to MIT.

So I was the last person to work on immunoglobulin disease, if you remember.

And then I decided to learn some virology because of a new disease called AIDS at that time.

Since then I've become a virologist. I really love it because it's really a cross talk between virology and immunology.

It's really important work.

Vincent: So you got your PhD at Columbia, which is where I am now, but I wasn't there at the time.

And then you post doc-ed at MIT.

Charles: That's right.

Vincent: We overlapped maybe a year at MIT.

Ah, but now here in Nebraska, this wasn't your only position, you were elsewhere?

Charles: Well a faculty at the University of Kansas. So I love the Midwest. And then the faculty of the University of Miami.

I learn of Nebraska because we fought those championship game, you remember.

And it was Nebraska-Miami, and Miami actually lost. So I decided to come to Nebraska.

It was football.

Yeah, well, I mean Miami people love to come to Nebraska. We just recruited an athletic director which is a Miami as well. So we have a lot of cross talk and exchanges between Miami and Nebraska.

I've been here 16 years. It's wonderful. Time just passes.

Vincent: Wonderful. Alright.

And Jim, I know the least about your background. Where you are from?

Jim: Well, these guys are rookies in terms of being in Nebraska. I came in 1966.

Anyhow, my background is that I came out of an antibiotics lab at the University of Illinois and graduated in 1965.

I was in the Plant Pathology Department and was offered a position at the University of Nebraska at the time but I had a fellowship from the National Science Foundation to go to Europe.

After visiting here, the net result was that they agreed to hold the position for a year and a half. I came to work on fungi.

Anyhow, I spent a year at the University of Pavia, in Italy, in the Department of Genetics learning what this new field of molecular genetics was all about.

At that time it was basically looking at protein synthesis where you took a message called polyuradelic acid and made polyphenylalaine.

You played around with ribosomes and all this stuff that really nobody knew much about.

So then I came to Nebraska the following year. And the lab I was working in I shared with a woman who just started at Nebraska whose husband was hired in the chemistry department.

She was a microbiologist who was looking for a place to work and we ended up sharing a lab and that's relevant to a point I'll make in a minute.

So, anyhow, I spent the first 16 years here studying fungal spore germination which was my background out of the antibiotics lab.

When sharing the lab with Ann Vetiver [?], she discovered what turned out to be a very unique bacterial virus called Phi-6, which was the first double-stranded RNA virus know. It had a lipid envelope. It had a lot of interesting properties.

And so I got involved with this because of the lab share.

So that was my introduction to virology. I've never had a course in virology or mycology.

And then that led to about 1979 or 1980 when I was drinking beer with a colleague, who was a former Director of the School of Biological Sciences before Jack became the Director.

He said something, I knew something and we ended up doing an experiment which led to the discovery of a whole new field of giant viruses that infect algae.

And these are viruses that have... encoded for over 400 proteins, transfer RNAs. Of course we didn't know any of that at the time.

But in the course of starting with these I..., over a two year period dropped my other two projects which were NIH supported.

Starting in about 1981 or two, we spent the rest of our career studying these viruses that infect algae and have had all kinds of fun studying.

So I'm the one that doesn't know much about viruses outside of a few double-stranded RNA viruses and, of course, these giant viruses like pox viruses and now amoeba viruses which are these things that have over a 1,000 genes.

Vincent: You spent time in Italy?

Jim: Yes, I spent a year there as a post doc. In fact I have three collaborations with labs in Italy right now.

And last summer I went to a meeting in Brussels, but spent the week before where I was 72 hours in Naples, 24 hours in Genoa, and 48 hours in Milan, all with people I collaborate on different projects with these viruses.

Vincent: You speak any Italian?

Jim: Ah, only the swear words. And that has gotten me into trouble once or twice, believe me.

Vincent: I'd love to hear you speak Italian with that accent.

Jim: We'll do that off camera.

Vincent: My son is taking Italian in high school and he bought, he was visiting, I think, Boston University, he went into the bookstore and came out with a book of all the bad things you can say in Italian.

It's this thick, it's an inch thick. It's unbelievable.

Jim: We could probably talk to one an... to each other.

Vincent: So what was the little conversation that led to you working on these giant viruses?

Jim: Well, at first.... Like most of my career, it's all been... it's been by sheer luck.

And in this case we actually got involved for the wrong reason.

So we had worked on this double-stranded RNA virus with Ann Vetiver.

I worked with fungi and fungi in the mid-60s and onward was finding these double-stranded RNA viruses as fungal viruses.

So I knew a lot about these.

I always thought of algae as just green fungi. So when in this conversation, this colleague of mine said he had reason to think that he had, he might have a virus on an algae.

And there's a whole symbiosis story and a whole lot of aspects I'm skipping over right now.

But anyhow, I said, why I know there's almost nothing known about viruses in algae and maybe this would be another double-strained RNA because I knew of these other double-strained RNA stories.

So the net result was that we took a look at these and over a couple years we found out that we could grow them and plaque them, which was the day I made the decision to drop the other two projects and start working on these.

But clearly, very shortly we found out these were huge DNA viruses. And not what, the reason we might find originally.

Really the thing that took off on us was curiosity driven research.

We knew there was almost nothing know about viruses in this area.

There was an interesting biology, which I have not mentioned. I'd talk about it but because of time I won't.

And that's turned out because these things encode for over 400 genes of which now about 40 percent are... there is a pretty good idea of what they might do.

But some of these proteins, of course, have never been found encoded by viruses before.

This has led us into DNA restriction in the nucleases encoded by viruses, the world's smallest potassium ion channel protein ever found on anything.

And we work with two electro-physiology groups in Europe, including one in Milan, Italy.

And now we are doing a lot with sugar metabolism which these viruses encode for a number of processes involved in sugar metabolism including, apparently encoding most, if not all, of the machinery to glycosylate their major capsid [?] which is clearly different from what any other virus does.

Vincent: Are you sure they're viruses?

Jim: We get that question every once in a while because of all the genes.

Yes, everything would indicate they are a virus.

Vincent: Why are they so big? So is every algal virus that you find this big?

Jim: No. Well for a long time it look... and we just worked with three, and these are ones that infect fresh water algae.

After we found these in the early to mid-90s, a few other people started looking at viruses in marine algae and finding large DNA viruses.

And so for a while it looked like the story might be that all viruses that infect algae might be these large double-stranded DNA genomes.

But it's turned out in the last five or six years as people start to look, there's been a double-strained RNA virus found on a marine alga, there have been single-strained RNA viruses, and also single-strained DNA viruses on alga.

So it is clear that algae have the whole gamut of virus types and it's just a matter of people looking for them.

Vincent: You said you are using fresh water algae. What are the names of them?

Jim: Okay, these are algae called chlorella. The ones that we work with are normally symbionts in protozoans.

When algae live in a symbiotic stage in an organism they are resistant to virus infection.

They are only inhibited by the virus... they are only infected by the virus once they are free of the protozoan.

Now fortunately in the lab we can grow these in culture.

So we just study the virus algal relationship.

But there is another aspect of this and that is we can go out in nature at certain times of the year, and just getting fresh water from a pond or a lake, we have found as many as 100,000 infectious particles per mil of native water.

And so there was a whole ecology that nobody even knows about and we are still struggling with in terms of trying to understand.

But it’s knotty because it's not even clear that the algae that we work in the lab can even exist free in nature.

So there may be another host out there but we don't know what it is..., or hosts.

Vincent: Well what was the origin of the algae that you work with?

Jim: Well it came from a protozoan called paramecium bursaria.

And the fella that I was working w... that I had the conversation with was actually studying the alga-protozoan symbiosis system and had just taken some EM pictures of the alga and had happened to have noticed something had looked like a virus.

And that was really the conversation that got this whole thing started.

Vincent: Explain this. There is a symbiosis between the algae and the paramecium?

Jim: Yeah.

Vincent: Who's inside whom?

Jim: Okay, the alga is inside the paramecium.

And the experiment that they had done was to isolate algae... actually it was done with hydra, but we'll use paramecium as an example.

They observed that if they isolated the alga from the paramecium and took electron micrographs of the alga over a period of time they saw a buildup of things that looked like virus particles.

And that is... in fact, he didn't even recognize it, but there was another visitor who came through that happen to be looking at note..., I didn't even know anything about this, happen to look at his notebook and said, well gee, that alga looks like it has a virus in it, and went of his way.

That was in about three days later when we were... when I was talking to him, I was hosting either a visitor or a seminar speaker at my house, he just happen to be there, this fellow by the name of Russ Mites [?], by the way, and we both remember exactly where we were standing in my kitchen.

We don't remember the type of beer. I've had that question.

Anyhow, it was that conversation that led to this whole thing.

Vincent: When the alga is inside the paramecium it has virus in it but it doesn't multiply, is that the way it is?

Jim: Well it turns out that... you can't see it there, I think it's because the alga... the virus cannot get to it. I think it's compartmentalized.

But if you isolate the alga from that, then they... at the time we thought it might be lysogenic, but I think it was probably an external infection. I think these viruses are quite common.

If you squash the paramecium the algae are released, then they are attacked by the virus.

And that was what they had taken pictures of, you know two or three hours after they had isolated the algae from the paramecium that had the particles.

Vincent: So once the virus gets in it kills the algae?

Jim: Yeah, this is a lytic.

Vincent: They are all a lytic infections?

Jim: Well, all the ones we work with. Now there's a brown algal virus that's related to ours that actually has a lysogenic lifecycle. And that has a really interesting biology.

There is a question even with ours. We've gotten some very interesting plaques in recent days from some samples we just collected that are cloudy. And so there may be an aspect of this story yet to be developed.

Vincent: So to make a plaque the algae have to stay on the dishes is that right?

Jim: Yes, we... it is just like you would do with a bacterial virus, where you have a soft... you have an overlay on an agar surface with the alga... you mix this... when you make the algal surface you mix it with various solutions of the virus.

And then two or three days later you get a beautiful plaque on a nice green lawn.

Yeah, it's ah... I can tell you a story about that. So when the first time I tried it in about 1982 or 3, I could see after a day, if you held the plate up, there might be plaques.

I remember going around talking to janitors or anybody who would talk to me about this. Man, this is exciting.

So that night, it was around Christmas, the School of Biological Sciences was having a Christmas party, so I drug this plate,

And I had people who didn't know the difference between a frog and a virus; I had to show them this plate that was starting to develop plaques.

So yeah, it was an exciting time.

Vincent: So because you can do plaques, you can do genetics?

Jim: Yeah, you have the potential of doing real genetics. And one of the disadvantages is that we still cannot do molecular genetics on the system because we haven't done the transform of the host [?].

We've tried off and on. And we will solve that problem. But that's been an on-going project for about 30 years.

Vincent: So you can't modify the genome and make direct changes.

Jim: Not intentionally yet, no. That's the one negative, yeah.

Vincent: And algae are the only hosts that will replicate it?

Jim: Well, as I say, I've got reason to think there may be other hosts out there. But that's the only one we know of. And they are highly specific.

Vincent: If you put the virus on HeLa cells, would it do anything?

Jim: Ah, now you're getting into something that is getting very interesting.

The answer to that is open to investigation.

Vincent: You know HeLa cells are easily transformable. It is worth trying HeLa cells.

Because I can imagine jumping into a pond with all these viruses... and they are going up your nose. You can get protozoa infections, parasitic infections, naegleria, that sort of thing.

So I can imagine big viruses getting up your nose as well.

But really, I think... getting back to this question, I know they are not all big but, the big ones, they include 600 proteins roughly?

Jim: Well, the ones we work with... the biggest ones include about... a little over 400.

And they are related to this mimivirus which encodes for over 1000 proteins. There's like 50 genes in common among....

And these viruses are also evolutionarily related to things like pox viruses, small pox (or, at least, there's some pretty good reasons for thinking that along with another group of viruses called iridoviruses which infect insects and some animals, and an African swine fever virus, which is a quarantine virus on swine, which is a very dangerous virus, if it gets into pigs.

These things are... again, there's reason to think that these may be very ancient viruses, at least the evolution.

And some people suggested they may go back to the time prokaryotes and eukaryotes actually split, came out of that same gene pool.

There is some hand waving with some of these arguments, but they are not totally ridiculous either.

Vincent: So I know with the mimis, if you start with the 1.2 million-base genome, you put it into a host, and they begin to throw off DNA. Does that happen with your viruses?

Jim: Are these DNA or viruses... I mean....

Vincent: So that the mimis throw off genes, the genome reduces after a few cycles in ah....

Jim: Well, okay, I know that story. I actually reviewed the manuscript.

Well, that's only under very... very specific situations where that happens. And we do have some very big dilution [?] mutants of our virus, so.... in that sense there is a similarity.

Vincent: But you see a stable genetic makeup in your viruses upon culture, they don't lose genes?

Jim: Well for the most part. But now you can, I say, you can isolate some of these with large deletions. And this has always been fortuitous, really, on our part.

The paper you're talking about was that they passaged a virus through about 200 cycles and at the end of it they found some fairly good-sized

And again, what I don't know is whether, or I can't remember, if that happened to the whole population or just a sub-population.

Vincent: Okay. Now, what are these doing in the environment besides, you know, looking out for themselves, and wanting to reproduce? Do we have sense that they play a role in limiting populations, carbon turnover, and geothermal cycles?

Jim: Yeah, in fact they play a big role in the environment.

All of you have heard of things like red tides and brown tides, these massive algal blooms in the ocean.

And you would have thought years... and some of these could disappear very rapidly, and you would have thought somebody some 50 or 60 years ago would have thought that might have been due to a virus infection.

Well it's only been in the last 15 years that people have found that the disappearance of some of these massive blooms is that viruses play a big role in it.

And the ones that they've studied the most again are very closely related to the ones that we had discovered 30 years ago.

So they have a huge role in terms of the environment. Most of you have heard of something called the White Cliffs of Dover, which appear off the coast of England.

Most of that is calcium carbonate which actually comes from an alga that is killed by these giant DNA viruses.

Of course this has been going on for thousands if not millions of years.

Vincent: That's EHUX right?

Jim: Yeah, EHUX virus. So, yes they have played a huge role... they do play a huge role in the environment.

Of course when you throw in all the bacteriophage which are in the ocean, the biggest source of genes on the planet are viruses without question.

Vincent: So the EHUX is involved in cloud formation and that's probably regulated by viral lysis, right?

Jim: That's right, yeah. In this case you get a release of sulphur compound when the virus lysis the alga, this goes into the atmosphere and creates clouds which leads to rain.

Vincent: So if ah, we are constrained for time, but if you could work on just one aspect of these big viruses and could answer one question, one important question, what would it be?

Jim: You're doing what the granting agencies want me to do. I'm spread all over the map because we have had excellent collaborations with people who are experts in various genes.

I mean the one thing that does frustrate us is not being able to do genetic manipulations of the virus.

If we could transform the host we think that would be a big way to get around that problem.

But these things have so many interesting aspects; I don't want to be pinned down to one thing. At least ...I've made a career... And we've met some wonderful people over the years in terms of collaboration.

Including, ah, one of the groups at Mount Sinai, a guy by the name of Ming-Ming Zhou who works on chromatin remodeling enzymes and we have the smallest protein that methylates one of the histones, lysine 27. We've worked with him.

Somebody put up a slide today that showed Stu Shuman at Sloan-Kettering; we've published a couple papers with him on a couple of our viral enzymes, coated enzymes.

So yeah, we've had all kinds of fun.

Vincent: How many groups are there working on these big viruses?

Jim: Well in terms of the viruses themselves, very few.

There's a group in Japan, and ah... but ah... in terms of working on various aspects, we work with Michael Rossmann's group at Purdue as a structural virologist.

These viruses have turned out the structure to be much more interesting. But we originally thought they were just going to be simple icosahedrons.

Turns out they've got a unique vertex with a spike. They've got some fibers that extend from them.

Though in terms of groups we work with, probably at least 20 or 25 over the last 15 years on various aspects.

But there are very few people that actually study the viruses as viruses.

Now there are a couple three groups that work on the EHOX virus that you mentioned earlier.

But there are all kinds of room for people to come into this field.

And where it's getting into a practical notion is that if there's this interest in using algae for biofuels, there's a lot of good reasons for thinking that, it's clear that if you're going to grow algae in large outdoor ponds, pathogens, including viruses, are an issue you're going to have to deal with.

So there is an interest in that down the road.

As well as using genetic components from the virus to genetically engineer algae.

Vincent: Right. So that's why it's important for you to be able to modify the virus and introduce it into cells so you can do those kinds of experiments.

Jim: Well, and also then taking promoters from the virus to genetically engineer the algae to be resistant.

Vincent: Right sure. So you can easily make a case for doing this kind of research for practical purposes, it's not just for purely educational purposes.

Jim: Yeah, we were fortunate, NIH supported us for about 25 years, I think mainly because we were sort of the odd person and people thought, at least we're interesting.

And right now most of our funding is actually coming from some of these algal, biofuels industry.

But we still hope to get some more money from the National Institutes of Health.

Vincent: So I will let you off the hook on that one question if you agree to come back on TWiV another time and we'll do a whole episode devoted to your viruses.

Jim: Be glad to.

Vincent: Is that a deal? Okay, because we have to move on now.

Let's move over to Charlie Wood.

I know you came back from Africa two days ago. It wasn't a vacation, right?

Charles: No, it wasn't a vacation. It was work.

Vincent: What do you do?

Charles: We have a research and training program over in Zambia, Africa.

So I've been working there for the past 15 years.

As expected, some of these infectious diseases they have these... it's epidemic, like HIV.

And then of course on top of HIV you have all kinds of cancers and strange diseases.

So I've been working over there, just to look at transmission, specifically mother-to-child transmission, and how different environmental factors of the infectious diseases are affecting these transmissions.

Vincent: Of HIV?

Charles: Of HIV and other viruses. We work on the herpes virus, which is known as the Kaposi's sarcoma associated with the herpes virus.

And these two viruses are really ravaging in that setting.

So we have a team of about 20 people, laboratory workers, physicians, nurses, and data persons who look at these two viruses.

It's amazing in terms of the disease burden over there. It changed my perspective of science really.

I have been a basic scientist looking at really laboratory stuff, molecular stuff.

But going there you see the patients actually affected by these diseases and you really go into more translational, how we can really... how research can be taken from the laboratory out to help some of these people.

Really, I think it's amazing how we can adapt some science, what we know in terms of affecting the population.

Vincent: You go and you try to get people who work there to help you obtain the data that you are interested in?

Charles: That is correct.

Vincent: You don't take a lot of people over from here?

Charles: No, actually we try to build capacity. And it's very important that one of our goals is to make sure the locals benefit from what we are doing, not only the outcome, but to build their ability to do the research.

So we build clinics, laboratories, and we train people, actually in Nebraska, and then let them go back and they become our colleagues and collaborators.

So that they can really address the question locally.

But at the same time, once the infrastructure there, people from Nebraska can go over there and also benefit from some of the things that they will learn locally.

So it's really becoming a bi-directional exchange. And building capacity is so important so we can our own research.

Vincent: So you were a basic scientist for many years, how did you transition into doing this as well?

Charles: Well, I think this is because of the disease that… the virus we work on is HIV and this Kaposi's herpes virus.

The disease burden is so high there and we want to see what we learn from the laboratory can be applied in the setting.

Now a simple example is for example, you learn how... the transmission route. And at that time when we started, about 15 years ago, we didn't know how this Kaposi's virus is transmitted.

Even the disease burden, how frequent it is in that setting.

So by doing our research, finding out this very high prevalence of infection, and especially in children, they are getting infection very early on, then we want to know where are they from, what is the route of transmission.

So by learning some of these things we can now actually design strategies. We now know, from some of our work, is that the virus is transmitted very early on via saliva.

Vincent: From mother to child.

Charles: From mother to children. Yeah, and then by the time the children get up to about four, five years old, they are almost at the adult level, which is about 40, 50 percent in that setting.

And on top of that is HIV as well [?].

So by understanding how they are transmitted, we can even implement public health strategies.

Actually we are doing that right now in our clinic. Our nurses are telling the mothers, "Well you really should not have... Minimize saliva exchange with the children."

So by this type of strategy we can really impact, maybe reduce the viral transmission rate in that setting.

So I think these type of things we can easily translate from what we learn in the laboratory into a real life setting.

This is... it is... I would call this implementation or translational research from laboratory to the real life.

Vincent: I would guess it's pretty hard to tell a mother not to kiss their kid, 'cause that's basically how the saliva is transmitted.

Charles: Yeah, it is not easy, but they listen actually. They do, because they see these children getting this Kaposi's, getting these skin lesions.

And our nurses do a great job in terms of really educating them. How to avoid do it. And they listening actually. And they actually understand.

We are talking about the people over there. They are not well off, they make like 50 dollars a month and it's a family. And they really have a poor educational background. But they listen.

And..., and I'm amazed that they actually remember what Kaposi sarcoma virus is from ... [?]

So it really is a whole different aspect of research.

Vincent: So can you measure the effect of your interventions on the seroconversion or whatever it is that you are measuring?

Charlie: That is something that we're following right now. Actually we are trying to measure how much they retained our knowledge. And that's some of the things we are already measuring.

And they do, they actually try to minimize the kissing or whatever.

Vincent: So you said up to 50 percent? What are you measuring, antibodies or virals?

Charles: Antibodies, yes.

Vincent: So by a certain age half of the population is seropositive, right?

Charles: That's correct, yep.

Vincent: And have you been able to lower that by your interventions?

Charles: Not yet because we're working with small populations. What we'd like to do is take this model and then maybe take it to the next step, to convince the local ministry.

And then try to develop or implement some policy in the government and then they can do some propaganda or whatever. I think that is when we'll see the impact.

Vincent: Okay. So when the children are first infected, by KSHV, at their young age is there any disease, overt disease?

Charles: No, that's the other thing, like most other herpes viruses, normally you don't really see anything unless your immune system gets messed up.

Like as in the case of HIV... so you get immunosuppressed and that's the time when you see Kaposi's coming up.

Vincent: Right. So it's only when... later on or whenever the children get HIV do they get the skin lesions?

Charles: They do. Yes.

Vincent: But if you don't get AIDS, very rare to get skin lesions?

Charles: Very rare. But in Africa, because of the high infection rate, you do get so-called high incidents of so-called endemic Kaposi's; these are normal, non-HIV infected people.

Vincent: Right. So for comparison, what's the sera prevalence rate in the US?

Charles: It is probably around 5 percent, it's very very low. So that is also interesting, the geographical distribution, it's not even throughout the world.

Certain populations are higher and other populations are lower.

Now you probably remember these so-called classical Kaposi when they were first discovered by Moritz Kaposi many years ago.

They found that in the Mediterranean area, these are the Jewish descent, so there are some of these genetic factors we still don't understand.

Why certain population is high and others are low.

Vincent: Are the viruses different?

Charles: We don't think so. Of course they might be different minor subspecies but not that different from each other.

Vincent: So you study just mother to child or do you look at the father? Or there isn't a father usually?

Charles: They do have fathers and actually extended families as well. So one of our projects is to look at what other sources there are besides the mothers.

And we actually found out that the sources are not limited by the mothers but from the household or even outside the household.

Because children play with other children, I mean they exchange candies, sweets and they bite each other, so they have saliva exchange.

So we do actually trace them because we do genetic analysis of the virus. There are some sequences that they do vary. So we track them, so where are they from.

So we have evidence that they could actually be from outside the household.

And so it's not really restricted to the same family.

Vincent: So if we didn't have an AIDS problem, you wouldn't worry about KSHV, right?

Charles: Probably not as important as what we're seeing right now.

Vincent: Okay. So you also look at HIV prevalence in these same populations?

Charles: That's correct. We also look at the HIV transmission from the mother to the children, more or less on the virological sides.

Basically their specific type of virus transmitted versus those that are not transmitted. Are there any differences virologically?

Vincent: How do you do that?

Charles: Well we look at the bottleneck of transmission because, as you know, that HIV is a quasispecies, meaning that in every single infected individual there are thousands of subspecies or genotypes present.

But the thing that is really interesting is that when it goes from a host to a new host you always have this bottleneck.

So it's a filter. From these thousands of species it's going to filter down to one or two minor species that go to the new host.

It happens in not only perinatal transmission, but it happens in adult sexual transmission as well.

So understanding how this bottleneck occurs has a lot of implication on prevention.

So we try to look at what is causing this bottleneck in mother to child transmission.

So we look at some viruses. We believe that there are certain characteristics for those viruses that are transmitted versus those that are not.

So that is what we are going after in terms of HIV side.

Vincent: So you look at the species that are in the mother and compare them to what's transmitted, is that right?

Charles: That's correct.

Vincent: And that you do by sequencing?

Charles: By sequencing genetic analysis. And also we do some assays in the laboratory to look at the biological properties such as the replication kinetics, the infectivity, binding, fusion, all those basic things. We look at how the virus enters the host cell.

Vincent: So when it's transmitted from mother to child it is perinatally?

Charles: That's correct.

Vincent: That's correct because the mother is infected and then it crosses the placenta?

Charles: It can go different routes, either in utero transmission through the placenta or actually intra-utero which is during delivery. That's the most frequent transmission route.

Then of course after delivery they can get it from breast milk as well.

Vincent: So during delivery, so there's virus present at birth and its contaminating the baby as it is being born. So how... it will enter through cuts, for example, the umbilicus, do we know how it gets in?

Charles: Well the exact route is still not clear. But most likely, probably, maybe ingesting some of the body fluid of the mothers, and get in to the gut and, I think, at the time the baby's system is completely not developed so that maybe the route.

Though how exactly it gets into the baby is still not clear.

Vincent: Okay.

Charles: And after all these years of people studying.

Vincent: So what is the sera prevalence of HIV in this same population that you are studying?

Charles: Well, in the beginning when we started, 15 years ago, it was about 30 percent, talking about three in ten people.

Now with the government education, the scale up of the entire retroviral treatment, people are being tested more openly now, the whole atmosphere is changing.

So we're seeing a stabilization of the HIV epidemic in Africa, throughout Africa.

So in Zambia, I think the official prevalence is about 16 to 18 percent. And it's maintaining stable... maybe dropping.

Of course there are pockets of areas that are much higher. And we see much higher in the population in the hospital.

Vincent: So you said in the case of KSHV you try to counsel the mother to reduce transmission, right. What do you do with HIV?

Charles: Well in HIV we work with the local government policies and trying to do counseling of every client that comes in and also encourage them to be tested.

I think the way to control HIV, as you know now, is to really... better detection, and try to prevent transmission.

I think there's a lot of hope recently because we have different strategies to really reduce transmission.

For example, prolixus, treating infected people with antiretroviral drug early, that will reduce the viral load so that the chance of passing it on to a recipient is much less.

So we are hopeful that if we can catch every infected individual and treat them, you will probably, eventually reduce the transmission rate and then the sera prevalence will go down.

So these really involve massive educational programs.

Vincent: But triple therapy is available?

Charles: It is available now in Africa because we have this government program, by US Government investing 15 billion dollars into the PEPFAR program and it is really helping in terms of providing drugs to the people.

So there is hope. I think that is really important. So people are coming out to be tested. Before, I can see it, people don't even care because the death... it's a death penalty basically. So there's no treatment.

So the attitude... I can see it completely changed attitude. It's amazing. People have hope now. They are actually very adherent to the treatment program.

Vincent: That's surprising because it's not without side effects and here in the US many people stop because it's not fun. It's like.... I would be surprised if you got good adherence there as well.

Charles: They do. I mean, but they still have side effects. A lot of people cannot take it. So those that can take it will adhere to it. But the side effect is still there.

Vincent: There have also been some trials of prophylaxis using triple therapy, is that right, in prophylaxis?

Charles: They are using a single therapy tenofovir so far. But there are other drugs they are looking into. It is actually quite effective in preventing transmission.

Vincent: So what do you think, that will be implemented where you are studying these individuals?

Charles: I think so. Actually the government is trying, at least in Zambia, the government is trying to treat… it is trying to implement a policy to treat everybody that is found positive.

So that will definitely lower the transmission rate.

But our concern is it really sustainable… because of the outside aid to Africa. But if all these outside aid are stopped, can the government really sustain this treatment program?

It's a big concern.

So the African countries have to take ownership to be able to really take over. That's the hope we all have.

Vincent: Do you think that we need a vaccine to get around this problem?

Charles: Yes we do, but I think... ah, if you remember maybe, when Regan was President, when the virus was first discovery in 1983, we're going to have a vaccine in five... in fact Margaret Heckler, who was the Secretary of Health and Human Services, she said we will have a vaccine in five years.

That was almost 25, 30 years ago. So it is going to be a tough one. A vaccine is going to be a little bit far ahead yet.

Vincent: But the drugs alone are not going to be enough to reall dent the spread, right?

Charles: It will if they can treat everyone that is infected. Theoretically you are going to keep reducing the infected people, or transmission, is going to go down.

There are models people can study that you can really get rid of HIV transmission.

Vincent: Before we leave you, why don't you tell us a little bit about this very unique place, The Center for Virology? How did this come to be and why do you have people doing the same thing in the same place?

Charles: It is very important to have the environment or the critical mass for anything and we are fortunate, even before I came, we had this great virologist here sitting next to me, right here.

And plus out in the audience and we already have a cadre of virologists, but we are so scattered into many different departments.

So the opportunity came in 2000 when we had a chance to compete for a center grant through the NCRR IDeA Program.

So we were able to pool all the virologists together and put a proposal in and we were lucky and got funded.

We were one of 18 centers back in 2000 that were funded. Here we are, 12 years later and we're still here and it's a great thing.

We continue to build on it and we will be able to recruit more virologists into different departments in different areas, different viruses.

We want to maintain the diverse expertise in plant, animal and human viruses. We are also lucky to have more positions coming in.

We are also unique in a sense; we have a building, which hopefully you will have a chance to see later on, that we all co-localize.

As our Vice Chancellor Dr. Paul mentioned earlier, it is quite unique in a sense, we were taking people away from their home departments and we co-localized.

So it is a lot of so-called I would say, water we have tread through, because it has never been done at a university but we have great supports from our administrators, from Chancellor down.

And really, I think, because of all the successes of all the faculties in the center we are able to maintain it.

We are also fortunate, as you heard, that we are going to be expanding. Our building is like four years old and we had the opportunity to get this ARRA funding to increase our capacity by 30 percent.

The Chancellor is now investing in faculty number, so we already have two positions given to us this to start expanding our center.

With the new facility we are very hopeful we are going to build it up to the next level.

We'd like to let the world know that we have great virology here and we want people to come to Nebraska.

Vincent: So have you started recruiting for these positions now?

Charles: We are starting and we are talking to colleagues to see who are interested. We want to hire people that are at different levels, especially senior people that can bring in a new perspective and take over the center and build it up to a next level. That's what we're hoping.

Vincent: So if some of our listeners are interested should they go to the web site for the center?

Charles: Well I think they just send us email, we want to really....

Vincent: Alright. Send Charlie an email.

Charles: Or to any one of us an email. Send the Vice Chancellor an email.

James [?]: Send them to Charlie.

Vincent: Because people have gotten jobs through TWiV before, so you never know.

We have lots of very connected and interested listeners.

Charles: That's perfect.

Vincent: You have two positions?

Jim: The plant virology one was one that was just released this week. It hasn't even been formed as.. in terms of an announcement, but the money has been released to recruit for it.

And then the more senior person which was released a couple, three weeks ago. Those are tenure track positions.

Vincent: And the senior person can be in any area of virology?

Charles: Can be in any area of virology, we are open.

As a matter of fact, I think that if we have the right person onboard, I am sure we can twist our vice chancellor's arm or chancellor's arm to get more positions to supplement that ….

Vincent: There you go. That's great to have a lot of virologists in one place. I'm very jealous. Right Terry, to have over a dozen. So I have two virologists at Columbia at the moment.

I went there because Harry Ginsberg had collected five many years ago. But now they're all gone and once you go below a critical mass it's very hard to build back up again.

There's nothing like having people who think similarly to you. They really really do help.

So I think it's great that you guys have this. I hope that you appreciate it, those of you that are here, and I hope it keeps on growing.

Ah, that brings us to you Jack. You've been a plant virologist all your career.

Jack: Well plants feed us. So one of the major justifications... so certainly one of the justifications for hiring plant virologists and doing plant virology has been the implications on food yield which are significant actually worldwide.

I think one of the interesting observations I'll make as part of the field of plant virology and Dr. Ding talked about it earlier, we can actually control virus diseases with fairly simple genetic engineering approaches.

Vincent: Can you first just give us an overview of what kind of plant diseases are agriculturally important?

Jack: Pick a crop and there will be five or six different viruses that you can find associated with that crop.

Many are insect vectored.

Many are a consequence of human domestication and vegetative propagation [?] methods.

A component of the field is really focused on controlling and managing virus diseases in crops.

Vincent: Tomato, corn, cucumbers, peppers, anything?

Jack: We just... we had a project not too long ago that with some facility we were able to genetically engineer soy beans to all three of the viruses that occur most commonly in soy bean.

So there are approaches now that allow us to begin to think about managing virus diseases.

I think though one of the more interesting areas... uh, to go back a little bit, I don't know how much time we've got left but... one of..

For a new plant virologist coming into the field, I think a strategic focus on virus discovery can lead to some really fascination new observations about viruses.

In fact that's how my career started. I inherited a lab at Berkley that was the electron microscopist's lab, Robbie Williams [?].

My discovery happened by looking in the refrigerator. And the viruses that I built a career on were those viruses I pulled out of the refrigerator that he had used for his electron microscopy.

Most of them were small RNA viruses, quite different from what Jim was working on.

These viruses had three or four genes.

I said oh, that's the ones to work on because you know you'll figure those out.

In a lifetime, right?

As it turns out, that really wasn't what happened. What happened was they became really excellent models for recruiting students to do good projects.

And probably one of the most rewarding things that I can say about being a virologist in the field was having smart students that wanted to do something interesting, and I had a couple.

We had all these small RNA viruses and that was the pre-molecular biology era. And I had a couple of students that came into the lab, Jim Carrington was one.

And he said, you know, we ought to do some molecular biology. So I said to him, I said to him, how are we going to do that?

And he says, well there's a guy over there in biochemistry, by the name of Bob Tiegen [?], and he's doing some molecular biology. I'm going to go work for him for a while.

So I call up Bob and I said, yeah, how about teaching us how to do that? And there were about a couple of students, Mark Young and Jim Carrington and Brad Hillman, that came out of my lab that learned how to do this stuff quite early.

So those small RNA viruses became model systems, tomato bushy stunt, and turnip crinkle. As our friend Ding will attest to, they led to a lot of fundamental discoveries about thing like RNA silencing, RNA virus assembly.

And those were all really basic and fundamental studies that one can do and at the same time carry a program that allows you to address the practical problems.

One of the outcomes of doing our research in the development of molecular probes was the development of diagnostic tools for the strawberry industry in California, which actually paid patent fees that were some of the highest for the University of California system, built on diagnosing virus diseases and creating clean stock.

So we do that now using these techniques for things like grapes, strawberries, and a lot of the fruit crops now.

So there are a lot of opportunities I think in the plant virology field, not only in understanding basic mechanisms of how viruses cause disease, which is where my focus is now.

Most people don't really fully appreciate that plants have defense systems. They have an inate immune response and that's another whole area of research you can get involved in.

And we heard a little bit about that today. It may be an RNAi based response, but there is an immune response.

Vincent: Well this is only the second time we've talked about plant viruses on TWiV. The first time was in Brazil about a year ago. You may know some of the plant virologists on that show.

Jack: And at ASB, you had a little... we did a little session.

Vincent: Marilyn Roosinck. That right So it's the third time. So we don't talk about it all that much and we need to do it more. And in fact you should come back and do a whole episode about it because we don't have time to really get into it here.

But I think most people don't realize some of the things that you've said, the RNAi advances made in plants, and also the fact that it's agriculturally very important and things are getting done right now. I think a lot of people don't realize that.

Jack: That's right. Some of the first structural models, the first crystallography were done with the virus system that I studied for many years.

And by mapping the crystal structure that Steve Harrison had done with the molecular biology we were doing we really were able to get at and make mutants that had structural sense.

Vincent: In fact that was the first virus structure determined, right, tomato bushy stunt?

Jack: Tomato bushy stunt, second to TMV, I think, yeah

Vincent: As a way of closing. I asked you a question the other day and maybe we can revisit it. Someone had sent us a question to TWiV, why is it that there aren't any DNA viruses of plants?

And although it's not exactly true, you know what they meant.

Jack: Right, exactly.

Vincent: They seem to be mostly RNA viruses. So, what are your thoughts about that?

Jack: Well much of our discovery, and we haven't really done discovery at the level of eco-systems in plants.

So I asked my colleague Dave Dunigan, I think Dave is here, because he has this diagram that says, well where are the viruses?

Yes what we haven't found in higher plants are DNA viruses of the polyoma sort. There's no fundamental reason why we shouldn't find them that we can think of.

Then again if you look at that branch that is the plant branch of the tree of life, there are all sorts of double-strained DNA viruses of humongous size in the algae and so on.

So these are all related, so why don't we have viruses of that sort in plants? I think there has to be two reasons. We either haven't looked properly or it's some sort of an evolutionary black hole.

And if there were DNA viruses they somehow disappeared.

Vincent: So you said last night that if they're too big they might not be able to move within the plant. Is that another possibility?

Jack: Probably not likely because what you have, you have pox viruses in... Well, not really pox type, but you've got rhabdoviruses in plants. They're pretty big.

You certainly have viruses of the size of papillomas in plants. They're pretty big.

Plant viruses have evolved mechanisms for passing through the cell walls that restrict movement. And so I don't really think that it would be a movement issue.

It may have more... it might have something to do with the fact that plant meristems function a bit differently from rapidly dividing cells that maybe DNA viruses need in vertebrates.

Vincent: So as you know people are looking like crazy for all sorts of viruses in different environments, in oceans and fresh water, in animals. Are people doing this in plants? Maybe it sounds like not.

Jack: There have been some ecosystem wide studies actually to look at viruses in natural ecosystems. And there... as a consequence have been new discoveries of different kinds of viruses that are not currently in the database.

So I think that the answer to that is... now that we have the kinds of tools that allow us to do virus exploration and virus discovery that are different from the ones that we had 30 years ago, I think that we're going to find all sorts of new things.

We just haven't looked very hard. And if you look at that tree of life, how many branches have we explored?

Very few… animals and plants, right? But, and some algae… and a few other things. But for the most part so far we haven't really applied the modern tools of virus discovery to really looking at where viruses reside in our ecosystem.

Vincent: Is that something you'd like to do?

Jack: Oh I think that'd be fantastic, that'd be fascinating. Except you have to learn how to do this bioinformatic stuff. Molecular biology was easy.

Vincent: But you know you can... you hire the bioinformatics people.

Jack: Yeah, that's certainly one of the things we'll have to think about doing.

Vincent: On the other hand viroids are only in plants, right?

Jack: As far as we know, other than the hep-b associated circle.

Vincent: So why's that? Haven't found them yet?

Jack: Well... Shou, he can tell us why. We haven't really looked.

And he's developed... ah, we didn't get to that part in his talk, a bioinfomatics approach for searching for small RNAs that are circular.

Vincent: Yeah. So we just haven't looked. So there is plenty of opportunities in virology. But I don't need to tell this audience that, right.

Jack: That's… I think so, I hope.

Vincent: They are already heard it. All of you are into virology, is that right? Anyone not into virology here? No... that's good.

Good, alright. So usually on TWiV we do email, but I'm going to skip that because we have a poster session starting soon and we don't want to impinge on that because that's really important.

But I would like to do our picks of the week. I have one and I have some listener picks.

Vincent: But I would like to do our picks of the week. I have one and I have some listener picks. Any of you guys, Jack did you want to pick something?

Jack: I know Charlie's got one because I was making him look on his iPad for something or other.

Charlie: I had to download this article a lot of people have been talking about this new reptile virus that causes hemorrhagic fever in Congo, in central Africa, it's just been published in PLoS Pathogen.

It's fascinating because they just discovered it in several patients and two of them died.

One of them actually got antibodies and recovered. There was a nurse taking care of those two patients. So whether this is an ebola like virus or not is it's something new, because of as a matter of fact it is only 34% homologous to reptile virus. So it might be something different

And again, I want to point out the reason they can piece this together real fast is because of this high-throughput sequencing. They were using this Illumina just to get them and piece them together. So really I think it represents viral discovery, it represents high technology, and presents a new agent. So I think it's a fascinating paper. It's an easy read, so everybody should take a look at it.

Vincent: I think they said it's the first time they could put together by deep sequencing of clinical specimens the whole genome. So they did it from serum?

Charlie: From serum, yes.

Vincent: And I think there were a million copies of viral DNA per mil, which is not terribly high. So that's pretty good.

But you know, we tend to gravitate to illness and look there. But as we know, there are plenty of viruses out there that don't make you sick that are really worth discovering. And there's a lot more to do.

So my pick actually come from my older son, and he hangs out on reddit all the time. You guys waste time on reddit, probably too, no? That's because you're mature. See, he's only 18.

Anyway, he sent me last night a post he found on reddit, which is bacteriophage graffiti.

So someone found on the wall somewhere next to someone's apartment a drawing of a bacteriophage. And so I have an image of that, which I think is good because graffiti is usually pretty weird stuff but a phage?

So someone is a budding virologist out there. Maybe it's one of you guys who put the graffiti up there? So phage graffiti on reddit, that's my pick.

I have two listener picks, these both came in last night. In case you don't know, for those of you who don't know TWiV, we also have a page on Facebook. It's Facebook.com/ThisWeekInVirology all one page. We have 2800 likes. Let's see if Nebraska can push it over 3000. Okay. So you should just go and like the page because I know you are on Facebook.

Anyway, last night Bob wrote, "Hey Vince, one of my past mentors did this piece, thought you and perhaps the greater virology community at large would appreciate it."

So this, I don't have internet here, let's see if I can find okay this is in the American Society of Tropical Medicine and Hygiene Journal. It's their blog actually. It's an article by Dan Bausch. It's about Penny Pinneo. Does anyone know what that name is, Penny Pinneo?

The older guys are the only ones that would know. Sorry? Ah, no. She was a nurse and she was among the first people to get Lassa Fever, in 1969 in Nigeria. She just died in August, she was 95 years old. Her story is so cool.

So there were some cases of Lassa in Nigeria. She was a nurse, she took care of them. She got sick. They air lifted her to Columbia Presbyterian, which is where I am, but this was before I was there. They just put her in an airplane in the passenger compartment and shipped her back with no precautions.

She recovered. They put her in intensive care, she recovered. They sent some of her serum to Yale. At the time the Yale Arbovirus Unit was there. And Jordi Casals began to work on and he infected himself and he got really sick. They used her serum. They gave her serum to him. She had antibodies and it saved his life basically.

And she's alive, or she was alive up until August and she knew this story.

And so this is a cool little blog about her. And you know, someone about a year ago emailed us on TWiV and said, "You ought to interview Penny Pinneo because she's just been discovered in Florida and you should interview her before she dies." I never got around to it.

So anyway, this is a cool article on her. AST of H remembers Penny Pinneo a pioneer in combating Lassa Fever, 1917-2012. So thanks for that Bob.

And then last night also, a few minutes later, Janet from Heidelberg, one of our fans, said, "Don't know if you TWiVers have already seen this but it's pretty funny and makes the point." It's a Penn and Teller little skit on YouTube about vaccination.

Have you seen this? Okay it's really really... I'm mean it's full of cursing, Penn and Teller right. But, it makes the point of why you should vaccinate your kids in a very illustrative way basically.

So check that out. We'll put a link to that in the show notes, it's really well done. So those are our two listener picks of the week.

You can find this show, we're going to be posting this as usual, it's being recorded, at TWiV.tv. That's our web site. We are also on iTunes and the Zune Marketplace. We also have an iPhone or an Android app you can use to listen to these. You can find that at MicrobeWorld.org.

And we always answer questions and comments. We didn't have time to do that today. We have tons of them. We love to get them. You can send them to TWiV@TWiV.tv.

I want to thank everybody for participating today. Jack, Jack Morris here at the University, thanks a lot.

Jack: Thank you.

Vincent: Come back again and we'll get into it in more depth. How's that?

Jack: That'd be great.

Vincent: Will that be a deal? Thank you so much.

Charles Wood, thank you.

Charles: Thank you.

Vincent: Thank you for having us here and for doing this.

Charles: It's great to have you here. Well, come back.

Vincent: Thank you.

Jack: We need to get you a big red souvenir of some sort, right?

Vincent: You mean a red sweater like. What is the motto here, Big Red?

Charles: Go Big Red.

Vincent: Go Big Red. You know I went to Cornell. That was Big Red, it's not Nebraska. Isn't Cornell Big Red? So what do we have a conflict here?

You know Columbia is the center of football power, Columbia University? We once lost 150 games in a row. We were proud of that.

I remember Michael Lai. Where was Michael Lai, USC? He came to give a seminar once and his losing streak was even longer than Columbia's. That was great.

Ah Jim Van Etten, and thank you for joining us.

Jim: Thanks for having me on your show. And I'm sure glad you came to Lincoln.

Vincent: You come back again because we want to hear more about big viruses.

Jim: As I get old I have plenty of stories to tell.

Vincent: Excellent, we've got to get more of them.

I'm Vincent Racaniello. You can find me at my web site which is Virology.ws.

You've been listening to This Week in Virology. Thanks for joining us. We'll be back next week.

Another TWiV is viral.

Steve Stokowski made this caption file using a YouTube Machine Translation and the online captioning tool Subtitle-Horse.